# International Journal of Advanced Engineering Research and Science

## (IJAERS)
### An Open Access Peer Reviewed International Journal

# International Journal of Advanced Engineering Research and Science

Vol-7, Issue-9

Sep, 2020

*Editor in Chief*

Dr. Swapnesh Taterh

*Chief Executive Editor*

S. Suman Rajest

# FOREWORD

I am pleased to put into the hands of readers Volume-7; Issue-9: 2020 (Sep, 2020) of **"International Journal of Advanced Engineering Research and Science (IJAERS) (ISSN: 2349-6495(P) | 2456-1908(O)",** an international journal which publishes peer-reviewed quality research papers on a wide variety of topics related to Science, Technology, Management and Humanities. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release print issue also, but this decision the journal issue will be available in various library also in print and online version. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind. This journal has DOI (Digital Object Identifier) also, this will improve citation of research papers. Now journal has also been indexed in **Qualis (Interdisciplinary Area) (Brazilian system for the evaluation of periodicals, maintained by CAPES).**

I thank all the authors of the research papers for contributing their scholarly articles. Despite many challenges, the entire editorial board has worked tirelessly and helped me to bring out this issue of the journal well in time. They all deserve my heartfelt thanks.

Finally, I hope the readers will make good use of this valuable research material and continue to contribute their research finding for publication in this journal. Constructive comments and suggestions from our readers are welcome for further improvement of the quality and usefulness of the journal.

With warm regards.

**Dr. Swapnesh Taterh**
Editor-in-Chief
Oct, 2020

# Vol-7, Issue-9, Sep 2020
## (10.22161/ijaers.79)

# Study of the Technical Feasibility of the Usage of Waste from Electric Posts as Coarse Aggregate in the Mixture of Concrete for Structural Purposes

Dênis Cardoso Parente[1], Pablo Teixeira Gonzaga Sousa[2], Rafael Alves Amorim[3], Daniel Iglesias de Carvalho[4], Larissa Moreira Cardoso[5], Edivaldo Alves dos Santos[6]

[1,2,4,6]Centro Universitário Luterano de Palmas – TO, CEULP/ULBRA, Brasil
[3]Universidade Federal do Tocantins, UFT, Brasil
[3]Instituto Brasília Ambiental, IBRAM, Brasil

*Abstract—This work aims to analyze the technical and economic feasibility of using concrete post waste as coarse aggregate for the manufacture of new electricity posts. In order to carry out the experimental study, waste processing, characterization and finally concrete dosage were carried out. The adopted methodology consists in the partial substitution of the natural aggregate by recycled aggregate originated from damaged concrete electricity posts collected in the city of Palmas - TO. In order to obtain the results, specimens and new concrete posts were tested with the replacement of the aggregate, respecting the approval guidelines for concrete post for electric power networks. The results obtained point to the use of waste from unusable posts as a potential alternative in removing the residue from the environment, replacing natural aggregates in the manufacture of new posts that meet the mechanical resistance specifications.*

*Keywords— concrete electric post, concrete electric pole, construction waste, electrical resistance.*

## I. INTRODUTION

The construction industry currently represents one of the largest consumers of natural resources in the world [1]. In addition, it is the largest generator of waste, in mass and volume, in urban environments. The lack of policies and guidelines related to this waste, culminates to its inadequate disposal on urban and natural environments, causing significant impacts to the environment, both on urban and rural [2].

According to the data from the National Department of Environmental Sanitation, construction and demolition waste (CDW) represents an amount of 40 to 70% of all solid waste generated in the country. The cleaning of this material improperly disposed in urban environments, generates a high cost for the municipalities, since they cannot be disposed in common sanitary landfills [3], a resource that could be used to benefit society and to improve urban infrastructure.

In this way, the recycling of construction waste is an effective alternative in reducing the extraction of natural resources for construction supplies, maintaining a healthy urban environment, decreasing municipal spending and increasing job creation [2].

Despite presenting itself as a viable alternative to all of the aforementioned problems, recycling is not a simple process and the product generated needs to undergo strict quality control so that this product can reach the market competitively enough to generate all the benefits that promises. In other words, it is not enough to adopt CDW recycling, it is necessary to meet market requirements [4].

Thus, in order of obtaining viability of the recycling of CDW, aspects such as technical performance of the recycled product, environmental impacts caused by the recycling process itself and disposal of the recycled waste at the end of the production chain and market viability must be taken into account [5].

Several studies have been developed to make the use of these recycled aggregates feasible in the constitution of concrete, among them, studies of evaluation of specific mass of aggregates from CDW and its reactions on the properties of concrete [6], use of steel fibers in concretes produced with recycled coarse aggregates [5], use of recycled CDW aggregates on the basis of paving structure [7], studies of the effects of the use of coarse and fine aggregates from CDW on the properties of structural concrete [8] and [ 9].

All of these work generate an important framework for studies on the use of recycled CDW materials in the constitution of structural concretes. Many of them show positive results in this area, such as the study by [6] that deals with the use of CDW residues separated by density in the concrete composition. In this study the author verified the direct relationship between the aggregate density and the ultimate strength range of the developed concrete.

These are the one works that motivate the study of the technical viability of the use of CDW obtained from concrete posts, in the composition of a concrete for structural purposes, since the source of the aggregate guarantees a homogeneity of its characteristics, both in relation to the density and the constituent materials and other features.

The viability of using this aggregate also enables the sustainability of posts production chain that grows every year along with urbanization, since the steel obtained from the demolition of the posts is already recycled and used for other purposes.

According to data provided by the company of electricity distribution in the state of Tocantins, [10], in 2019 3,940 reinforced concrete posts were discarded. According to the company, the main factor in the demolition of electricity distribution poles is the collision of cars, which damages completely the posts. Table 1 shows the number of posts lost in 2019 per month and the monthly average.

*Table 1. Number of damaged posts during 2019.*

| Month | Quantity of posts |
|---|---|
| January | 124 |
| February | 218 |
| March | 297 |
| April | 222 |
| May | 293 |
| June | 243 |
| July | 371 |
| August | 270 |
| September | 277 |
| October | 515 |
| November | 630 |
| December | 480 |
| **Total** | **3.940** |
| **Monthly Average** | **328** |

## II.    METHODOLOGY

In order to achieve the proposed objectives, the applied experimental methodology compared the results of resistance to compression and flexion of samples from posts dosed with conventional concrete and concrete posts with the substitution of natural coarse aggregate for recycled aggregate.

### 2.1  Sample preparation and crushing

In this phase, the preparation of the post residues was carried out, with the separation of the concrete from the steel bars. The removal of the bars was made manually in the company that manufactured the posts, with the aid of mallets and pneumatic hammers.

After the separation, the demolished concrete was sent for crushing in a jaw crusher, in order to obtain a similar granulometry to that of the natural aggregate, with a maximum characteristic length of 19 mm, the same maximum characteristic length of the natural aggregate with the removal of the fine material.

### 2.2  Characterization of the aggregate

Following the parameters of [11], the granulometric compositions of the coarse aggregate were determined, both natural and recycled, as well as the granulometry of the coarse aggregate.

To determine the specific mass and unit mass of the fine aggregate, the guidelines of [12] were adopted, it should be noted that only natural fine aggregates were used. For coarse natural (pebble) and replacement aggregates, the same determinations were made based on [13].

### 2.3  Concrete dosing

In this stage, the concrete was produced with the reference mix design, dosed by the method of the Brazilian Portland Cement Association (ABCP) and with the replacement of the coarse aggregate crushed concrete from the discarded posts.

This method consists of collecting data in the laboratory of the materials used in the production of concrete, they are: fineness modulus (MF), maximum characteristic length (MCL), humidity (h%), specific ($\gamma$) and unitary ($\delta$) mass. From the data obtained, tables and graphs were used to

support obtaining the appropriate proportions for the mix design.

The fck (characteristic strength at 28 days) of 25 MPa was defined for an aggressiveness class II [14], a moderate aggressiveness class and a low risk of deterioration of the structure. Another characteristic adopted was a concrete slump equal to 50 ± 10mm.

Based on the mix mass, it was calculated the consumption of the inputs needed to make 6 specimens for each mixture, in percentages of 0%, 25% and 50% of replacement.

## 2.4 Characterization of dosed concrete

In the fresh state, for the determination of the slump of the material, the criteria presented in [15] were used, which determines the consistency by slump of the cone trunk, known as slump test.

In the hardened state, tests were carried out to determine water absorption, void ratios and specific mass, resistance to axial compression and, finally, bending tests on posts manufactured with the new concrete matrix.

The determination of water absorption, void ratios and specific mass were made based on [16], for this assay, two specimens were molded for each mixture, totaling 6 (six) specimens.

Three mixtures were performed, 6 specimens per mixture, totaling 18 specimens which, according to [17], were molded with 10x20 centimeters for each sample. After 28 days of normal curing, the samples were taken to the hydraulic press and broken according to [18], in order to obtain their compressive strength.

## 2.5 Bending Test on electric posts

The last and main test performed is the bending test on posts, which seeks to verify the resistance of the posts when subjected to bending efforts. 6 poles with a height of 7.5m were molded and tested according to the standard requirements of [19].

The procedure consists of the following stages:

The setting of the base of the post to the test bench, with the length provided by the following equation:

$$e = \frac{L}{10} + 0{,}60$$

Where: "L" is the nominal pole length in meters and "e" is the footing length in meters. With the footing measure thus obtained, the post is fixed to the bench.

The distance from which the effort should be applied to the top of the post must be 200mm. The application and withdrawal of effort should always be slow and gradual, avoiding sudden sweeping of the load during the tests.

With the post set, the effort Rn, corresponding to its nominal resistance, was applied at a distance of 200mm from its top, for at least 1 (one) minute, to allow the accommodation of the footing.

After the setting, an effort is applied at 1.4 times the Rn, corresponding to the minimum rupture load of the pole, for a minimum of 5 (five) minutes. After the time of the first application, the load is progressively increased until the rupture load of the part is obtained.

## III. RESULTS AND DISCUSSIONS

### 3.1 Granulometry

The results of the granulometric characterization test of the natural fine aggregate revealed the fineness modulus of 3.39mm and the maximum characteristic length and 4.8mm.

In the analysis of the results collected in the granulometric characterization of the recycled aggregate (Figure 1 1), it was found a better distribution among the fractions retained on the sieves when compared to the natural aggregate.
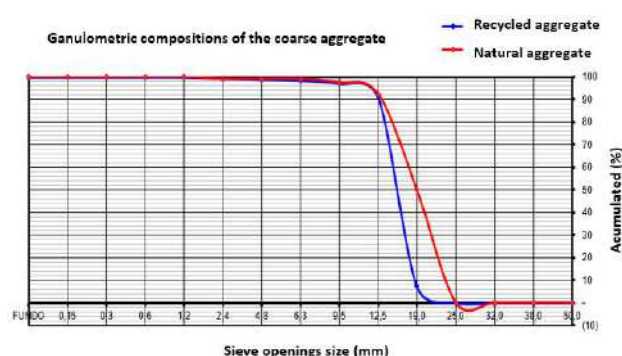


*Fig.1: Granulometric distribution of coarse aggregates.*

The result of this is a higher percentage of material with a diameter of less than 12.5mm as well as a greater amount of powdery material in the sample, which can affect the slump and resistance of the dosed concrete, since this material can subtract hydration water and kneading of the cement.

### 3.2 Water absorption, specific and apparent mass.

The specific mass, apparent mass and water absorption values of recycled and natural coarse aggregates can be observed in the table below.

*Table 2. Results of water absorption, specific and apparent mass of the aggregates.*

| Properties | Natural Aggregate | Recycled Aggregate |
|---|---|---|
| Water Absorption (%) | 1.19 | 2.88 |
| Especific mass (kg/m³) | 2,650 | 2,560 |
| Unit Mass (kg/m³) | 1,360 | 1,270 |

The percentage of water absorption by the recycled aggregate is much higher than that of the natural aggregate, a common situation when it's about demolition material. The presence of fine aggregate and the porosity of the demolished concrete are the main responsible for the absorption of the mixing water, which ends up impairing the workability of the dosed concrete.

For the fine aggregate used, the specific and apparent mass values found are shown in the table below.

*Table 3. Values of specific and unit mass of the fine aggregate.*

| Properties | Natural Aggregate |
|---|---|
| Especific Mass (kg/m³) | 2,630 |
| Unit Mass (kg/m³) | 1,670 |

### 3.3 Concrete mix design in mass

The dosages elaborated according to the ACI method, to resist the compression of 25 MPa, which is the adequate strength for the manufacture of new concrete posts, with slump of 100mm for reinforced parts, with a deviation of 4.0 for reasonable control, resulted in the mass proportions shown in table 04

### 3.4 Slump

The dosage made with natural aggregates showed good workability and consistency within satisfactory standards, observing the standards established by [20] and [21]. The table 4 shows the results obtained for both mix designs.

*Table 4. Slump values for different dosages.*

| Properties | Reference | 25% | 50% |
|---|---|---|---|
| Slump | 110mm | 100mm | 85mm |

What is observed is that the dosage with 25% recycled coarse aggregate did not show a substantial change in its workability when compared to the reference mix design. However, on the second mix design, with a 50% substitution, there was a reduction in the concrete slump,

even though, within the tolerance limits of +/- 2.0 mm of the slump test.

### 3.5 Concrete in the hardened state

According to the adopted methodology, tests were carried out on cylindrical shape specimens and on molded posts. At 28 days of curing, axial load and water absorption tests were made on the cylindrical specimens, at *CEULP / ULBRA materials and structures laboratory, in Palmas - TO*.

The results of resistance and absorption can be seen in table 5.

*Table 5. Values of compressive strength and water absorption by concrete.*

| Concrete Specimen | Rupture Stress Average (MPa) | Average Absorption (%) |
|---|---|---|
| Reference | 28.05 | 3.85 |
| 25% | 26.40 | 3.59 |
| 50% | 25.65 | 4.54 |

Both results of compressive strength and water absorption remained within the adopted reference values. [22] fixes the average absorption of the specimens by up to 5.5% and the individual limit of water absorption by concrete, for electric posts, up to 7%.

### 3.6 Bending resistance

The bending tests (Figure 2) were carried out at the company *Concreto Artefatos de Cimento* in *Araguaína Tocantins,* with 6 posts of 5m length, two specimens of each mix design, all with an approximate age of 28 days of cure.



*Fig.2: Bending test on molded posts.*

Deflection results were obtained with the project load (150 kgf), residual deflection, number of cracks, in addition

to the modulus of rupture. Table 6 shows the results obtained during the experiment.

*Table 6. Deflection values, rupture load and number of cracks in posts tested on bending.*

| Post | Deflection (cm) | Residual Deflection (cm) | Number of Cracks | | Modulus of Rupture (kgf) |
|---|---|---|---|---|---|
| | | | Face A (Minor inertia) | Face B (Major inertia) | |
| Reference – Post 1 | 24 | 3,5 | 17 | 14 | 350 |
| Reference – Post 2 | 23 | 3,5 | 23 | 17 | 350 |
| 25% - Post 1 | 22 | 3,5 | 26 | 21 | 330 |
| 25% - Post 2 | 23 | 3,5 | 19 | 20 | 300 |
| 50% - Post 1 | 24 | 2,0 | 33 | 27 | 300 |
| 50% - Post 2 | 24 | 2,0 | 38 | 29 | 300 |

As noted in the table above, the deflections for the nominal load of 150 kgf applied in the direction of lower inertia did not exceed the limit established by [19]. The deflections of all evaluated posts were within the range of 5% of their height, which corresponds to 37.5 cm.

The residual deflections measured after the removal of the load were below the established limit, 0.5% of the post nominal length

The posts with 25% replacement showed residual deflections identical to those of the posts with a reference mix design, while the posts molded with 50% replacement showed a reduction in their residual deflections, which may be an indication of an increase in their elasticity module (less plastic deformation), still, meeting the parameters of the standards for concrete posts.

The number of cracks when applying the force of 140% of the nominal load value was accentuated in posts with 50% replacement, however, with their holes remaining below the limit of 0.30mm. After the load ceased, the cracks closed,

becoming capillary pores, meeting the requirements of the standard, as shown in Figure 3.
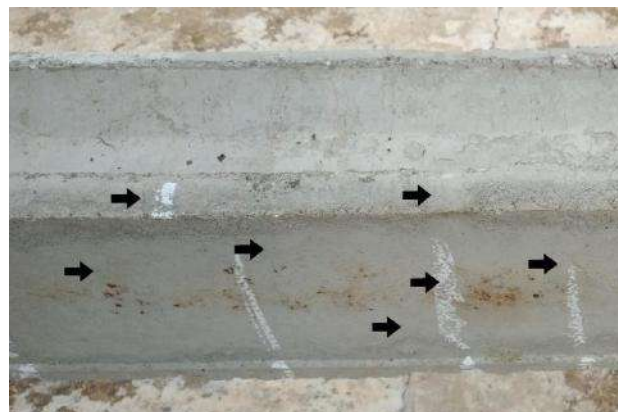


*Fig.2: Identification of closed cracks after bending test.*

As for the rupture load, all posts reached similar results ranging from 300 and 350 kgf, both meeting the minimum of twice the nominal load value (150 kgf) established by the standard for concrete posts.

## IV.    CONCLUSION

The results obtained in this study were confirmed when compared with the concepts used in the research and through experimental tests.

It can be said that the use of recycled concrete aggregates, originating from the crushing process of waste posts, presents itself as a potential solution for the manufacture of new concrete electric posts. Its quality allows a satisfactory behavior from the point of view of its mechanical resistance, the main aspect observed in the approval and acceptance of a concrete pole.

It is verified that the use of recycled concrete aggregates contributes to the removal of a significant volume of waste per discarded unit, thus contributing to a reduction in the amount of material that could be discarded. Not least, there would be a decrease in the extraction of natural aggregates obtained from mineral deposits.

## REFERENCES

[1] JOHN, V. M.; ANGULO, S. C.; KAHN, H. Controle da qualidade dos agregados de resíduos de construção e demolição reciclados para concretos a partir de uma ferramenta de caracterização. 2006.

[2] ANGULO, Sé. C.; JOHN, V. M. Normalização dos agregados graúdos de resíduos de construção e demolição reciclados para concretos e a variabilidade. IX Encontro Nacional de Tecnologia do Ambiente Construído, p. 1613-1624, 2002.

[3] PINTO, T.P. Metodologia para a gestão diferenciada de resíduos sólidos da construção urbana. São Paulo.189p. Tese (Doutorado) – Escola Politécnica, Universidade de São Paulo. 1999.

[4] MOREIRA, L. H. H. Avaliação da influência da origem e do tratamento dos agregados reciclados de resíduos de construção e demolição no desempenho mecânico do concreto estrutural. 2010. Tese de Doutorado. Universidade de São Paulo.

[5] PIETRA, L. Avaliação do concreto com agregados graúdos reciclados e resídus de construção e demolição reforçado com fibras de aço. 2005. 129 p. Dissertação (Mestrado). Escola Politécnica da Universidade de São Paulo, São Paulo, 2005.

[6] CARRIJO, P. M. Análise da influência da massa específica de agregados graúdos provenientes de resíduos de construção e demolição no desempenho mecânico do concreto. São Paulo: USP, 2005. Dissertação (Mestrado em Engenharia Civil), Escola Politécnica da USP, Universidade de São Paulo, 2005.

[7] MIRANDA, L. F. R.; ANGULO, S. C.; CARELI, E. D. A reciclagem de resíduos de construção e demolição no Brasil: 1986-2008. Ambiente Construído, v. 9, n. 1, p. 57-71, 2009.

[8] TENÓRIO, J. J. L. et al. Avaliação de propriedades do concreto produzido com agregados reciclados de resíduos de construção e demolição visando aplicações estruturais. 2007.

[9] GOMES, S. C.; PIMENTEL, L. L. Análise da viabilidade de incorporação de agregados reciclados provenientes do beneficiamento de resíduo classe A na produção de concretos c20 e c30. 2015.

[10] ENERGISA. Relatório interno de geração de resíduos sólidos. Palmas, Tocantins. 2016.

[11] ABNT. NBR NM 248. Agregados - Determinação da composição granulométrica. Rio de Janeiro 2003.

[12] ABNT. NBR NM 45. Agregados - Determinação da massa unitária e do volume de vazios. Rio de Janeiro 2006.

[13] ABNT. NBR NM 52. Agregado miúdo - Determinação de massa específica e massa específica aparente. Rio de Janeiro 2009.

[14] ABNT. NBR 6118. Porjeto de estruturas de concreto – procedimento. Rio de Janeiro 2014.

[15] ABNT. NBR NM 67. Concreto - Determinação da consistência pelo abatimento do tronco de cone. Rio de Janeiro 1998.

[16] ABNT. NBR 9778:2009 Argamassa e Concreto Endurecidos: Determinação da Absorção de Água, Índice de Vazios e Massa Específica. Rio de Janeiro, 2009. 3 p.

[17] ABNT. NBR 5738:2015. Concreto – Procedimento para moldagem e cura de corpos de prova.. Rio de Janeiro, 2015.

[18] ABNT 5739:2018. Concreto – Ensaio de compressão em corpos de prova cilíndricos. Rio de Janeiro 2018.

[19] ABNT. NBR 8451-3. Postes de concreto armado e protendido para redes de distribuição e de transmissão de energia elétrica - Parte 3: Ensaios mecânicos, cobrimento da armadura e inspeção geral. Rio de Janeiro 2020.

[20] ABNT. NBR 11172 Tb 371 - Aglomerantes de Origem Mineral. Rio de Janeiro 1990.

[21] ABNT. NBR 12655. Concreto de cimento Portland — Preparo, controle, recebimento e aceitação — Procedimento Rio de Janeiro 2015.

[22] ABNT. NBR 8451-4. Postes de concreto armado e protendido para redes de distribuição e de transmissão deenergia elétrica - Parte 4: Determinação da absorção de água. Rio de Janeiro 2020.

# Coastal regionalization with self-organizing maps-Water quality variables applied to cluster formation

Oliveira, Bruno Meirelles[1]*; Carneiro, Cleyton de Carvalho[2]; Harari, Joseph[3]; Belosevich, Pablo de Sosa[4]

[1]Institute of Energy and Environment of the University of São Paulo, Brazil.
[2]Polytechnic School of the University of São Paulo, Brazil.
[3]Oceanographic Institute of the University of São Paulo, Brazil.
[4]Institute of Energy and Environment of the University of São Paulo, Brazil.
*Corresponding author

**Abstract**— *Human sewage disposal can interfere with water quality and thus diminish the ecosystem services provision, including Phytoplankton lifespan. Understanding the role played by sewage disposal in water quality can be useful not only for tourism planning but also for characterizing beaches based on water quality using secondary data and avoiding the costs of sampling and monitoring. The objectives of this paper were to understand the water quality behavior at several small bays in a coastal city of Brazil and to test the use of self-organizing maps in forming clusters similar to those derived from geomorphology and to understand how representative these maps were of the water quality of the whole city. According to our results, self-organizing maps showed similar behavior to geomorphological processes, confirm the hypothesis of cluster formation due to quality and also presented a new pattern of data variation related to seasonality that was not noticed before in the sampling.*
**Keywords**— ***Batheability, self-organizing maps, coastal management, water quality.***

## I. INTRODUCTION

Marine ecosystem services (ES) such as supplying fisheries, carbon sequestration, food provision, and recreation—all of which make an undeniable contribution to human well-being—are being affected by changes in the climate system (Costanza, 1997;Pauly, 2005; Beaumont et al., 2007; de Groot, 2012). Ocean ES contribute more than 60% of the total economic value of the biosphere (equivalent to almost US$21 trillion per year [1994 US$]; Costanza et al., 1997). De Groot (2012) shows an average income from coastal zones of $2,384.00/ha/year from food provision plus $256/ha/year from recreation. These values reinforce the importance and irreplaceability of marine ecosystem services, putting their management firmly on the decision-making agenda. However, despite various initiatives in this direction, including the development of an ecosystem approach to fisheries management (Pauly, 2005) and an assessment of the state of health of the global ocean (Halpern et al., 2012), ocean management is still neglected by governments, even at the highest international level.

One of the issues most relevant to ocean ecosystem services is that related to phytoplankton (photosynthetic microalgae), which are responsible for 50% of global annual marine net primary production (NPP). Phytoplankton, which link the atmospheric and ocean carbon cycles via the biological carbon pump, have crucial importance in trophic chains and ecological balance (Rither, 1969;Field et al., 1998;Falkowski and Oliver, 2007;Falkowski and Raven, 2007;Behrenfeld, 2014). The study of phytoplankton within the marine realm is of vital importance, given the threat of climate change and its knock-on effects on local oceanographic regimes (Armbrecht et al., 2014).

Human sewage disposal can interfere with phytoplankton communities and affect the ecosystem services they provide (KIMOR, 1992), including the recreational use of beaches. Sewage, because of it organic contents, impacts the marine ecosystem when discharged into the ocean, providing high nutrient loads to the coastal zone, especially of nitrogen (N) and phosphorous (P). Furthermore, a high seasonal flow of tourists, together with their related economic attributes, contributes to a significant increase in sewage rates, and this directly interferes with the nutrient rates available for phytoplankton.

This problem is not new, but the perspective of a coastal city losing income due to human sewage in the water is still alive. That is why, since the 1980s, the environmental protection agency of the state of São Paulo in Brazil has had a program dedicated to monitoring seawater quality and to informing the population of the batheability of coastal waters. We used their data from 2004 to 2015.

Nevertheless the amount of data produced by this monitoring program is overwhelming and then the use of some sort of artificial intelligence is necessary. Although sewage discharge is a global problem, our case study focuses on Ubatuba, a small coastal city in southeast São Paulo state, Brazil, with a 200 km long coastline. The city has been designated a priority zone by Brazil's National Council of Tourism, through a Federal Decree: the diversity of its natural resources makes it a place of high ecological importance, with tourism as its main economic activity (IBGE, 2015).

The city has several beaches with low human interference, as well as beaches with a moderate to high human presence which presents some issues regarding scale and representativeness of each of those beaches in the overall picture of the city.

In this paper we discuss the formation of clusters of beaches along the coastline, created by several natural bays, using water quality data. Then, the individual participation of the clusters in the overall picture of the city is presented and discussed.

Finally the goal of this paper was to discuss the application of self-organizing maps to batheability data to understand variations in coastal attributes. More specific questions relate to: i) the representatives of geomorphology in the overall settings;ii) the possibility of artificial clusters being correlated and representing a coherent group of data;iii) the use of SOMs to create an overall picture of Ubatuba;iv) how individual collaborations fit into the overall picture; and finally v) the emergence of unnoticed patterns in the data. This paper does not represent a novelty in artificial neural network research but may be useful for local management and sustainability.

## II.    METHODS
### Ubatuba case study

The Ubatuba municipality in São Paulo, Brazil, is located on the northern coast of São Paulo state (Figure 1) and has an approximate area of 723,883 square kilometers: 87.04% of the area is covered by native vegetation and 68% lies within a protected area (IBGE, 2015). Ubatuba's economy is seasonal, its predominant development factor being tourism (SMA / CPLEA, 2005).
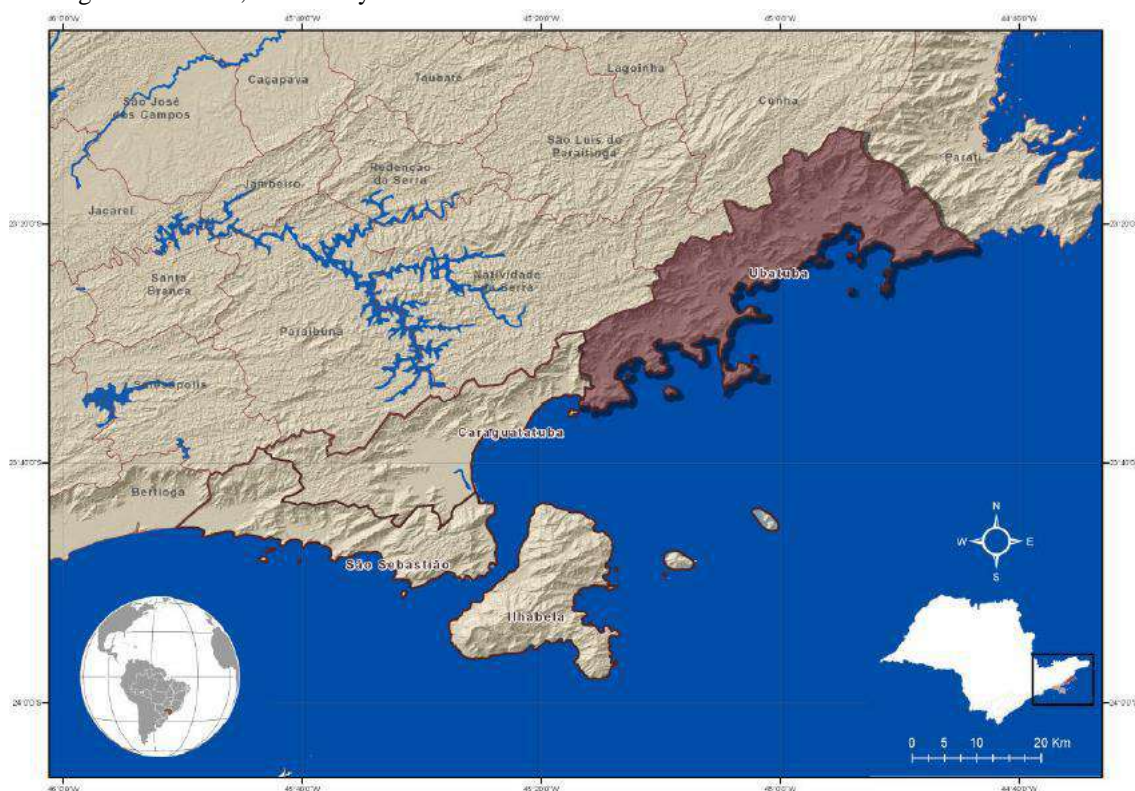


*Fig.1: Location map of the north coast of São Paulo. Ubatuba is the dark-shaded area*
**Source:** Karlla Arruda (2017)

It has been estimated that, over the last ten years, the city has welcomed more tourists each year than its actual number of inhabitants (CETESB, 2013; SEADE, 2015). In recent decades, the coastal region of São Paulo has been undergoing significant environmental changes because of intense land use transformation, demographic expansion, and investment inflows into large projects.

Among the major impacts suffered by the region, are tourism and fishing-related impacts on marine ecosystems, as well as impacts caused by high load effluents released to water bodies. Note that the sewage system of the city has only 27.65% coverage (IBGE, 2010) which has increased to 50% currently (CETESB, 2016).

To understand the complex and dynamic behavior of water quality, we directed our focus to sewage disposal as a hypothetically influential factor with respect to the marine ecosystem.

The data set we used to analyze the sewage discharge to the ocean was the annual report on batheability published by the environmental agency of the state of São Paulo. The annual report presents weekly data on the amount of thermo tolerant coliforms[1] collected at 26 sampling points on beaches along the entire city coastline. One was discarded because the sampling point—although very close to the beach—was on a river, which was considered to be a different environment.

The remaining 25 samples showed the presence of coliform concentrations. There were two distinct issues regarding the use of these data in further dynamic analysis. First, if we were to use statistical analysis (average values), all variation would disappear (Figure 8), and the variations are where the batheability problems can best be seen. Second, not all the data can be considered in the same analysis because the quantity of information is colossal (Figure2).

Figure 2 shows the distribution of batheability data from one sample point. Although the volume of data, just for one point, is huge, no pattern can be perceived. We then converted weekly data into monthly data, transforming 572 samples into a more manageable 143 samples. We obtained the linear tendency, shown as the dotted line in Figure 2.

When analyzing the database for the entire coast, we found an issue related to scale in the sense that we could not use whole city scale. Merging all the data meant

losing peaks of sewage disposal and lack of batheability, making the city seem like an ecological paradise. Moreover, using every monitored beach as an individual study meant losing the overall picture. Thus, to analyze the batheability of the entire coast, we had to cluster sampling points to make the analysis feasible.

**Artificial neural networks and simulations**

The information revolution during the last decades has altered the traditional water quality management, planning and decision making (Chau, 2006). Same author claims that four types of models have been used to help researches in coastal water quality management: knowledge-based systems (where the decision making can be simulated in an automatic algorithm); Genetic algorithm (simulating natural evolutionary processes and applying them in solving problems); Fuzzy inference systems (when objectives and constrains are vague and the systems are imprecise); and Artificial Neural Networks - ANN (using an information-processing paradigm to simulate relationships that are not fully understood). This paper uses one type of ANN analysis because the objectives are to understand patterns presented in data and not well understood by the researchers and considering it has been used before by other researchers (Maier and Dandy, 1996, Muttil and Chau, 2006; Singh et al., 2009; Najah et al., 2013)

**Self-organizing maps**

Self-organizing maps (SOMs) are a computer algorithm dedicated to analyzing and interpreting large data sets. The technique is also known as Kohonen maps in honor of the developer of the method.

The main goals of SOMs are to understand and analyze big data and propose results in a "meaningful fashion" (Fraser and Dickson, 2007). Since their discovery, SOMs have been used in finance, industrial control, speech analysis, astronomy, to analyze seismic activity, and in the geochemical and petroleum industry (Fraser and Dickson, 2007). A broad review applied to ecology showed SOMs being used at several hierarchical scales within biology, such as molecules and genes, organisms and ecosystems, and in different ways, ranging from molecular response to poisons to patterning macro invertebrates in coastal ecosystems (Choon, 2011).

Aguilera et al. (2001) also used SOMs to forecast water quality variations due to disposal of human sewage from tourist cities off the Spanish coast. In a broad comparative study using SOMs and other algorithms focusing on ecological data, it was concluded that SOMs area powerful machine that is perfectly suited to ecological studies, Giraudel and Lek (2001) also recommended SOMs

---

[1] The thermotolerant coliforms are used as indicators of recent fecal pollution because they present high densities of feces, which are collected by the sewage network (CETESB, 2013). Available on: <http://www.cetesb.sp.gov.br/agua/praias/25-publicacoes-/-relatorios>

"to be used in an exploratory approach in which unexpected structures might be found."

One of the mains advantages of SOMs is the simultaneous clustering of objects and variables (sampling locations; Olkowskaet al., 2014). The method can also be used to predictor estimate data, pattern recognition, noise reduction, classification, and clustering (Fraser and Dickson, 2007).
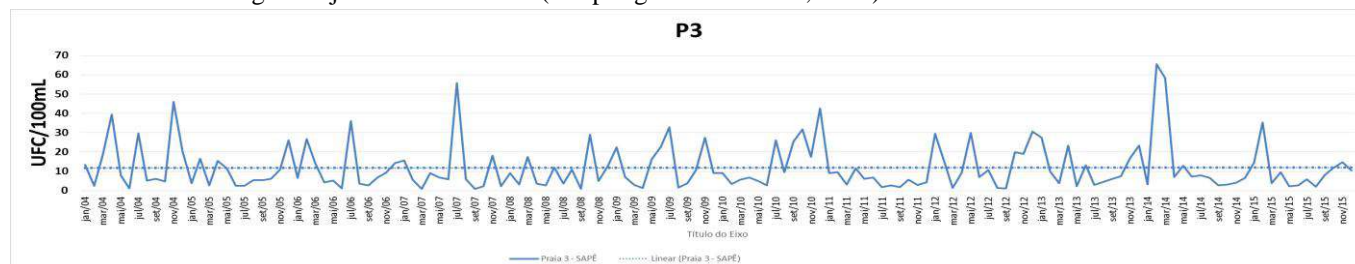


*Fig.2: Distribution of sample point P1*

**Source.** The authors

Kohonen maps, unlike normal maps, are formed by a regular grid of (commonly hexagonal) cells. These cells are called neurons and the number of neurons is proportional to the size of the samples (5√number of samples).

Neurons are special cells that represent an amount of data (input vectors or seed vectors) inserted (seeded) into the machine. The algorithm will then classify the data—a process called training. In this phase, all input vectors are translated into neurons. This process occurs in two steps, the first being competitive and the second cooperative.

The algorithm sees all the input vectors (in our case water quality values) displaced as a layer within a two-dimensional form (with this being repeated many times, as the variables demand). The normal hexagonal grid is applied over this distribution in such a way that every input vector underlies one or more hexagons on the neuron layer. Theclosera hexagon is to the input vector, the higher the probability of this hexagon becoming the so-called best- matching unit(BMU). This occurs in a competitive way between the hexagons (neurons), meaning that the closer the neuron is from the input vector, the higher its probability of winning the representation of that vector. At the end of this competitive phase, every input vector is replaced by its best-matching neuron.

The cooperative phase moves all the best-matching neurons within a given radius in the direction of the data they represent, inside the data space, changing a small percentage of their attributes so that they better represent the data they are replacing. In other words, the data topology is preserved from the competitive phase, but cooperation means that every neuron will move toward the data it represents, with few changes in its attributes, and this movement will influence all the other neurons to move along a little. The movement in the cooperative phase is performed individually for each neuron, but as each neuron pushes all its adjacent neurons, the movement subsequently affects all neurons.

The starting point is important for the final result. The final overview will be different for each neuron depending on its program starting point. The topology remains invariable, independent of the stochastic characteristics of the process. After hundreds or thousands of iterations have been run, the final result is a trained (self-organized) map.

This self-organized map is a "2D representation of a complex multi parameter data set" (Fraser and Dickson, 2007), and some visual exploration of the data can be made(U-matrix and component plots). Unified Distance Matrix (U-matrix) indicates how close adjacent nodes are on the map, typically using Euclidean distance. Component plots are another visualization of the neurons where it is possible to see each contribution for a particular variable (beaches in our study) and to display the values using a color–temperature scale so that low values are blue and high values are red.

The errors in the process are measured in two forms, the topographic error (TE) and the quantization error (QE). TE is a measure of the topological preservation errors of input vectors; QE is a measure of the average distance between each input vector and its BMU. Topologies and distances are very important, as they assume that "close placed planes are indication for similar behavior or correlation between respective variables" (Olkowska et al., 2014).

One of the best features of SOMs and the main reason for their use in this type of work is that SOMsarean unsupervised method of cluster formation. This means that there is no need to observe the algorithm working, or to eventually help it with some parameterization and decision (supervision). SOM works alone.

### III. RESULTS

**Clustering process—Batheability time series.**

The bathing data cover the period from 2004 to 2015, using the best available data from the State of São Paulo environment protection agency (CETESB) - number of colony-forming units (CFU/100 mL) for thermo tolerant coliforms. The distribution of the sampling points can be seen on the map in Figure 3.



*Fig.3: Location of sample points*

**Source:** CETESB, 2016



*Fig.4:.Location of bays*

**Source**: Google maps, modified by the authors

The geomorphological criterion we adopted was based on the hypothesis that the bays and coves in the region tend to have similar characteristics in terms of a lower water circulation rate than the more open regions on the coast.

However, the question arises as to whether this criterion, based on geographic observation and the characteristics of the bays, would be the best one for analyzing all the region's beaches with respect to the load of pollutants presented by each. To address these issues, we developed two approaches: first, we performed a statistical analysis and second, we compared the results of this with self-organizing maps.

For the statistical analysis, the correlation between the beaches comprising each bay was verified. All the data were tested for their normality with Minitab® statistical software, and their on-parametric distribution was noted. Because of this, the Spearman correlation, which is appropriate for this type of data set, was applied. The level of significance was set at least 5% (p value <0.05), rejecting the hypothesis that there is no statistically significant correlation for cases where the p value is less than 0.05. The results are shown in Table 1, where the present value of all analyses is less than 0.05: this supported the existence of a statistically significant correlation and that the geomorphological criterion adopted made sense from the statistical point of view.

*Table 1. Correlation analysis for each cluster*

| | Pulso | | | Maranduba | | | Sapê | | | Lagoinha Rua Engenho | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Baía 1** | | | | | | | | | | | | |
| | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? |
| **Maranduba** | 0,098 | 0,014 | SIM | | | | | | | | | |
| **Sapê** | 0,114 | 0,004 | SIM | 0,581 | 0,0000 | SIM | | | | | | |
| **Lagoinha rua engenho** | 0,085 | 0,034 | SIM | 0,489 | 0,0000 | SIM | 0,454 | 0,0000 | SIM | | | |
| **Lagoinha camping** | 0,105 | 0,009 | SIM | 0,409 | 0,0000 | SIM | 0,434 | 0,0000 | SIM | 0,452 | 0,0000 | SIM |
| **Baía 2** | Dura | | | Domingas Dias | | | Lázaro | | | | | |
| | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | | | |
| **Domingas Dias** | 0,427 | 0,0000 | SIM | | | | | | | | | |
| **Lázaro** | 0,543 | 0,0000 | SIM | 0,397 | 0,0000 | SIM | | | | | | |
| **Sununga** | 0,353 | 0,0000 | SIM | 0,418 | 0,0000 | SIM | 0,369 | 0,0000 | SIM | | | |
| **Baía 3** | Perequê - Mirin | | | Santa Rita | | | | | | | | |
| | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | | | | | | |
| **Santa Rita** | 0,475 | 0,0000 | SIM | | | | | | | | | |
| **Enseada** | 0,41 | 0,0000 | SIM | 0,427 | 0,0000 | SIM | | | | | | |
| **Baía 4** | Toninhas | | | Praia Grande | | | Tenório | | | | | |
| | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | | | |
| **Praia Grande** | 0,471 | 0,0000 | SIM | | | | | | | | | |
| **Tenório** | 0,398 | 0,0000 | SIM | 0,503 | 0,0000 | SIM | | | | | | |
| **Praia Vermelha** | 0,297 | 0,0000 | SIM | 0,324 | 0,0000 | SIM | 0,27 | 0,0000 | SIM | | | |
| **Baía 5** | Itaguá 1 | | | Itaguá 2 | | | Iperoig | | | Perequê açu | | |
| | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? |
| **Itaguá 2** | 0,594 | 0,0000 | SIM | | | | | | | | | |
| **Iperoig** | 0,436 | 0,0000 | SIM | 0,508 | 0,0000 | SIM | | | | | | |
| **Perequê açu** | 0,403 | 0,0000 | SIM | 0,475 | 0,0000 | SIM | 0,48 | 0,0000 | SIM | | | |
| **Vermelha do Norte** | 0,338 | 0,0000 | SIM | 0,336 | 0,0000 | SIM | 0,359 | 0,0000 | SIM | 0,412 | 0,0000 | SIM |
| **Baía 6** | Rio Itamambuca | | | Itamambuca | | | Félix | | | | | |
| | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | Correlação | p Valor | Rejeita H0 ? | | | |
| **Itamambuca** | 0,343 | 0,0000 | SIM | | | | | | | | | |
| **Félix** | 0,316 | 0,0000 | SIM | 0,436 | 0,0000 | SIM | | | | | | |
| **Prumirim** | 0,094 | 0,0180 | SIM | 0,134 | 0,0010 | SIM | 0,169 | 0,0000 | SIM | | | |

**Source.** The authors

### Results of Self-organizing maps

Ubatuba unified matrix presents the distribution of the data after the treatment with SOM algorithm. It is presented in three visual forms (Figure 5): i) node representation; ii) smoothed; and iii) 3D. This U-matrix is a spatially explicit representation of the neurons trained by the SOM algorithm and ultimately represents the data set inserted into the program. Red cells represent great dissimilarity between data and blue cells represent great similarity.
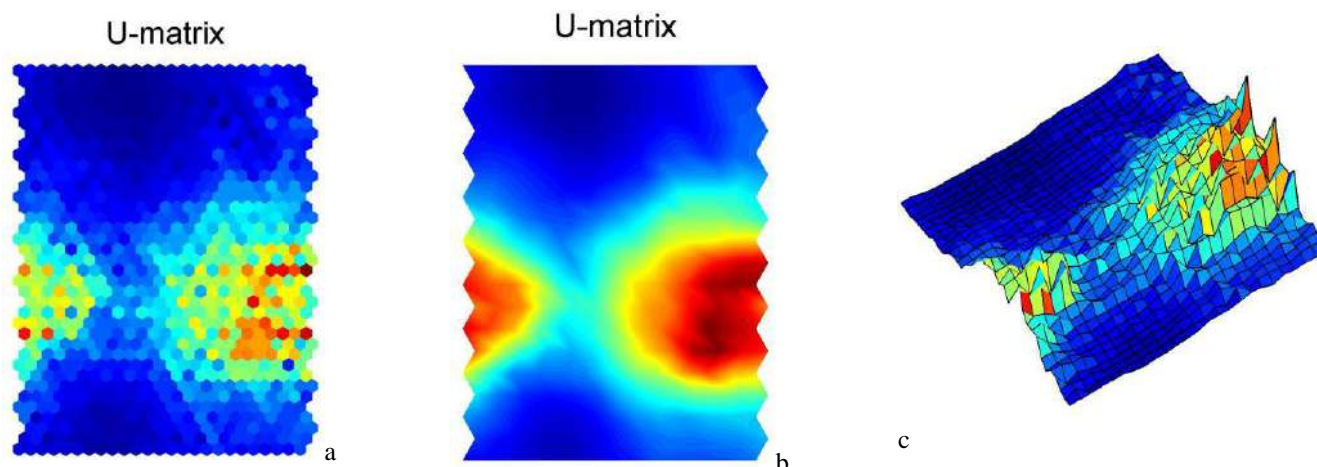
*Fig.5: Ubatuba U-matrix for all data sets: i) U-matrix showing neuron patterning; ii) smoothed version; iii) 3D plot of the same pattern*

**Source.** The authors

The U-matrix allows a comparative study of the groups of data (sample points) included in the analysis. The universe of several U-matrices is made up of component plots which provide visual information on the particular contribution of every sample point of the whole formation of the Ubatuba U-matrix (Figure 6).
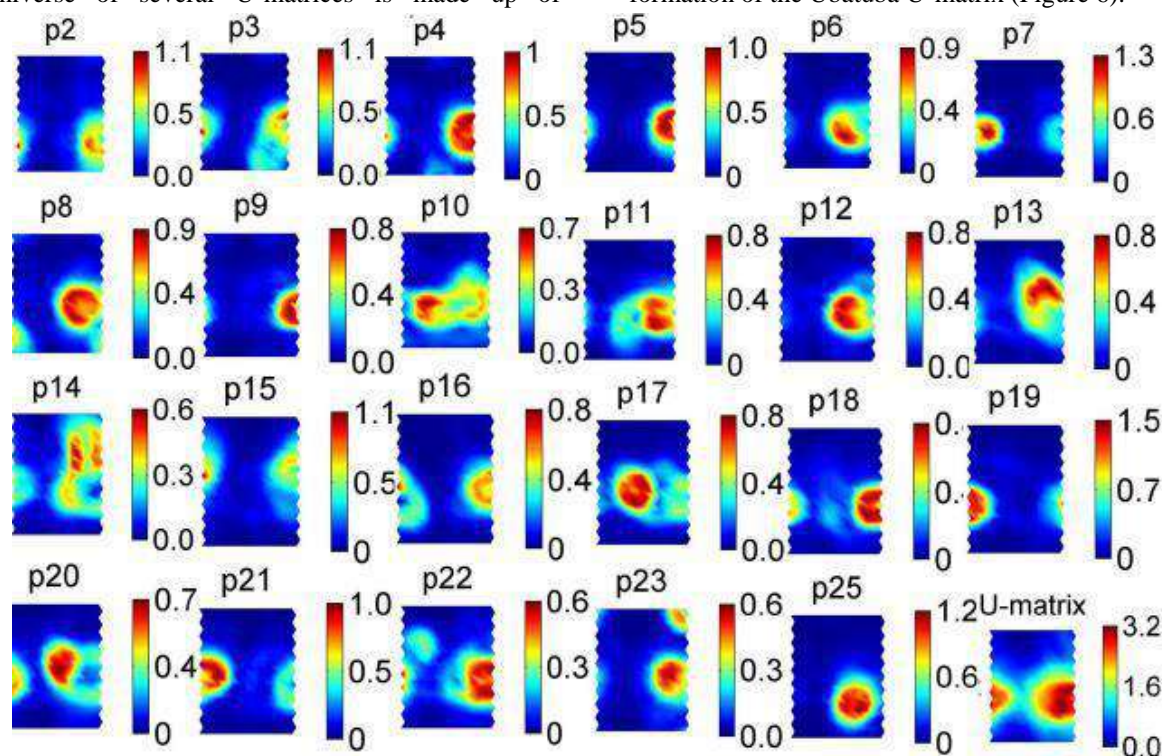


*Fig.6: Ubatuba component plots showing contributions of every sample point to the total profile (U-matrix)*
**Source:** The authors

The visual analysis of those beach pro files allowed us to grasp that some of the sample points are highly representative of Ubatuba's general profile, namely, points p2, p4, p5, p6, p7, p8, p9, p12, p15, p16, p18, p19, p22, p23, and p25. These are understood as being the cleanest beaches or even the least frequently polluted.

Other points clearly present other distribution patterns, namely, p3, p10, p11, p13, p14, p17, p20, and p21. These are taken to be the most polluted points or those with a more variable pollutant-dispersion pattern throughout the year.

*Table 2. Names and codes for each sample point*

| Nameandreferencenumberof Ubatuba Sample Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Name | N° | Name | N° | Name | N° | Name | N° | Name | N° |
| Pulso | 1 | Dura | 6 | Santa Rita | 11 | Praia Vermelha | 16 | Vermelha do Norte | 21 |
| Maranduba | 2 | Domingas Dias | 7 | Enseada | 12 | Itaguá1 | 17 | Itamambuca | 22 |
| Sapê | 3 | Lázaro | 8 | Toninhas | 13 | Itaguá2 | 18 | Félix | 23 |
| Lagoinha | 4 | Sununga | 9 | Praia Grande | 14 | Iperoig | 19 | Prumirim | 24 |
| Lagoinha (Camping) | 5 | Perequê Mirim | 10 | Tenório | 15 | Perequè-Açu | 20 | Picinguaba | 25 |

**Source.** The authors

The map in Figure 5 (a and b) is a 2D representation of a toroid, that is, an nD figure. To visualize this, join the upper border to the lower border to form a horizontal tube. Then link the beginning and the end of the tube to form a never-ending tube ortoroid.

The figure thus formed raises the suspicion that is possible to have different clusters of data within the samples. However, the assumption that the U-matrix is produced stochastically cannot be confirmed without a further specific test—the k-means clustering test—an algorithm created for the analysis of clustering processes.
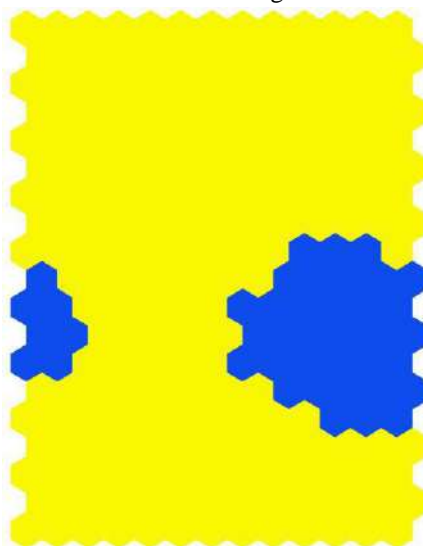


*Fig.7: K-means representing clustering of Ubatuba batheability data.*
**Source:** The authors

The k-means is represented in Figure 7. The cluster formation is determined by the David-Boulding Index (DBI), a subroutine on the k-means algorithm. The DBI represents the number of clusters found in the analysis, in this case, 2. Assuming that the DBI is stochastic and that the results depend on which data in the data set the algorithm begins the calculations with, the procedure to obtain the DBI was repeated 70 times and the most frequent number was selected (2).

The maps show an island of dissimilarity within an ocean of similarity. Considering local reality, this can mean two different possibilities: first, that the data vary as a function of geomorphology, meaning that the most populated beaches have a different pattern of sewage disposal compared with the most isolated ones; or, second, that

there is a temporal pattern of waste disposal occurring only within a time interval determined by the data, in other words, there is seasonal variation

## IV. DISCUSSION

The results obtained using statistical analysis were clear and corroborate the geomorphological hypothesis of clustering. This result could be useful for grasping the behavioral characteristics of each individual bay and what locally adapted policies need to be developed to enhance water quality and displace sewage pollution.

The SOM clustering does not show whether a bay is polluted or not, as expected. However, results did give us several insights into the dynamics of the complex sewage dispersal system on the coast.

SOMs organized the information for all beaches and showed that there is a strong pattern of sample division into two main realms (Figure 7). Atfirst glance, we could not understand if this was due to seasonality or to the north–south position of the bay. However, when we compared individual collaborations to overall behavior using component plots (Figure 6), the latitudinal variation of samples does not make sense—the two groups formed have interpolated samples, which discards that possibility. The results show a similar group (formed by p2, p4, p5, p6, p7, p8, p9, p12, p15, p16, p18, p19, p22, p23, and p25) and also a dissimilar group (formed by p3, p10, p11, p13, p14, p17, p20,and p21)

Understanding that the two groups are relative to seasonal variations makes much more sense and also allows us to focus on the problem group in order to prevent pollution and expand sewage treatment.

Another positive application was that all the variations in each point were organized into a suitable view that not only allows the overall picture to be understood (Figure 5) but also the particular collaborations involved(Figure 6). To understand the city, it does not make sense to analyze each sample point individually. Analyzing every bay is possible (Table 1), but there are still some variations that can perturb the analysis.

Figure 8 exhibits the k-means and David Boulding index for every cluster formed using statistics. These clusters are tested using SOMs, but they were artificially formed using the geomorphological hypothesis and the statistical analysis presented in Table 1. Nevertheless, they present many more variations internally when compared to the whole Ubatuba scenario obtained in Figures 5 and 7.
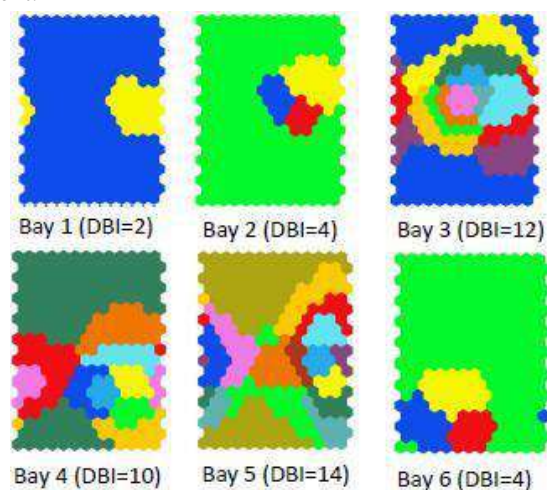


*Fig.8: K-means and David-Boulding index for six clusters.*

**Source.** The authors

This outcome represents the possibility of exploring this tool to create representative maps of more regional- and country-scale features, albeit ignoring some local variations. This could help direct policy development.

## V.   CONCLUSIONS

In this paper we carried out clustering and pattern analysis of a complex dynamic coastal system in Brazil, using batheability time series (2004–2015).

To reach our goals, we used self-organizing maps—a technology deployed to mine big data—to form and analyze clusters by means of a competitive/collaborative algorithm, and to compare outcomes with traditional statistics (Spearman correlation).

The results show that geomorphology can be used as a bias for understanding similarities within batheability data and cluster formation. SOM was shown to be a powerful tool for cluster formation when it was applied to

coastal batheability, and it resulted in unexpected cluster formations. The program was able to separate the whole coast into two groups (pristine and seasonally influenced areas) and was also used to test the remaining variations on that six divisions pattern suggested by geomorphology.

SOMs of individual beaches, visually compared with whole-city data results, showed that one group (more pristine beaches) was more significant in the overall picture. One final conclusion is that SOMsare more than a substitute for statistics; they can be an additional tool for working with coastal data.

## REFERENCES

[1] AIDAR E., GAETA S.,GIANESELLA-GALVÃO S., KUTNER M., TEIXEIRA C.(1993). Ecossistema costeiro subtropical: nutrientes dissolvidos, fitoplâncton e cloroflla-a e suas relações com as condições oceanográficas na região de Ubatuba, SP. Publição especial Instituto oceanográfico, São Paulo, (10): 9-43[in Portuguese].

[2] AGUILERA, P. A. et al. (2001). ApplicationoftheKohonen neural network in coastalwater management: Methodologicaldevelopment for the assessment and prediction of water quality. WaterResearch,35(17), 4053-4062.

[3] ARMBRECHT L. H. ROUGHAN M., R V., SCHAEFFER A., DAVIES P., WAITE A., ARMAND L. (2014). Phytoplankton composition under contrasting oceanographic conditions: Upwelling and down welling (Eastern Australia). Continental Shelf Research 75, pp.54–67.

[4] BEHRENFELD M. (2014). Climate-mediated dance of the plankton. Nature Climate Change, 4(10):880-887

[5] CHAU, Kwok-wing. A review on integration of artificial intelligence into water quality modelling. **Marine pollution bulletin**, v. 52, n. 7, p. 726-733, 2006.

[6] CETESB (São Paulo) (2013). Relatório de qualidade das praias litorâneas no estado de São Paulo. Available at: http://www.cetesb.sp.gov.br/agua/praias/25-publicacoes-/-relatorios[in Portuguese].

[7] CHON, TAE-SOO.(2001). Self-organizing maps applied to ecological sciences. Ecological Informatics, 6(1), 50-61.

[8] FALKOWSKI,P.G. and OLIVER,M.J. (2007).Mix and match: how climate selects phytoplankton. Nat. Rev. Microbiol 5(10), 813–819.

[9] FALKOWSKI, P.G. and RAVEN,J.A. (2007).Aquatic Photosynthesis, 2$^{nd}$edition. Princeton University Press, Princeton.

[10] FIELD, C.B. BEHRENFELD,M.J. RANDERSON,J.T.,and FALKOWSKI,P. (1998). Primary production of the biosphere: Integrating terrestrial and oceanic components. Science(281), 237–240.

[11] FRASER, S. J. DICKSON, B. L. (2007). A new method for data integration and integrated data interpretation: self-organizing maps. In: Proceedings of Exploration, pp.907-910.

[12] GIRAUDEL, J. L. andLEK, S. A.(2001). Comparisonof self-organizing map algorithm and some conventional statistical methods for ecological community ordination. Ecological Modelling,146(1) 329-339.

[13] HALPERN,B.S. (2012). An index to assess the health and benefits of the global ocean, Nature 488(7413):615-20.

[14] KIMOR, B. The impact of eutrophication on phytoplankt on composition in coastal marine ecosystems. In: **Marine Coastal Eutrophication**. Elsevier, 1992. p. 871-878.

[15] MILLS M., RIDAME C., DAVEY M., La ROCHE, and GEIDER R. (2004). Iron and phosphorus co-limit nitrogen fixation in the eastern tropical North Atlantic. Nature, 429.

[16] MAIER, Holger R.; DANDY, Graeme C. The use of artificial neural networks for the prediction of water quality parameters. **Water resources research**, v. 32, n. 4, p. 1013-1022, 1996.

[17] MUTTIL, Nitin; CHAU, Kwok-Wing. Neural network and genetic programming for modelling coastal algalblooms. **International Journal of Environmentand Pollution**, 2006

[18] NAJAH, A. et al. Applicationof artificial neural networks for water quality prediction. **Neural Computing and Applications**, v. 22, n. 1, p. 187-201, 2013.

[19] OLKOWSKA, E., et al. (2014) Assessment of the water quality of Kłodnica River catchment using self-organizing maps. Science of the Total Environment, 476, 477-484.

[20] RYTHER J. (1969). Photosynthesis and fish production in the sea: The production of organic matter and its conversion to higher forms of life vary throughout the world ocean. Science, 166.

[21] SINGH, K P., et al. "Artificial neural network modelingof the river water quality—a case study." *Ecological Modelling* 220.6 (2009): 888-895.

[22] SVERDRUP, H. U. (1955). The place of physical oceanography in oceanographic research.Journal Marine Research, 14, 287–294

[23] SMETACEK V. and Nicol S. (2005).Polar ocean ecosystems in a changing world. Nature, 437.

# Geographical Indication and Centrality: A Hypothesis test in the Northeastern Region of Brazil

Denise Lemos Garcia[1], Gabriel Francisco da Silva[2], André Luiz Gomes de Souza[3], José Pereira Mascarenhas Bisneto[4], Emerson de Souza Silva[5]

[1,2,3]Post-Graduation Program in Intellectual Property Science, Federal University of Sergipe
[4]Federal University of Recôncavo da Bahia
[5]Post-Graduation Unit of Administration of UFBA, Federal University of Bahia

*Abstract*— *Geographical Indications (GIs) refer to products and services with unique characteristics of a given region, granting a certain level of excellence to these goods and services. Moreover, GIs are connected to the locations, in recognition of their territoriality, as well as to the region's cultural and historical identity, being attached to the level of centrality of the region and promoting greater trust, as centrality is directly linked to its catchment area. In this regard, the present work is aimed at carrying out a temporal comparison of the centrality indices of the five groups of Geographical Indications in Northeastern Brazil between the years of 2006 and 2017, in order to test the hypothesis established, determining whether such event is enough to explain the influence of the products and goods on their respective cities of origin. This is a quality-quantitative research, based on a bibliographic and documentary survey by analyzing five GI groups from the Northeastern region of Brazil, focused on their relative share of the Gross Domestic Product of private services in certain municipalities and taking into account five higher-order spatial cutouts: microregion, mesoregion, state, region and country. Besides determining the centrality indices, carried out using the well-known Principal Component Analysis (PCA), the Analysis of Variance (ANOVA) was also applied. The results of the present research did not identify any indications that granting GIs is enough to promote a distinct level of development to the municipalities. Therefore, GIs did not exhibit any relevant effect on the municipal levels of centrality.*

*Keywords*— *Centrality, Geographical Indications, Northeastern Brazil.*

## I. INTRODUCTION

Two different theoretical frameworks comprise the analytical support of the present study: the Central Place Theory and Geographical Indication. The former theory contributes to the perception that the existence of a provision of services structure reflects the level of development of a certain geographical location, with larger stocks being associated to greater levels of centrality. On the other hand, a Geographical Indication is a certification that allows to not only add greater value to products, but also to distinguish and qualify the production, boosting development and making the production unique, as well as creating competitivity in the internal and external market through local production chains that are connected to the territory of origin, to the unique traditions and customs.

Brazilian geographical indications are regulated by Law no. 9.279/96 (Industrial Property Law), which establishes the National Institute of Industrial Property (INPI, in Portuguese) as the entity responsible for granting a certification of Geographical Indication according to Normative Instruction PR no 095/2018, from 28/12/2018. Geographical Indications are subdivided into Indication of Provenience (IP) and Designation of Origin (DO). Between 2002 and 2019, 75 geographical indications were granted by INPI in Brazil, consisting of 55 Indications of Provenience and 20 Denominations of Origin, divided into 11 national DOs and 9 foreign DOs. According to the national scenario in Brazil, the regions with the most GI grants are as follows: Southeast (22), South (20), Northeast (14), North (06) and Central-West (04) (INPI, 2019).

It is worth pointing out that the first GI granted in the Northeastern region of Brazil was an Indication of Provenience (IP) from the sub-medium São Francisco Valley in 2009, located in the Brazilian semiarid (west of the State of Pernambuco and north of the State of Bahia) associated to the production of table grapes and mangoes. Another important highlight for the Brazilian Northeast was the first label of indication of provenience, granted to Porto Digital, in the city of Recife, for its technological services. Other Northeastern products with Geographical Indications include: Black Coast Shrimp (from the State of Ceará), Divina Pastora Lace (in the State of Sergipe) and the Cariri lace (in the State of Paraíba), Abaíra cachaça (in the State of Bahia), green coffee grains, from the Coffea Arábica species (from the State of Bahia), opal and artisanal jewelry of Pedro II (in the State of Piauí), red propolis from the mangroves of the State of Alagoas, colored cotton from Paraíba, the melon from Mossoró (in the State of Rio Grande do Norte), cajuína from the State of Piauí and embroidery from the region of Alagoas de Mundaú-Manguaba (in the State of Alagoas). Only the Northeastern State of Maranhão does not hold a geographical indication.

The Northeastern region of Brazil is the largest in terms of the number of States, distributed over nine Federal States: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe. Its territory comprises 1,554,257.0 m$^2$, being the third largest regional complex in Brazil, occupying 18.2% of the country's area (IBGE, 2010).

With this vast territorial extension, the country has a myriad of products, with a wide range of cultural and touristic identities, with a vast environment and biodiversity, besides the local knowledge of its territories. In this regard, the Brazilian Northeast shows a great potential for awarding Geographical Indications, granting unique attributes to products and services, which have a positive impact on aspects related to the local production chains and to the development of the region.

With this in mind, the present work was aimed at carrying out a temporal comparison of the performance of centrality in the five subregions of Geographical Indications in the Brazilian Northeast, between the years of 2006 and 2017, testing the influence hypothesis.

This hypothesis is based on the fact that the existence of a Geographical Indication is able to hierarchize the municipalities from the Northeastern region of Brazil, as the municipalities with higher centralities are a reference in terms of their social and economic organization.

## II. THEORETICAL BACKGROUND

### Central Place Theory

The Central Place Theory (CPT) is an attempt of explaining the nature of spatial arrangements, their sizes, numbers and foundations. This conceptual design was developed in 1933 by Walter Christaller, a German geographer who studied the colonization patterns in southern Germany (CANTARIM, 2015).

The results of his research conclude that cities of a given size are approximately equidistant. The author subsequently developed a combination of assumptions taking into account the spatial arrangement structures and their respective catchment areas, having then proposed a model to be used in the interpretation of location patterns of cities (HSU, 2012).

Such assumptions are rather strong and can be combined into the following topics:

• a flat surface with little or no changes in its profile as the distance increases (isotropic);

• Proportionally distributed economic resources;

• Similar levels of purchase power of economic agents;

• Consumption preference for closer markets (aversion to travel);

• The markets are structured in a context of perfect competition, in which the possibility of extraordinary profits is inexistent.

According to the CPT, a central location is that which exhibits a specific combination of goods and services to its surrounding population, so that basic and ubiquitous activities are provided in places of lower order (inferior), while complex and specialized activities are found in places of higher order, considered superior (VIONIS; PAPANTONIOU, 2019).

It is worth noting that it can be possible to identify the presence of basic and ubiquitous activities within higher-order locations. Nevertheless, within the context of the CPT, the opposite is not possible, as more elaborate transactions are those which define the importance of a given location.

Therefore, higher-order locations are sources of more elaborate goods and services, which will meet the demand for these in the lower-order locations, thus forming its catchment area, i.e. its centrality perimeter (SILVA, 2011).

This catchment area is determined by two factors:

• Population density – a minimum demographic threshold is required to enable the provision of certain

goods and services. The more elaborate these services are, the greater this threshold will be and, consequently, the higher the catchment area of the central location;

• Measurement of maximum distance travelled – communities favor the lowest travelling distance possible. Thus, centrality is also determined by minimizing this average distance travelled for most inhabitants (HSU, 2012).

In this regard and taking into account these factors, the spatial threshold and range of central locations are established. Goods and services which attract the greatest frequency of attention of consumers generate a maximum distance, which is then unfeasible or not to those who travel to supply their needs (IPEA, 2002).

Under the Central Place Theory (CPT), cities are hierarchized in the form of a hexagon, as this polygonal shape can best describe the location of these territorial units within their own geographical coverage, maximizing the relation between distance and demographics more than any other figure (STAMM, 2013).

Based on the geographical assumptions of his model, Christaller (1966) developed the idea that the hierarchical organization between geographical locations can be defined under three different perspectives: the marketing principle, the transport principle and the administrative principle. According to Portela (2016), in each of these perspectives, the coordination shape between locations is changed, thus modifying their spatial arrangement.

Under the aegis of the administrative principle, cities are ordered according to their political power and cities with the least importance orbit those with greater prominence. In this perspective, each group of cities – represented by Christaller's hexagonal patterns – is inserted in a single perimeter and do not affect any contiguous groups, thus, contiguity is directly correlated with distance, besides influencing the polarization of contiguous groups which are socioeconomically connected to a central city (FERRERA DE LIMA, 2010b).

The drawback of this format is the interaction between the arrangement, which prevents the relationship between locations and terminating the contact between those included within the same spatial arrangement, as if only political factors determine the exchange between places (BESSA, 2012).

In turn, in the market principle, the quality of services provided defines the hierarchy between places, under which the quality of economic transactions will establish the importance of each spatiality. Higher-level locations are those which provide more elaborate goods and services,

while those lower-level locations provide lower value-added goods and services (PORTELA, 2016).

This analytical perspective leads to a more fluid setting of the inter-relationship between locations, placing each city on the limit with other centrality arrangements, as it interacts with several other locations (TINEU, 2012).

Finally, the transport principle determines spatial ranking as a function of market distances. The more accessible a given place is, the greater the chances of centralizing its surroundings (PORTELA, 2016).

Therefore, the spatial arrangement is adapted to the transport offers, in which faster, safer and cheaper journeys, which are able to reach the highest number of central destinations, will result in highest levels of centrality of a given location. In fact, this is the classic approach of the Central Place Theory (CANTARIM, 2015).

Nevertheless, the CPT has some practical restrictions, including the fact that, differently to what the approach proposes, production costs are not uniform in relation to space, which, in turn, are systematically changed not only by economies of scale but also by internal factors associated to the location ( NASCIMENTO ARAÚJO; SOARES ALMEIDA; RODRIGUES, 2009).

Moreover, the predictability of the theory is also hampered by the fact that unit transport costs are not constant in all directions, i.e. it does not vary proportionally to the distance travelled (ALMAS, 2012).

Therefore, agricultural production is not uniformly dispersed, varying according to both soil and weather conditions but also due to production decisions of all stakeholders and entities involved in the activity (ALVES, 2011).

Moreover, the presence of market failures which erode economic efficiency levels is another noticeable drawback, which disguises the possibility of competitive markets, with market power emerging from some handful agents (LIBERATO, 2008).

Nonetheless, the Central Place Theory (CPT) is a valid framework to understand the hierarchization of locations and of urbanization profiles. Accordingly, this theory is in constant progression within this subject, as spatial planning is a fact (CANTARIM, 2015).

## Geographical Indication

Geographical Indications (GIs) recognize the quality of a certain product originated from a region with unique characteristics within its geographical area. The GI recognition depicts a quality connected to human and

natural factors, with particularities which ensure territorial specificity and gives certain notoriety to the product (MAIORKI; DALLBRIDA, 2015). Therefore, it constitutes a product with unique qualities due to aspects such as know-how, climate, vegetation and soil conditions (SAKR; DALLABRIDA, 2015).

Although Geographical Indications were only recognized in Brazil under law no. 9.279/96 (BRASIL, 1996), its recognition in other countries around the world is long dated. In ancient times there were already signs to distinguish certain commercial products according to their properties. Over time, the term "geographical indication" has been adopted by consumers and producers to recognize the characteristics of a product with a particular origin. Officially, the first institutional act to protect GIs was established in Portugal in 1756, when the Marquis of Pombal established a decree to recognize the designation Porto for wines produced in this Portuguese region, thereby protecting local producers from any disloyal and barbaric market competition (BARBOSA; PERALTA; FERNANDES, 2013).

Therefore, GIs have a strong potential of promoting the production of certain products which bear fruit of local knowledge and the traditional culture of certain places. This recognition is one of the legal frameworks (the Brazilian Industrial Protection Law) to protect market principals and intangible products (SILVA; BRITO, 2016).

In Brazil, manufacturing registrations with GIs have increased every year. These include products manufactured in certain places which are directly linked to the production by using specific manufacturing and cultivation methods, climate, land use, etc. Such specificity adds value to the final product, having a great impact on the local economic and social development (MAIORKI; DALLABRIDA, 2015).

Moreover, there are national and international regulations in place which grant geographical indications to certain products and may be understood as a way of facilitating the insertion of regional products in the international market, further promoting the regional social and economic development under a legal protection against any disloyal market competition. Thus, this subject is clearly not only of socioeconomic concern, but also involves legal and judicial considerations (SIEDENBERG; THAINES; BAGGIO, 2017).

Under a legal perspective, Geographical Indications are recognized as a type of industrial property, granting private rights of collective importance. With this right granted, a specific product is recognized as originating from a certain location, region or territory when certain characteristics,

reputation or quality is explained by the geographical space where this product is produced or manufactured (MARINS; CABRAL, 2015).

GIs have been demonstrated to be an instrument for promoting personal freedoms, as they enable local and regional development. Moreover, GIs ensure appreciation and promotion of traditional regional know-how, resulting in the production of services and/or products (SILVA; BRITO; DANTAS, 2016).

This is observed as the product's notoriety has a direct connection with the place where it is produced, that is, it associated with harvesting factors, production methods, climate and soil. These particularities distinguish the product and add greater value, generating greater financial returns to products and may have a positive impact on the population's quality of life (MAIORKI; DALLABRIDA, 2015).

In their work, Maiorki and Dallabrida (2015) showed how a Geographical Indication is important in the development of certain regions and territories. The authors highlighted that this does not occur autonomously but requires the support of the economic sector and from civil society, otherwise GIs would be worthless.

Only an integrated and articulated work between local actors enables a Geographical Indication to act as an enabler of development and innovation, culminating in real changes under a country's cultural, social and economic sphere (MARINS; CABRAL, 2015).

Therefore, GIs become relevant as a strategic action for supporting regional development, as the recognition of specific good and services with unique potential, identity and characteristics prevents the theft of intellectual property. At the same time, GIs add greater financial, cultural, social, economic and even environmental value to a product's manufacturing process (SAKR; DALLABRIDA, 2015).

## III. METHODOLOGICAL PROCEDURES

The present study is characterized as exploratory, descriptive, documentary, historical and quali-quantitative.

The research was based on the Gross Domestic Product of private services of municipalities within five spatial cutouts: microregion, mesoregion, state, region and country.

Subsequently, the centrality indices of all municipalities were calculated using the technique of Principal Component Analysis (PCA) within a range of seven years. Having calculated this parameter, the cities

with GI registrations were compared with cities without any GI registration, through a one-way ANOVA test.

A spatial and temporal cutout grid was applied, with the present study analyzing the years of 2006 until 2017. With these restrictions, two GI registrations were excluded: South of the State of Bahia (granted in 2018) and West of Bahia (granted in 2019).

The spatial cutout used in this research, taking into account GIs in the Northeastern region of Brazil, covers six Federal States which have been recognized with GI registrations for their agricultural products, except for the State of Piauí.

Accordingly, the catchment areas of the GIs are as follows:

a) the Sub-medium São Francisco Valley, which englobes two states (Bahia and Pernambuco), with a total of 75 municipalities, including 17 municipalities in the State of Bahia and 58 in Pernambuco;

b) Costa Negra, comprising 04 municipalities in the State of Ceará;

c) Mangroves of Alagoas, including 16 municipalities in the State of Alagoas;

d) Mossoró, consisting of 13 municipalities in the State of Rio Grande do Norte;

e) Abaíra Microregion, consisting of 04 in the State of Bahia.

The period analyzed corresponds to 100% of the data population provided by the Brazilian Institute of Geography and Statistics (IBGE) regarding the GDP of services in Brazilian municipalities.

The variation of the level of centrality of the municipalities where the respective GI registrations originated from was compared with the remaining municipalities from the respective States in order to analyze any possible difference in their development patterns.

Therefore, the following parameters were verified:

• The centrality of municipalities from the States where the Geographical Indications are registered;

• Calculation of the variation of the centrality indices for the municipalities of the States where the Geographical Indications are registered;

• Null-hypothesis testing that the variation in centrality indices of the locations with registered Geographical Indications is different than those with no GI registration.

The centrality indices were measured according to the methodology proposed by Garcia, Silva, Souza, Bisneto and Silva (2019) and considering the data regarding the municipal products, provided by the Brazilian Institute of Geography and Statistics (IBGE) in their automatic database system (SIDRA), in Table 5938, with the Northeastern agricultural Geographical Indications granted by the Intellectual Property Institute (INPI).

Principal Component Analysis (PCA) was applied for the period of seven years, using the data collected in each operationalization (Geographical Indication), with the registration year of the title being taken as the reference date in this phase, according to the study carried out by GARCIA et al. (2019).

The degree of variation of the municipal centrality indices was determined by the ratio between the final indicator and the initial indicator obtained in each period. The higher this ratio, the greater the intensity of this phenomenon and vice-versa.

The hypothesis that the average variation of the centrality indices of the municipalities with GI, in each seven-year period, was different than the index presented in the respective State was then tested with the one-way analysis of variance (ANOVA). Thus, each group of GIs was tested against a group of municipalities within their own States, thereby ensuring randomness by using a random-number generator page[1].

The PCA was carried out in the GNU Regression, Econometric and Time-series Library (GRETL) statistical package, version 1.9.14, with the remaining computational routines being applied in a Microsoft Excel 2010 spreadsheet.

The results are presented for each of the six (06) Geographical Indications analyzed, except for the Cajuína GI, from the State of Piauí, as this GI covers most of the State's municipalities, which prevents the application of the present research protocol.

## IV.    ANALYSIS OF THE RESULTS

The analyses of the documents identified demonstrated that between 2009 and 2019, six Geographical Indications related to agricultural products have been granted in the Northeastern region of Brazil, as presented in Figure 1.

---

[1] Available at: www.invertexto.com/numeros-aleatorios. Access on: 16 June 2020.

| Geographical Indication | State | Products | Type | Concession |
|---|---|---|---|---|
| Submedium São Francisco Valley | PE, BA | Table grapes and mango | Indication of Provenience | 07/07/2009 |
| Costa Negra | CE | Shrimps | Designation of origin | 16/08/2011 |
| Mangroves of Alagoas | AL | Red própolis and red propolis extract | Designation of origin | 17/07/2012 |
| Mossoró | RN | Melon | Indication of Provenience | 17/09/2013 |
| Piauí | PI | Cajuína | Indication of Provenience | 26/08/2014 |
| Abaíra microregion | BA | Sugarcane brandy, cachaça type | Indication of Provenience | 14/10/2014 |

*Fig.1: Geographical Indications related to agricultural products in the Northeastern region of Brazil, granted between 2009 and 2017*

*Note: AL= Alagoas, BA= Bahia, CE=Ceará, PE= Pernambuco, PI= Piauí, RN = Rio Grande do Norte*

*Source: Author's own compilation (2020)*

## Sub-medium São Francisco Valley

This GI comprises 75 municipalities, including 58 located in the State of Pernambuco and other 17 in Bahia, being the oldest GI in the Northeast of Brazil and it is of most strategic importance for the Brazilian Northeast, regarding the production of grapes and mangoes.

The PCA applied on the municipalities of both States involved with this GI showed that the 602 municipalities have expanded their centrality indices over the past seven years when reaching some level of regional or national notoriety, with the centrality at a microregional level having the least explanatory influence over this phenomenon.

On average, between the years of 2006 and 2012 – period of time established for determining the centrality indices – the indices attached to the respective municipalities increased approximately 3.5-fold. In comparative terms, in the municipalities of both States, an average growth of 5.7 times was observed. Nevertheless, it is important to note that in the year of 2012, 93.3% of these municipalities exhibited centrality indices above the average of the Northeast region.

Within the catchment area of the Sub-medium São Francisco Valley GI, the five municipalities with the

highest degrees of variation in the centrality indices were: Ouricuri (PE), Moreilândia (PE), Remanso (BA), Iguaracy (PE) and Macururé (BA). Similarly, the worst performance levels were observed in Santa Filomena (PE), Glória (BA), Solidão (PE), Inajá (PE) and Jaguarari (BA).

It is worth highlighting that the cities with the highest relative shares in the GDPs of the States of Pernambuco and Bahia are Arcoverde (PE), Juazeiro (BA), Paulo Afonso (BA) and Petrolina (PE) observed a reduction in their centrality indices. On the other hand, this measurement increased in those municipalities with the lowest share in the states' gross domestic product, namely in Afogados da Ingazeira (PE), Salgueiro (PE) and Serrita (PE).

The results of the hypothesis test through the one-way ANOVA test prevents rejecting the null-hypothesis, in which there is no significant difference between the average centrality index of the municipalities inserted in the GI's catchment area and those within this area, as pointed out in Figure 2.

| SUMMARY | | | | |
|---|---|---|---|---|
| **Group** | **Count** | **Sum** | **Average** | **Variance** |
| **IG Group** | 75 | 2.625.717 | 3.500.956 | 4.177.247 |
| **Control Group** | 75 | 4.398.901 | 5.865.201 | 6.937.031 |
| ANOVA | | | | |
| *Variation* | *SQ* | *Gl* | *MQ* | *F* | *P-value* | *Critical F-value* |
| Between groups | 209.612 | 1 | 209.612 | 0.377194 | 0.540052 | 390.506 |
| Within the group | 82245.65 | 148 | 5.557.139 | 82245.65 | | |
| **Total** | **82455.27** | **149** | | | | |

*Fig.2: One-way ANOVA –Sub-medium São Francisco Valley*

*Source: Author's own compilation (2020)*

## Mangroves of Alagoas

The catchment area of this GI consists of 16 out of the 102 municipalities form the State of Alagoas, with the GI being granted in 2012. Among the five areas observed in the present work, the area comprising the Mangroves of Alagoas is the only including a State capital city, the city of Maceió.

The PCA applied to the cities of Alagoas showed that throughout the seven-year period, the municipalities of the region observed an increase in their centrality indices as a result of greater state, regional and national relevance, with the microregional centrality having the least explanatory influence.

On average, the degree of variation of the centrality indices of the municipalities was of 0.992, that is, between

2009 and 2015, the local notoriety level was constant, without any particular features.

Incidentally, the centrality profiles of the State of Alagoas were practically constant throughout the seven-year period studied, as the average variation in the centrality indices was of 1.070 at a municipal level. Only the municipality of Olho D´água do Casado presented a noteworthy performance, observing a 13-fold growth of their products and services.

Therefore, it can be deduced that the effects of the Mangroves of Alagoas – GI is irrelevant for changing the centrality patterns of the municipalities involved, as this recognition had little influence on the economic growth of the area.

The results of the ANOVA (Figure 3) show that the F-value obtained was below the critical F-value, i.e. outside the rejection region and with a statistical level of significance higher than the acceptable value.

| SUMMARY | | | | |
|---|---|---|---|---|
| **Group** | **Count** | **Sum** | **Average** | **Variance** |
| **IG Group** | 16 | 1.587.799 | 0.992375 | 0.106099 |
| **Control Group** | 16 | 1.332.073 | 0.832546 | 0.283703 |
| **ANOVA** | | | | |
| *Variation* | *SQ* | *Gl* | *MQ* | *F* | *P-value* | *Critical F-value* |
| Between groups | 0.204362 | 1 | 0.204362 | 1.048.541 | 0.31403 | 4.170.877 |
| Within the group | 5.847.026 | 30 | 0.194901 | | | |
| **Total** | **6.051.388** | **31** | | | | |

*Fig.3: One-way ANOVA – Mangroves of Alagoas GI*

*Source: Author's own compilation (2020)*

## Mossoró

The catchment area of this GI consists of 13 municipalities from the State of Rio Grande do Norte and is associated to the production of melon. The region is considered one of the largest producers and exporters of high-quality melon.

The PCA applied to this GI showed a similar centrality profile to the State of Alagoas, where the three higher geographical levels are determinant in economic terms.

The average variation of the centrality indices was of 0.553 points. This result corroborates the assumption that a loss of economic importance was observed in the municipalities. Nine of the region's municipalities obtained a lower-than-average share of services and goods when compared to the 167 municipalities from the State of Rio Grande do Norte.

The performance of this GI, in terms of centrality, was not worse as the municipality of Mossoró observed an eight-fold increase in the relative share of services and goods, while the municipality of Açú doubled this share. However, all other municipalities experienced a decrease in their centrality indices.

The results of the one-way ANOVA process applied to the municipalities inserted within the Mossoró – GI was not able to attest that the development of services in these locations was different than all other municipalities in the State of Rio Grande do Norte, as demonstrated in Figure 4.

| SUMMARY | | | | |
|---|---|---|---|---|
| **Group** | **Count** | **Sum** | **Average** | **Variance** |
| **IG Group** | 13 | 1.898.824 | 1.460.634 | 2855982 |
| **Control Group** | 13 | 1.369.171 | 1.053.209 | 0.141894 |
| **ANOVA** | | | | |
| *Variation* | *SQ* | *Gl* | *MQ* | *F* | *P-value* | *Critical F-value* |
| Between groups | 1.078.970.418 | 1 | 10.789.704 | 0.719823 | 0.404585 | 4.259.677 |
| Within the group | 359.745.162 | 24 | 1.498.938.175 | | | |
| **Total** | **3.705.348.661** | **25** | | | | |

*Fig.4: One-way ANOVA –Mossoró GI*

*Source: Author's own compilation (2020)*

## Abaíra Microregion

The catchment area of this GI consists of only four municipalities in the Chapada Diamantina region, in the State of Bahia: Abaíra, Jussiape, Mucugê and Piatã. The Indication of Provenience granted to these municipalities is associated to the production of sugarcane brandy/cachaça. All four locations presented a much higher variation in the centrality indicator when compared to the combination of municipalities from the State of Bahia.

A new PCA was carried out to validate the null-hypothesis of this research, having demonstrated that the basic driver of this association was the share on the municipal services and products at a national level, with the total contribution to the microregional gross domestic product also having a lower explanatory power.

Between 2011 and 2017, the shares of the products and services in the economy of the State of Bahia did not change significantly, which resulted in little changes in its centrality hierarchy. Unsurprisingly, the average variation of this indicator was of 0.999 (stagnated).

Once again, the ANOVA process rejected the hypothesis that the progress of the levels of centrality of the municipalities with GI was different than those from the other municipalities in the Abaíra Microregion (Figure 5).

| SUMMARY | | | | | |
|---|---|---|---|---|---|
| Group | Count | Sum | Average | Variance | |
| IG Group | 4 | 4.110.343 | 1.027.586 | 0.013091 | |
| Control Group | 4 | 3.845.054 | 0.961263 | 0.008831 | |
| ANOVA | | | | | |
| Variation | SQ | Gl | MQ | F | P-value | Critical F-value |
| Between groups | 0.008797 | 1 | 0.008797 | 0.802593 | 0.404826 | 5.987.378 |
| Within the group | 0.065767 | 6 | 0.010961 | | | |
| Total | 0.074564 | 7 | | | | |

*Fig.5: One-way ANOVA – Abaíra Microregion*

*Source: Author's own compilation (2020)*

## Costa Negra

This GI from the State of Ceará consisted of four cities (Acaraú, Cruz, Itarema and Jijoca de Jericoacoara) and is dedicated to shrimp farming. Its levels of centrality are lower than the State's average, exhibiting negative scores in the seven years covered in the present research.

The degrees of variation of this area were also, on average, lower than that of their peers, having observed a decrease of 18% in their centrality levels, against an increase of 24% in the remaining municipalities from the State of Ceará.

Similar to the other GIs, the ANOVA test could not approve the alternative hypothesis – average variance of the group of municipalities different than that of the remaining population – as observed in Figure 6.

| SUMMARY | | | | | |
|---|---|---|---|---|---|
| Group | Count | Sum | Average | Variance | |
| IG Group | 4 | 3,278822 | 0,819706 | 0,047175 | 0,047175 |
| Control Group | 4 | 4,313213 | 1,078303 | 0,019236 | 0,019236 |
| ANOVA | | | | | |
| Variation | SQ | Gl | MQ | F | P-value | Critical F-value |
| Between groups | 0,133746 | 1 | 0,133746 | 4,027799 | 0,091542 | 5,987378 |
| Within the group | 0,199234 | 6 | 0,033206 | | | |
| Total | 0,332979 | 7 | | | | |

*Fig.6: One-way ANOVA – Costa Negra*

*Source: Author's own compilation (2020)*

It is important to highlight that this was the test which was the closest to the possibility of rejecting the null-hypothesis – of similarity between the variance of the average centrality indices. This enables the possibility of retesting such reality, by carrying out new ANOVA tests with other municipality samples, in a research specifically aimed to this purpose.

However, the results of the present research indicate that granting Geographical Indications (GIs) to agricultural products in the regions analyzed herein did not have a

significant effect on the socioeconomic context in order to change the levels of productions associated to the degree of centrality of these municipalities.

In the municipalities with noteworthy changes in their levels of centrality, the phenomenon was similar in most of the other municipalities of their respective States. Thus, the changes observed could be have a different nature than that necessarily linked to the concession of GIs.

Regarding the concession of GIs, it is worth noting that it cannot be claimed that substantial changes to the socioeconomic profile of the region have occurred due to this fact. Nevertheless, a more precise analysis of the specific social indicators can contribute to settling any remaining doubts and can be the scope of future researches.

However, certain assumptions can be drawn regarding the reason for such behavior pattern, such as the different structures of the activities involved, the absence of a better integration between the economic agents, which would promote greater synergies and more complex inter-industrial demand. Moreover, it is worth noting that the institutions have a relevant role in supporting and promoting the correct functioning of GIs in Brazil.

Other studies have been carried out in other Brazilian regions, such as in Paraty, South of the State of Rio de Janeiro, in a study carried out by Almeida, Alimonda, Meirelles Júnior et al. (2015). The study analyzed the chachaça label, having concluded that the GI led to a positive local effect, improving the local quality of life. Moreover, there are also several other positive examples in the international literature, such as the work by Marie-Vivien, Garcia, Kushalappa and Vaast (2014) on Indian coffee. The introduction of a GI in the Indian region of Kodagu was of fundamental importance to increase the socioeconomic development of the region, but also for protecting its biodiversity, thus, with positive extra-market effects.

Fagundes, Padilha, Sluszz et al. (2012), for instance, argue that the introduction of GIs led to a better economic performance in the region of Vinhedo Valley, in the State of Rio Grande do Sul. According to the authors, the certification resulted in a greater number of tourists, higher value of rural properties, substantial changes in the technological standards, among other empirical improvements.

A similar case was analyzed by Pellin and Vieira (2015), when studying the region of Urussanga, in the State of Santa Catarina. The authors argue that after the recognition of GIs, a significant increase of economic performance was observed, with consequent surge in the

sale of traditional and sparkling wine, besides greater access to other markets and the development of complementary activities. These examples show the positive effect of the introduction of GIs on local development, different than the result of the present study, which showed that the concession of GIs associated to agricultural products in Northeastern Brazil did not have a significant effect on the level of centrality.

## V. CONCLUSION

The findings of the present research show that more in-depth studies regarding GIs in the Northeastern region of Brazil are needed, in order to clearly identify their deficiencies and intensity. As inferred herein, GIs are aimed at strengthening regional productive activity, reinforcing the connection between the different sectors, as they would otherwise be further apart. Moreover, GIs also expected to consolidate the expertise of a certain region, in terms of the production of a certain good or service, with positive externalities and socioeconomic impacts on the entire State.

This is crucial as GIs from Northeastern Brazil are mostly formed by municipalities of little economic relevance, in terms of economic volume, density and dynamics. These are small municipalities still linked to primary activities (agriculture or extraction), which reinforces the low technological complexity in the case of small producers, which is the result of a labor-intensive sector, thus reinforcing their important role for job generation.

The findings found in the present study allow to draw conclusions regarding the municipalities from Northeastern Brazil which were granted Geographical Indications, indicating that their respective centrality levels were not influenced by such concession. This phenomenon was observed as the importance of the gross domestic products of the municipalities in the private service sector was a result of systemic reasons – having reached the group of Northeastern municipalities – rather than due to specific reasons associated to each municipality.

On the other hand, the results of present study do not prove that the implementation of GIs does not contribute to regional socioeconomic development, rather showing that, under an overall regional behavior, no significant changes were observed wherever GIs were present. Therefore, further research is necessary, focusing on social indicators which motivate these changes.

Thus, the elements that constitute the concession of GIs and the levels of municipal centrality are more pronounced

in the market structure. The absence of institutional support and of a regional strategy for integrating the different markets may hamper the extraction of positive effects under an economic and social perspective. With this in mind, Geographical Indications from the Brazilian Northeast should be subject to more thorough research, which can identify their deficiencies and intensity, with a collective interest, ensuring the economic relevance, density and dynamics of small-scale municipalities inserted in the region where GIs have been granted.

Finally, it is worth highlighting the relevance of the agricultural sector for the region, which has a significant importance for generating wealth, particularly in a continental country such as Brazil. Accordingly, there is also a significant need of further studies applied to the sector, especially regarding the understanding of socioeconomic impacts, measured by indicators such as GDP per capita, HDI, the Gini coefficient, among other indicators which can assess marginal or structural changes.

## ACKNOWLEDGEMENTS

## REFERENCES

[1] BRASIL (1996). Lei nº 9.279, de 14 de maio de 1996. Regula direitos e obrigações relativos à propriedade industrial. Brasília, 1996. Disponível em: http://www.planalto.gov.br/ccivil_03/ Leis/L9279.htm. Acesso em: 01 abr. 2020.

[2] INSTITUTO NACIONAL DE PROPRIEDADE INDUSTRIAL (INPI). **Instrução Normativa n° 95 de 28 de dezembro 2018.** Estabelece as condições para o Registro das Indicações Geográficas. Disponível em: <https://www.gov.br/inpi/pt-br/servicos/indicacoes-geograficas/arquivos/legislacao-ig/INn095de2018.VersoocerizadaparaPortalINPI.pdf. Acesso em: 27 abr. 2020.

[3] INSTITUTO NACIONAL DE PROPRIEDADE INTELECTUAL (INPI). **Mapa de Indicações Geográficas.** Disponível em: <https://www.gov.br/inpi/pt-br/servicos/indicacoes-geograficas/mapa-de-indicacoes-geograficas/2019>. Acesso em: 27 abr. 2020.

[4] INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTÁTISTICA (IBGE). **Censo demográfico 2010**. 2010. Disponível em: < https://censo2010.ibge.gov.br/>. Acesso em: 15 mar. 2020.

[5] CANTARIM, Fernanda. Estudos de redes urbanas no Brasil: Reflexões sobre transformações metodológicas. **Revista Paranaense de Desenvolvimento**, Curitiba, v. 36, n. 129, p. 117-133, jul/dez. 2015.

[6] HSU, Wen-Tsai. Central Place Theory and city size distribuition. *The Economic Journal*. v. 122, n. 563, pp. 903-932, 2012.

[7] VIONIS, Athanasios K.; PAPANTONIOU, Giorgos. **Land**. v. 8, n. 36, pp. 1-31, 2019. doi:10.3390/land8020036.

[8] SILVA, Fernanda Faria. **Centralidade e impactos regionais de política monetária:** um estudo dos casos brasileiro e espanhol. Tese (doutorado). 312f. Universidade Federal de Minas Gerais. Belo Horizonte: UFMG, 2011.

[9] HSU, Wen-Tsai. Central Place Theory and city size distribuition. *The Economic Journal*. v. 122, n. 563, pp. 903-932, 2012.

[10] IPEA /IBGE/UNICAMP. Caracterização e tendências da rede urbana do Brasil: Configurações atuais e tendências da rede urbana. Brasília: IPEA, vol. 1, 2002.

[11] STAMM, Cristiano. **Determinantes do movimento de trabalhadores pendulares na aglomeração urbana do nordeste do Rio Grande do Sul**: Uma análise a partir dos transportes coletivos. Porto Alegre, 2013, 279f. Tese (Doutorado em Planejamento Urbano e Regional) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2013.

[12] CHRISTALLER, Walter. **Central places in Southern Germany**. Prentice-Hall/ Englewood Cliffs, 1966.

[13] PORTELA, Francisco Carneiro. **Região, planejamento e geografia modelo-teórica**: Contribuições basilares à intervenção governamental interfederativa. Brasília, 2016, 172f. Dissertação (Mestrado em Geografia) – Universidade de Brasília, Brasília, 2016.

[14] FERRERA DE LIMA, J**. La diffusion spatiale du développement économique regional:** l'analyse de la diffusion au sud du Brésil dans le XX° siècle. Sarrabruck: EUE, 2010b.

[15] BESSA, Kelly. Estudos sobre a rede urbana: Os precursores da teoria das localidades centrais. **GeoTextos**, v. 8, n. 1, p. 147-165, jul. 2012.

[16] PORTELA, Francisco Carneiro. **Região, planejamento e geografia modelo-teórica**: Contribuições basilares à intervenção governamental interfederativa. Brasília, 2016, 172f. Dissertação (Mestrado em Geografia) – Universidade de Brasília, Brasília, 2016.

[17] TINEU, Rogério. Centro e centralidade conceitos e aproximações à cidade de São Paulo. **Revista Belas Artes**, p. 12-10, 2012.

[18] PORTELA, Francisco Carneiro. **Região, planejamento e geografia modelo-teórica**: Contribuições basilares à intervenção governamental interfederativa. Brasília, 2016, 172f. Dissertação (Mestrado em Geografia) – Universidade de Brasília, Brasília, 2016.

[19] CANTARIM, Fernanda. Estudos de redes urbanas no Brasil: Reflexões sobre transformações metodológicas. **Revista Paranaense de Desenvolvimento**, Curitiba, v. 36, n. 129, p. 117-133, jul./dez. 2015.

[20] NASCIMENTO ARAÚJO, José Júlio César; SOARES ALMEIDA, Neuler André; RODRIGUES, Francisco Mendes. A Teoria dos Lugares Centrais e sua aplicabilidade no Programa Zona Franca Verde no Amazonas. **Redes**,

Santa Cruz do Sul, v. 14, n. 1, p. 106-120, set. 2009. ISSN 1982-6745. Disponível em: <https://online.unisc.br/seer/index.php/redes/article/view/876>. Acesso em: 24 mar. 2020. doi:https://doi.org/10.17058/redes.v14i1.876

[21] ALMAS, Rondinaldo da Silva. **Economia regional**: Conceitos, pressupostos teóricos e as primeiras formulações. 2012. Disponível em: http://www.eeb.sei.ba.gov.br/pdf/2012/er/economia_regional.pdf. Acesso em: 12 jun. 2020.

[22] ALVES, Flamarion Dutra. Notas Teórico-Metodológicas entre Geografia Econômica e Desenvolvimento Regional. **Anais...** V Seminário Internacional sobre Desenvolvimento Regional, Rio Grande do Sul, 17-19 ago. 2011.

[23] LIBERATO, Rita de Cássia. Revisando os modelos e as teorias da análise regional. **Caderno Geografia**, Belo Horizonte, v. 18, n. 29, p. 127-136, 2008.

[24] CANTARIM, Fernanda. Estudos de redes urbanas no Brasil: Reflexões sobre transformações metodológicas. **Revista Paranaense de Desenvolvimento**, Curitiba, v. 36, n. 129, p. 117-133, jul./dez. 2015.

[25] MAIORKI, Giovane José; DALLABRIDA, Valdir Roque. **Indicación geográfica de productos**: un estudio de su contribución económica en el desarrollo territorial. Interações (Campo Grande), v. 16, n. 1, p. 13-25, 2015.

[26] SAKR, Mayara Rohrbacher; DALLABRIDA, Valdir Roque. **O marketing territorial como estratégia de construção e divulgação da imagem dos territórios**: a indicação geográfica como referência. Seminário Internacional sobre Desenvolvimento Regional, Santa Cruz do Sul, Brasil, 9 a 11 set. 2015.

[27] BRASIL (1996). Lei nº 9.279, de 14 de maio de 1996. Regula direitos e obrigações relativos à propriedade industrial. Brasília, 1996. Disponível em: http://www.planalto.gov.br/ccivil_03/ Leis/L9279.htm, acessado em: 01 de abr. 2020.

[28] BARBOSA, P. M. S.; PERALTA, P. P.; FERNANDES, L. R. R. M. V. Encontros e desencontros entre indicações geográficas, marcas de certificação e marcas coletivas. In: LAGE, C. L.; WINTER, E.; e BARBOSA, P. M. S. (Org.) **As diversas faces da propriedade intelectual**. Rio de Janeiro: EdUERJ, 2013. p. 141-173.

[29] SILVA, Cínthia Kaline Vieira; BRITO, Luísa Medeiros; DANTAS, Thomas Kefas de Souza. A indicação geográfica como promotora do desenvolvimento local e regional: o caso (em potencial) do bordado do Seridó. **Revista GEINTEC-Gestão, Inovação e Tecnologias**, v. 6, n. 1, p. 2982-2990, 2016.

[30] MAIORKI, Giovane José; DALLABRIDA, Valdir Roque. **Indicación geográfica de productos**: un estudio de su contribución económica en el desarrollo territorial. Interações (Campo Grande), v. 16, n. 1, p. 13-25, 2015.

[31] SIEDENBERG, Dieter Rugard; THAINES, Aleteia Hummes; BAGGIO, Daniel Knebel. Desenvolvimento regional sob a ótica do reconhecimento da indicação geográfica: o case do vale dos vinhedos, a partir da

percepção dos atores sociais. **Gestão & Regionalidade**, v. 33, n. 99, p. 4-20, 2017.

[32] MARINS, Maíra Freixinho; CABRAL, Danièle Hervé Quaranta. O papel da Indicação Geográfica como propulsor da inovação e do desenvolvimento local: caso Vale dos Vinhedos. **Cadernos de Prospecção**, v. 8, n. 2, p. 406, 2015.

[33] SILVA, Cínthia Kaline Vieira; BRITO, Luísa Medeiros; DANTAS, Thomas Kefas de Souza. A indicação geográfica como promotora do desenvolvimento local e regional: o caso (em potencial) do bordado do Seridó. **Revista GEINTEC-Gestão, Inovação e Tecnologias**, v. 6, n. 1, p. 2982-2990, 2016.

[34] MAIORKI, Giovane José; DALLABRIDA, Valdir Roque. **Indicación geográfica de productos**: un estudio de su contribución económica en el desarrollo territorial. Interações (Campo Grande), v. 16, n. 1, p. 13-25, 2015.

[35] MAIORKI, Giovane José; DALLABRIDA, Valdir Roque. **Indicación geográfica de productos**: un estudio de su contribución económica en el desarrollo territorial. Interações (Campo Grande), v. 16, n. 1, p. 13-25, 2015.

[36] MARINS, Maíra Freixinho; CABRAL, Danièle Hervé Quaranta. O papel da Indicação Geográfica como propulsor da inovação e do desenvolvimento local: caso Vale dos Vinhedos. **Cadernos de Prospecção**, v. 8, n. 2, p. 406, 2015.

[37] SAKR, Mayara Rohrbacher; DALLABRIDA, Valdir Roque. **O marketing territorial como estratégia de construção e divulgação da imagem dos territórios**: a indicação geográfica como referência. Seminário Internacional sobre Desenvolvimento Regional, Santa Cruz do Sul, Brasil, 9 a 11 set. 2015.

[38] Lemos Garcia, D., Gabriel Francisco da Silva, André Luiz Gomes de Souza, José Pereira Mascarenhas Bisneto, & Emerson de Sousa Silva. (2019). Geographical Indication: a proposal for measuring centrality. *International Journal for Innovation Education and Research*, *7*(12), 462-473. https://doi.org/10.31686/ijier.vol7.iss12.2096

[39] Lemos Garcia, D., Gabriel Francisco da Silva, André Luiz Gomes de Souza, José Pereira Mascarenhas Bisneto, & Emerson de Sousa Silva. (2019). Geographical Indication: a proposal for measuring centrality. *International Journal for Innovation Education and Research*, *7*(12), 462-473. https://doi.org/10.31686/ijier.vol7.iss12.2096

[40] Almeida, A.C.R.A de; Alimonda, H.A.; Meirelles Júnior, J.C. et al. Rural Territorial Development with Social Management: The Case of Geographic Indication of Paraty's Cachaça. **European Journal of Economics, Finance and Administrative Sciences**. ISSN 1450-2275 Issue 81 October, 2015.

[41] Marie-Vivien D., Garcia, C.A. Kushalappa, C. G., Vaast. P. Trademarks, Geographical Indications and Environmental Labelling to Promote Biodiversity: The Case of Agroforestry Coffee in India. **Development Policy Review**, 32, nº 4 (2014): 379-398.

[42] de Mattos Fagundes, P., Padilha, A., Sluszz, T. *et al.* Geographical indication as a market orientation strategy:

An analysis of producers of high-quality wines in Southern Brazil**. *J Database Mark Cust Strategy Manag* 19,** 163–178 (2012). https://doi.org/10.1057/dbm.2012.18

[43] Pellin, V.; Vieira, A.C.P. Contributions of geographical indications for territorial strengthening in rural space: a case study in southern Brazil. **Espacios**. Vol. 36 (nº 08), 2015.

# In Vitro analysis of the Antibacterial action of the Extract of Costus Spiralis (Costaceae) on Enterococcus Faecalis

Eduardo Fernandes Marques, Albério Batista de Oliveira, Thales Gustavo Menezes Santana Ferreira, Larissa Coelho Bitencourt, Guilherme Nobre Lima do Nascimento, Rodney Haulien Oliveira VianaandCarina Scolari Gosch.

*Abstract— Enterococcus faecalis is an important cause of endodontic and nosocomial infections, making the search for new antimicrobial drugs important. To analyze in vitro the antibacterial action of Costus spiralis extract on E. faecalis. The antimicrobial sensitivity test was performed using the well agar diffusion method. E. faecalis strains (NEWProv-0012) were revitalized in BHI broth and incubated at 37 ° C for 18 h. Subsequently, the microbial suspension was adjusted to a concentration of 5x105 CFU mL-1 and sown on Mueller Hinton agar, after which 6 mm wells were made. The crude alcoholic extract paste of C. spiralis was used as a positive control 2.5% sodium hypochlorite and as a negative control 96% ethanol and BHI broth. The halos of minimal inhibitory inhibition (MIC) using the crude extract paste and solutions prepared with BHI broth in different concentrations. The viability and microbial quantification of E. faecalis in culture with MIC were determined by serial dilution after 24, 48 and 72 h. Results: The crude extract of C. spiralis has an effective action in inhibiting the growth of E. faecalis. MIC was observed at a concentration of 25% of the extract in solution and promoted the inhibition of E. faecalis growth by 50% after 24 h and 98% in 48 h of incubation. Conclusion: The C. spiralis extract has antibacterial action and can be a therapeutic alternative for infections caused by E. faecalis.*

*Keywords— Costus spiralis. Medicinal plants. Antibacterials.*

## I. INTRODUCTION

Enterococcus are characterized as gram-positive cocci arranged in a single form, in pairs or in short chains. They are facultative anaerobic microorganisms, producers of lactic acid and negative catalase (IKE, 2017). It has the ability to form biofilm, which can be found in the gastrointestinal tract, oral cavity and vagina (LEE D. et. Al., 2019; GARCÍA-SOLACHE et.al., 2019). Harmless commensal microorganisms have already been considered, however, research increasingly shows the potential of Enterococcus to survive in a hospital environment, colonize patients and cause human infections such as bacteremia, peritonitis, endocarditis, urinary tract infection, with E. faecalis responsible for more than 90% of enterococcal infections (SAVA et al., 2010; POCHHAMMER et.al, 2017; KAYAOGLU; ORSTAVIK, 2004).

Enterococcus faecalis seem to have acquired over time an ability to accumulate and share chromosomal elements that have characteristics to encode both virulence and antimicrobial resistance genes, perhaps this explains their increasing presence in hospital environments, being the main bacterial group related to infections nosocomial (LEBRETON et al., 2017; SHARIFI et al., 2013). The species stands out for presenting new phenotypes resistant to important antibiotics, both those of conventional use and against the latest generation antibiotics, such as vancomycin, and transmitting this capacity to other gram-positive and gram-negative species, leading to serious public health problems and economic expenses (COURVALIN, 1994; LEBRETON et al., 2017; NUÑEZ et al., 2016; WILLEMS; BONTEN, 2007).

In dental research, the survival mechanisms of E. faecalis in the root canals and the methods used by the bacteria to

establish themselves in these sites have expanded the studies with the species (ALSHWAIMI et al., 2016; HAAPASALO; ORSTAVIK, 1987; ORSTAVIK; HAAPASALO , 1990; SANTA-ROSA et al., 2019;). Visa which are the main microbial agents responsible for secondary endodontic infections, stand out for their high prevalence and causes of failure in dental treatments (DELBONI et al., 2017; NACIF; ALVES, 2010; SIQUEIRA JUNIOR; RÔÇAS, 2004).

Due to the appearance of microorganisms resistant to the action of the most used drugs, there was a growing search for new agents, aiming at alternatives to control the spread of these strains (FRIERI et al., 2017). Historically, many drugs come from natural products, and these are being increasingly researched, in search of improving existing drugs and developing new, more efficient classes (BOLDI, 2004; BRAGA; SILVA, 2015; PREETHA, 2017).

The marsh cane, Costus spiralis (Jacq.) Roscoe, widely found in tropical South America, has been used as a medicinal plant, mainly in communities in the Amazon region (DUARTE et al., 2017; LORENZI; MATOS, 2002 ). With leaf infusions, communities have used it as a diuretic, healing, antidiabetic and against infections (ALBUQUERQUE, 1989; BRAGA et al., 2007; FERREIRA et al., 2015; HABSAH et al., 2000; MARTINS et al., 2003). In view of these considerations, it is necessary to investigate and develop new alternative antimicrobial options to those already used, and it is relevant to verify the effectiveness of medicinal plants found in our territory. Therefore, the present study sought to analyze the antibacterial action and the determination of the Minimum Inhibitory Concentration (MIC) in vitro of the crude ethanolic extract of the Costus spiralis plant on Enterococcus faecalis.

## II. MATERIALS AND METHODS

The leaves and branches of caninha-do-brejo (Costus spiralis [Jacq.] Roscoe) were collected, following the herborization techniques of Fidalgo&Bononi (1984), at the Sítio Novo farm, municipality of Divinópolis do Tocantins, in the western region of state of Tocantins, Brazil, between the geographical coordinates 9 ° 54'32 "south latitude and 49 ° 09'27" west longitude. The species was identified by the botanist responsible for the herbarium of the Federal University of Tocantins campus Porto Nacional.

The exsiccates are incorporated into the collection of the referred herbarium, under registration number 12098 HTO. The leaves were washed with water and dried, then crushed

and subjected to maceration with 96% ethanol for five days. After that period the macerate was filtered on filter paper and the ethanolic solution was concentrated on a rotary evaporator, with temperature controlled at 40 ° C, to recover the solvent and obtain the crude extract, with 6.44% yield.

**Antimicrobian activity**

A commercial strain of Enterococcus faecalis (NEWProv-0012) was used, revitalized in BHI broth, incubated at 37 ° C ± 2 ° C in a bacteriological oven until visible turbidity (18 h). After the microorganisms were inoculated in a plate of non-selective nutrient medium (Nutrient agar, KASVI) by the depletion technique and they were again incubated at 37 ° C ± 2 ° C for 24 h. In order to carry out the tests, the microbial concentration was adjusted to the concentration of 5x105 CFU / mL of BHI broth, controlled by reading the turbidity in a spectrophotometer with a wavelength of 600 nm and later counting of plate colonies by performing serial dilutions. in 0.95% saline solution.

To determine the antibacterial action on plates, Mueller Hinton agar (MH, KASVI) was prepared, previously melted, sterilized and cooled to 45-50 ° C, then distributed in 150 mm diameter Petri dishes until reaching a thickness of approximately 4 mm. After obtaining solid consistency of the MH agar, sterile swabs were used to collect microorganisms in the bacterial suspension (≈ 5x105 CFU / mL) and the surface seeding technique was performed in three directions on each plate, paying attention to uniform distribution, avoiding the growth of isolated colonies. Then, 6 mm diameter wells were made, with four perforations in each plate.

The MIC determination was performed by diluting the crude extract in brain heart infusion broth (BHI, KASVI), to prepare solutions in different concentrations: 100%, 50%, 25%, 12.5%, 6.25%, 3, 1%, 1.5% and 0.7%, to determine the MIC. As a positive control, 2.5% sodium hypochlorite was used and as a negative control, 96% ethanol and BHI broth. The inhibition halos were measured with the aid of a caliper, the results being expressed in millimeters. MIC was considered to be the lowest concentration of the extract solution that enabled the formation of an inhibition halo. The wells were completely filled with sufficient quantities of crude extract or controls and incubated at 37 ° C ± 2 ° C.

After MIC determination, the microorganisms (≈ 5x105 CFU mL-1) were grown in a bacteriological incubator at 37 ° C ± 2 ° C, in the presence or absence of the crude extract of C. spiralis at 25%. For the analysis of viability and microbial

quantification, after 24, 48 and 72 h of culture, the counting of colonies in the plate was carried out by performing serial dilutions in 0.95% saline solution.

All experiments were carried out in triplicates. To determine the antimicrobial action of the C. spiralis extract, the final result was the arithmetic mean of the inhibition halos or the number of CFU / mL obtained from triplicates of three experiments carried out consecutively.

## III. RESULTS AND DISCUSSION

The results obtained show that the vegetable preparation of the leaves of Costus spiralis has potential antimicrobial activity against the tested strain of Enterococcus faecalis. The crude extract was able to inhibit microbial growth after 24 h of incubation, with inhibition halos with an average diameter of 13 mm (Figure 1), which were maintained even after 30 days of culture.

**Figure 1. Sensitivity test of E. faecalis (NP 0012) to the C. spiralis Crude Extract paste.** Microorganisms at a concentration of 5x105 UFC mL-1 were seeded in a confluent manner on the surface of Mueller-Hinton agar (KASVI). Well made in the center of the plate was completely filled with the paste of the crude extract of C. spiralis and after 2 h of pre-diffusion at room temperature the plate was incubated at 37 ° C. The diameter of the inhibition zone was measured in millimeters, with the aid of a caliper, after 24 h and 30 days of incubation, keeping the same.
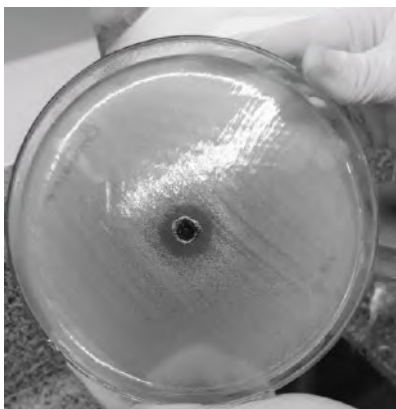


*Fig.1: Sensitivity test of E. faecalis culture (NP 0012) to the Crude Extract of C. spiralis paste.*

The determination of the Minimum Inhibitory Concentration (MIC) was performed with the extract of C. spiralis in paste

and with solutions prepared in concentrations 100%; 50%; 25%; 12.5%; 6.2% 3.1%, 1.5% and 0.7%, (Table 1). Growth inhibition was directly proportional to the concentration of the extract, with MIC being fixed in the dilution of the crude extract in 25% solution in BHI medium, with the formation of an inhibition halo of 7 mm in diameter.

*Table 1. Minimum Inhibitory Concentration (MIC) in a solid medium of C. spiralis Extract, on E. faecalis.*

| Extract concentration (g ml-1) (%) | measured between the edge of the well and the inhibition zone (mm) | Inhibition halo diameter (mm) |
|---|---|---|
| Crude paste extract | 3,5 | 13 |
| Crude extract in solution 100% | 2,5 | 11 |
| Crude extract in solution 50% | 1,5 | 9 |
| Crude extract in solution 25% | 0,5 | 7 |
| Crude extract in solution 12,5% | 0 | 0 |
| Crude extract in solution 6,2% | 0 | 0 |
| Crude extract in solution 3,1% | 0 | 0 |
| Crude extract in solution 1,5% | 0 | 0 |
| Crude extract in solution 0,7% | | |
| Sodium hypochlorite 2,5% | 6,5 | 19 |
| Alcohol 96% | 0 | 0 |
| Medium BHI | 0 | 0 |

Source: own authorship.

The evaluation of the in vitro growth curve of E. faecalis in the presence or absence of the crude extract of C. spiralis in the MIC 25% identified an effective reduction in microbial growth in the presence of the plant extract after 24 h of culture and that there was no more growth colonies visible after 48 h of incubation (Figure 2).

**Figure 2. Growth curve of in vitro E. faecalis in the presence and absence of Crude Extract of C. spiralis.**

Microorganisms at a concentration of 5x105 CFU mL-1 were grown in BHI broth or in BHI broth + C. spiralis Crude Extract paste, forming a 25% solution (EB C. spiralis), corresponding to CIM. After 24, 48 and 72 h of incubation in a bacteriological oven at 37 ° C, serial dilutions (10-1 to 10-9) and respective sowing on non-selective agar for colony counting and determination of the number of CFU mL-1 . Source: prepared by the researchers.
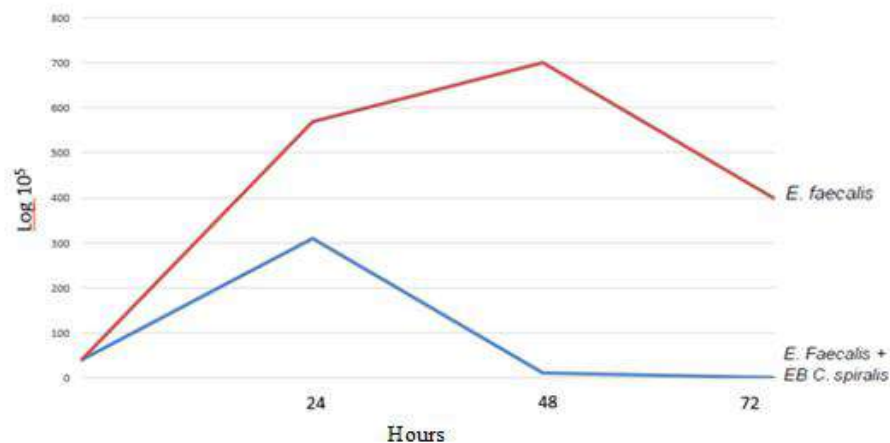


*Fig.2: Growth curve of in vitro E. faecalis in the presence and absence of Crude Extract of C. spiralis*

The rate of inhibition of microbial growth in the presence of the crude extract of C. spiralis at MIC 25% was compared with microbial growth free of any limiting factor. The extract at MIC 25% was able to inhibit microbial growth by 54% in 24 h, 98% after 48 h and in 72 h it inhibited 100% (Figure 3).

**Figure 3. In vitro growth inhibition rate of E. faecalis by the crude extract of C. spiralis.** After evaluating the in vitro growth curve of E. faecalis in the presence and absence of the 25% crude extract of C. spiralis (EB), the inhibition of microbial growth by the presence of the plant extract was calculated.
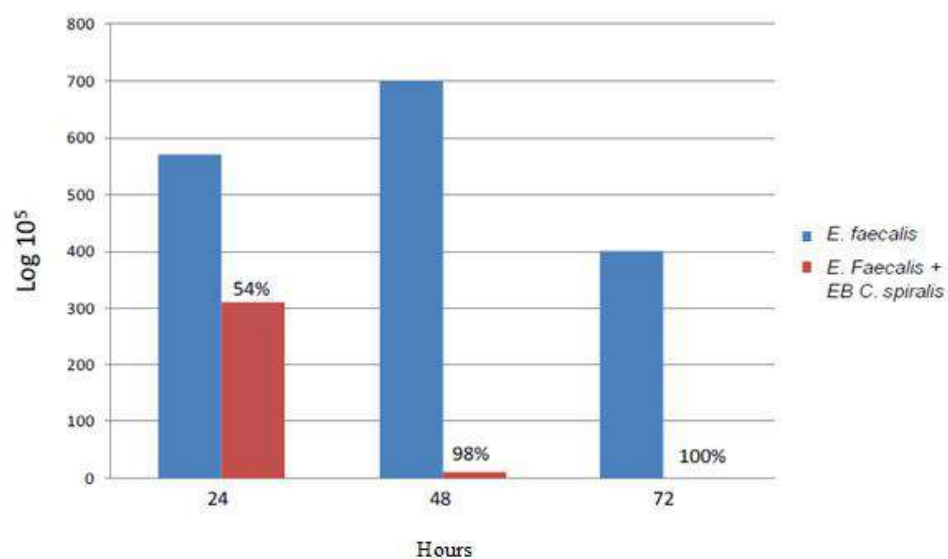


*Fig.3: In vitro growth inhibition rate of E. faecalis by the crude extract of C. spiralis*

The formulations with concentrations of the crude extract of caninha do-brejo from 25% analyzed in this study showed action against E. faecalis. Previous research using plant extract of Costus spiralis shows antibacterial activity in vitro against different gram-negative bacteria Pseudomonas aeruginosa, Shigella sonnei, Salmonella sp., Vibrio cholerae and against gram positive bacilli, Bacillus cereus, (BOUZADA et al., 2009; PÉREZ et al., 2008). In none of these studies, the species E. faecalis was included among the strains analyzed, not allowing the comparison of results with the present study.

Uliana et al., (2015) when researching the antibacterial activity of Costusspicatus revealed that such action could be related to the presence of phenolic and flavonoid compounds identified in the extract. This potential may also be related to the composition of the methanol extracts of C. spiralis, holders of both substances, considering that phytochemical studies have identified its main

components, especially alkaloids, flavonoids, steroids, saponins, inulin, tannins, sitosterol, mucilages, sapogenins, pectins and calcium oxalate (ALBUQUERQUE, 1989; BRAGA et al., 2007; DUARTE et al., 2017; SILVA; PARENTE, 2004). Although the exact nature of compounds that have an antimicrobial effect on the extract of C. spiralis are unknown, these results can be useful forfuture isolation tests of the active ingredients that act on the strains.

In the experiments carried out by Bouzada et al. (2009), using plant extract of C. spiralis, obtained as a result inhibition halos of 10 mm against Shigella sonnei, 10 mm against Klebsiella pneumoniae and 9 mm against Pseudomonas aeruginosa and 15 mm against Bacillus cereus. In the present study, the inhibition halos recorded in the tests against E. faecalis were 13 mm, suggesting that gram positive bacteria may be more sensitive to the active principles present in the plant.

Sodium hypochlorite at 2.5% is a substance of global use, mainly in endodontic treatments, being the first option for irrigation of root canals, with capacities beyond the antibiotic, antifungal and antiviral effects, still allows to lighten, deodorize, dissolve tissues organic, having low surface tension and alkaline pH (BORIN et al., 2007; GOMES et al., 2018; TARTARI et al., 2016;). Despite being the substance of choice because it has versatile

capacities, hypochlorite, due to its denaturing effect on proteins, is considered a substance that causes cytotoxicity when in contact with tissues adjacent to the root canal space,

which can cause hemolysis, ulceration and inhibit the migration of neutrophils (FIDALGO et al., 2009; HAND et al., 1978; SERMEÑO, et al., 2009). On the other hand, Braga et al. (2007), when studying the effects of Costus spiralis extract at a concentration of 250 μg ml-1, revealed non-significant cytotoxicity in mammalian cells.

The caninha-do-brejo, due to its wide use as a medicinal plant, was researched in other segments that have confirmed its therapeutic effects using its plant extracts, corroborating its medicinal properties. The hypoglycemic, anti-lipid and antioxidant actions in experiments with rats (DUARTE et al., 2019), action against Leishmania chagasi and Leishmania amazonenses (BRAGA et al., 2007), anti-inflammatory capacity, inhibition of vascular permeability, protection stand out cardiovascular and anti-atherosclerotic (SILVA; PARENTE, 2004), and antiurolytic activity in kidney stones formed by calcium oxalate crystals in living experimental models (VIEL et al., 1999), validating the different medicinal functions present in the same plant, and with potential for new discoveries, such as those described in the present study.

## IV.    FINAL CONSIDERATIONS

It was found in in vitro studies that Costus spiralis leaf extracts have antimicrobial activity against Enterococcus faecalis from concentrations of 25% crude extract. The evidence from the present study indicates a relevant contribution of C. spiralis as a raw material for new arsenals of antimicrobial substances that will combat the feared infections by E. faecalis. The results encourage the development of new studies to prove its effectiveness, isolation of active ingredients, synergism with other substances and clinical applicability, enabling its use as an auxiliary substance in future treatments.

## REFERENCES

[1] ALBUQUERQUE, J. M. Plantas medicinais de uso popular. **Associação Brasileira de Educação Agrícola Superior (ABEAS)**. Brasília: Ministério da Agricultura, 1989. 96p.

[2] ALSHWAIMI, E.; BOGARI, D.; AJAJ, R.; AL-SHAHRANI, S.; ALMAS, K.; MAJEED, A. In vitro antimicrobial effectiveness of root canal sealers against *Enterococcus faecalis*: a systematic review. **Journal of Endodontics**, [S.l.], v.42, n.11, p.1588-1597, 2016.

[3] BOLDI, A. M. Libraries from natural product-like scarffolds. **Current Opinion in Chemical Biology**, [S.l.], v.8, n.3, p.281-286, 2004.

[4] BORIN, G.; BECKER, A. N.; OLIVEIRA, E. P. M. A história do hipoclorito de sódio e a sua importância como substância auxiliar no preparo químico mecânico de canais radiculares. **Rev Endod Pesq Ens on-line**, [S.l.], n.5, p.1-5, 2007.

[5] BOUZADA, M. L.; FABRI, R. L.; NOGUEIRA, M. M.; KONNO, T. U.; DUARTE, G. G.; SCIO, E. Antibacterial, cytotoxic and phytochemical screening of some traditional medicinal plants in Brazil. **Pharmaceutical biology**, [S.l.], v.47, n.1, p.44-52, 2009.

[6] BRAGA, F. G.; BOUZADA, M. L. M.; FABRI, R. L.; MATOS, M. D. O.; MOREIRA, F. O.; SCIO, E.; COIMBRA, E. S. Antileishmanial and antifungal activity of plants used in traditional medicine in Brazil. **Journal of Ethnopharmacology**, [S.l.], v.111, n.2, p.396-402, 2007.

[7] BRAGA, M. D.; SILVA, C. M. Atividade antimicrobiana do extrato aquoso de *Copaiferalangsdorffii*Desf. sobre *Staphylococcus aureus*. **Unimontes Científica**, [S.l.], v.9, n.1, p.91-98, 2015.

[8] COURVALIN, P. Transfer of antibiotic resistance genes between gram-positive and gram-negative bacteria. **Antimicrob. Agents Chemother**, [S.l.], v.38, n.7, p.1447–1451, 1994.

[9] DELBONI, M. G.; GOMES, B. P.; FRANCISCO, P. A.; TEIXEIRA, F. B.; DRAKE, D. Diversity of *Enterococcus faecalis* genotypes from multiple oral sites associated with endodontic failure using repetitive sequence-based polymerase chain reaction and arbitrarily primed polymerase chain reaction. **Journalofendodontics**, [S.l.], v.43, n.3, p.377-382, 2017.

[10] DUARTE, R. C.; TALEB-CONTINI, S. H.; PEREIRA, P. S.; OLIVEIRA, C. F.;MIRANDA, C. E. S.; BERTONI, B. W.; ... PEREIRA, A. M. S. Effect of *Costus spiralis* (Jacq.) Roscoe leaves, methanolicextract and guajaverino blood glucose and lipid levels in a type II diabetic rat model. **Chemistry&Biodiversity**, [S.l.], v.16, n.1, e1800365, 2019.

[11] DUARTE, R.; ANDRADE, L.; OLIVEIRA, T. Revisão da planta *Costusspiralis*(Jacq.) Roscoe: Pluralidade em propriedades medicinais. **Revista Fitos**,[S.l.], v.11, n.2, p.119-249, 2017.

[12] FERREIRA, A. L. S.; BATISTA, C. A. S.; PASA, M. C. Uso de plantas medicinais na comunidade quilombola Mata Cavalo em Nossa Senhora do Livramento – MT, Brasil. **Biodiversidade**, [S.l.], v.14, n.1, p.151-160, 2015.

[13] FIDALGO, O.; BONONI, V. L. Técnicas de coleta, preservação e herborização de material botânico. **São Paulo: Instituto de Botânica**, São Paulo, 1984.

[14] FIDALGO, T. K. D. S.; BARCELOS, R.; PETRÓPOLIS, D. B.; AZEVEDO, B. R.; PRIMO, L. G.; SILVA FILHO, F. C. Citotoxidade de diferentes concentrações de hipoclorito de sódio sobre osteoblastos humanos. **Revista Gaúchade Odontologia**, [S.l.], v.57, n.3, p.317-321, 2009.

[15] FRIERI, M.; KUMAR, K.; BOUTIN, A. Antibioticresistance. **Journal of Infection and Public Health**, [S.l.], v.10, n.1,

p.369-378, 2017.GARCÍA-SOLACHE, M., & RICE, L. B. The Enterococcus: a Model ofAdaptability to Its Environment. **ClinicalMicrobiology**. [S.l.], v.32. 2019.

[16] GOMES, F. A.; SANTIAGO, N. S.; SENA, F. M.; DIAS, R. A.; FERREIRA, C. M.; ROCHA, V. G. A.; PAPPEN, F. G. Capacidade da dissolução tecidual do hipoclorito de sódio em diferentes concentrações Capacity of sodium ypochloritetissuedis solution in different concentrations. **RSBO**, [S.l.], v.15, n.2, p.101-107, 2018.

[17] HAAPASALO, M., ORSTAVIK, D. In vitro infection and desinfection of dentinal tubules. **Journal of Dental Research**, [S.l.], v.66, n.8, p.1375-1479, 1987.

[18] HABSAH, M.; AMRAN, M.; MACKEEN, M. M.; LAJIS, N. H.; KIKUZAKI, H.; NAKATANI, N.;.ALI, A. M. Screening of Zingiberaceae extracts for antimicrobial and antioxidant activities. **Journal of Ethnopharmacology**, [S.l.], v.72, n.3, p.403-410, 2000.

[19] HAND, R. E.; SMITH, M. L.; HARRISON, J. W. Analysis of the effect of dilution on the necrotic tissue dissolution property of sodium hypochlorite. **JEndod**., [S.l.], v.4, n.2, p.60-64, 1978.

[20] IKE, Y. Pathogenicity of enterococci. Nihon saikingakuzasshi. **Japanese journal of bacteriology**, [S.l.], v.72, n.2, p.189–211, 2017.

[21] KAYAOGLU G.; ORSTAVIK D. Virulence factors of *Enterococcus faecalis*: relationship to endodontic disease. **Crit Rev Oral Biol Med**, [S.l.], v.15, p.308-20, 2004.

[22] LEBRETON, F.; MANSON, A. L.; SAAVEDRA, J. T.; STRAUB, T. J.; EARL, A. M.; GILMORE, M. S. Tracing the enterococci from Paleozoic origins to the hospital. **Cell**, [S.l.], v.169, n.5, p.849–61, 2017.

[23] LEE, D., IM, J., NA, H., RYU, S., YUN, C.-H., & HAN, S. H. The novel enterococcus phage vb_efas_hef13 has broad lytic activity against clinical isolates of *Enterococcus faecalis*. **Front microbiol**., [S.l.], v.10, n.2877,2019.

[24] LORENZI, H.; MATOS, F. J. A. Plantas medicinais no Brasil: Nativas e exóticas. **Nova Odessa: Instituto Plantarium**, [S.l.], 511 p. 2002.

[25] MARTINS, E. R.; CASTRO, D. M.; CASTELLIANI, D.; DIAS, **J. E. Plantas medicinais. 5° Reimpressão**,Viçosa: Editora UFV, v.220, 2003.NACIF, M. C. A. M.; ALVES, F. R. F. *Enterococcusfaecalis*na Endodontia:um desafio ao sucesso. **Rev. Bras. Odontol**., [S.l.], v.67, n.2, p.209-214, 2010.

[26] NUÑEZ, L.; TORNELLO, C.; PUENTES, N.; ESPIGARES RODRÍGUEZ, E.; MORENO ROLDÁN, E.; ESPIGARES GARCÍA, M.; MORETTON, J. Hospital effluentconstitutes a sourceofvancomycin-resistantenterococci. **Ars Pharm**, [S.l.], v.57, n.3, p.121-126, 2016.

[27] ORSTAVIK, D.; HAAPASALO, M. Disinfection by endodontic irrigants and dressing of experimentally infected dentinal tubules. **Endod. Dent. Traumatol**, [S.l.], v.6, n.4, p.142-149, 1990.

[28] PÉREZ, C.; FALERO, A.; HUNG, B. R.; LEDÓN, T.; FANDO, R. Antibacterial effect of *Costus spiralis* leaves extract on pathogenic strains of *Vibriocholerae*. **Revista CENIC CienciasBiológicas**, [S.l.], v.39, n.1, p.70-72, 2008.

[29] POCHHAMMER, J., KRAMER, A., & SCHÄFFER, M. Enterokokken und postoperative Wundinfektionen. **Der Chirurg**, [S.l.], *v.88*, p.377–384. 2017.

[30] PREETHA, S. P. In silico methods for herbal research. **Tanuvas**, [S.l.], p.133- 137, 2017.

[31] SANTA-ROSA, C. C.; ARAÚJO, C. V.; DE CARVALHO, M. F. F.; ARAÚ- JO, P. V. Estudo piloto da análise comparativa da atividade antimicrobiana da PDT e agentes irrigantes em canais radiculares inoculados com *Enterococcusfaecalis*"in vitro". **Arquivosem Odontologia**, [S.l.], v.55, 2019.

[32] SAVA, I. G.; HEIKENS, E.; HUEBNER, J. Pathogenesis and immunity in enterococcal infections. **Clinical Microbiology and Infection**, [S.l.], v.16, n.6, p.533-540, 2010.

[33] SERMEÑO R. F.; BEZERRA, A.; HERRERA, H.; HERRERA, H.; SILVA, R. A. B.; LEONARDO, M. R. Tissue damage after sodium hypochlorite extrusion during root canal treatment. **Oral Surg Oral Med Oral Pathol OralRadiolEndod**, [S.l.], v.108, n.1, p.46-49, 2009.

[34] SHARIFI, Y.; HASANI, A.; GHOTASLOU, R.; NAGHILI, B.; AGHAZADEH, M.; MILANI, M.; BAZMANY, A. Virulence and antimicrobial resistance in enterococci isolated from urinary tract infections. **Advanced PharmaceuticalBulletin**, [S.l.], v.3, n.1, p.197–201, 2013.

[35] SILVA, B. P.; PARENTE, J. P. New steroidal saponins from rhizomes of *Costusspiralis*. ZeitschriftfurNaturforschung, **Section C: Journal of Biosciences**, [S.l.], v.59, n.1-2, p.81-85, 2004.

[36] SIQUEIRA JUNIOR, J. F.; RÔÇAS, I. N. Polymerase chain reaction-based analysis of microorganisms associated with failed endodontic treatment. **OralSurg. Oral Med. Oral Pathol. Oral Radiol. Endod**, [S.l.], v.97, n.1, p.85-94, 2004.

[37] TARTARI, T.; BACHMANN, L.; MALIZA, A. G. A.; ANDRADE, F. B.; DUARTE, M. A. H.; BRAMANTE, C. M. Tissue dissolution and modifications in dentin composition by different sodium hypochlorite concentrations. **J Appl.Oral Sci**., [S.l.], v.24, n.3, p.291-298, 2016.

[38] ULIANA, M. P.; DA SILVA, A. G.; FRONZA, M.; SCHERER, R. In vitro antioxidant and antimicrobial activities of *Costusspicatus*swartz used in folk medicine for urinary tract infection in Brazil. **Lat Am J Pharm**, [S.l.], v.34, p.766-72, 2015.

[39] VIEL, T. A.; DOMINGOS, D. C.; SILVA, A. P. M.; LIMA-LANDMAN, M. T. R.; LAPA, A. J.; SOUCCAR, C. Evaluation of the antiurolithiatic activity of the extract of *Costus spiralis* (Jacq.) Roscoe in rats. **Journal of Ethnopharmacology**, [S.l.], v.66, n.2, p.193-198, 1999.

[40] WILLEMS, R. J. L.; BONTEN, M. J. M. Glycopeptide-resistant enterococci: deciphering virulence, resistance and epidemicity. **Curr. Opin. Infect. Dis**.,[S.l.],v.20, n.4, p.384-390, 2007.

# Matrix of Strategic Entrepreneurship Process in Small and Medium Enterprises of the Brazilian and Canadian Aeronautical Industry

Marcela Barbosa de Moraes, Eveline Galvan, Erivaldo Alves Ribeiro, Eudes da Silva Vieira, Zilma Cardoso Barros Soares, Leonardo Santos da Cruz

Department of Management and Regional Development, University of Taubaté (UNITAU), Taubaté, Brazil

*Abstract*— *The central proposal of this paper is to study the process of strategic entrepreneurship in small and medium enterprises in the Brazilian and Canadian aeronautical industry. The research was based on the qualitative approach with multiple case studies, following the recommendations of Eisenhardt (1989). The study addressed the reality of four small and medium technology-based companies in the aeronautical industry, being two Brazilian and two Canadian. Data were collected with in-depth semi-structured interviews, lasting approximately 2h and 40min, with owner-managers and analyzed with Atlas-ti software. The analysis took place in depth in each case and then in a comparative way between the cases in search of similarities and differences that led to the formation of valid results for the whole sample studied. Finally and based on the analysis of the results, it was concluded that the companies analyzed, through the process of strategic entrepreneurship, obtained a competitive advantage, since they incorporated to the entrepreneurial activity, strategic partnerships and the development of innovation as activities to be developed in a continuous, identifying the innovative elements of production chains in which companies viewed greater potential for profit and ultimately worked together with customers to develop and improve processes and products. This allowed the Brazilian and Canadian SMEs to identify and explore new opportunities in the face of the greater circulation of tacit and explicit knowledge in the productive chain and the execution of R&D together.*

*Keywords*— *Strategic Entrepreneurship, Small and Medium Enterprises, Aeronautical Industry, Brazil, Canada.*

## I. INTRODUCTION

Historically, small and medium-sized enterprises (SMEs) have a substantial importance in the evolution of societies, contributing to the economic, social and political factors of nations, both from the point of view of employment generation and income, as well as their potential for generation of innovation (Acs; Tarpley, 1998; Amato Neto, 2000). His importance also extends to SMEs in the aeronautical industry, since they contribute to import substitution with the technological products that they produce internally in the country; contribute to increasing the number of exports; help in the transfer of technology from research and development centers (R&D); value the country's scientific and technological system; and help in the formation of centers of technological competence (Montoro; Migon, 2009).

Another relevant aspect is that SMEs, both the high technology companies in general and those of the aeronautical industry, are inserted in the new economic scenario based on the techno-economic paradigm of the knowledge age, in which the business environment is becoming more competitive every day. Small and medium organizations are continually facing changes in the economic landscape. In addition, how to deal with ambiguities and how to achieve competitiveness and the level of performance expected are real challenges for any organization.

In this environment, where many factors and variables intertwine in an increasingly complex way, identify new opportunities and create a competitive advantage that leads organizations to success, especially small and medium technology-based companies, to success are activities increasingly difficult to be developed by the owner-

managers who are ahead of these companies. Given this context, this work was developed with the intention of contributing to the expansion of knowledge about the identification and exploration of new opportunities and the creation and maintenance of competitive advantages in the aeronautical industry SMEs, exploring a new field of knowledge called strategic entrepreneurship.

The scientific papers on strategic entrepreneurship began in the early 21st century, when Ireland, Hitt, Camp and Sexton in 2001 highlighted the importance of the integration between strategic management and entrepreneurship to create wealth for organizations (Hitt et al., 2011). Ireland, Hitt and Sirmon (2003), complementing the initial idea, have created a model of strategic entrepreneurship with four fundamental dimensions: (1) mentality, culture and entrepreneurial leadership; (2) the strategic management of organizational resources; (3) the application of creativity; and, (4) the development of innovation. Based on additional research and critical analysis, Kyrgidou and Hughes (2010) developed an alternative model, adopting the initial structure of Ireland, Hitt and Sirmon (2003), but adding bi-directionality to evidence the interactivity between dimensions, contributing, thereby, for the refinement of decision-making.

Already Hitt et al. (2011) elaborated a model richer than the previous ones. The authors extended the models created by Ireland, Hitt and Sirmon (2003) and Kyrgidou and Hughes (2010), incorporating a larger and multilevel domain, with the aim of improving the understanding of this new field of study. The model encompasses three types of focus (environmental, organizational, and individual) and three dimensions (input of resources and factors, resource orchestration processes and benefits outgoings) that contribute to the process of seeking opportunities and competitive advantage.

A major difficulty with which studies in strategic entrepreneurship are confronted is the fact that the studies show little compatibility with the need for flexibility and dynamism of SMEs. In this context, it is necessary to seek new ways of thinking about the strategic management and entrepreneurship of SMEs (Lima, 2010), especially in the aeronautics industry. In this context, and according to the literature review made as basis for the present study, there is no study in the national or international literature that relates the dimensions of strategic entrepreneurship to the particularities of SMEs, not even those of the aeronautical sector. It is precisely this gap that this work aims to explore, generating contributions that help to heal it. Thereby, the research question that guided the work was: How does the process of strategic entrepreneurship in small and medium enterprises of the Brazilian and Canadian aeronautical industry occur?

## II. CONCEPTUAL BASES OF STRATEGIC ENTREPRENEURSHIP

Work on strategic entrepreneurship began in the early 21st century, when Ireland, Hitt, Camp and Sexton in 2001 highlighted the importance of the integration between strategic management and entrepreneurship for wealth creation for organizations (Hitt et al., 2011). Strategic actions are those adopted to select and implement company strategies (Ireland et al., 2001). They are activities that organizations develop, exploit, and take advantage of current advantages while supporting entrepreneurial actions to explore opportunities that will help create competitive advantages for the company in the future (Hitt et al., 2002). Already entrepreneurial are actions through which companies identify and then seek to exploit business opportunities that have not been fully exploited by their competitors (Hitt et al., 2002).

For Ireland et al. (2001), strategic and entrepreneurial actions are often adopted with the purpose of finding a new market or a new competitive space for the organization to create wealth, but to generate wealth, it is necessary first to create value (Hitt et al., 2011). Companies seek to find new ways of doing business that may interrupt existing rules in each sector, leading to the development of new business models that will create new competitive advantages. It is important to emphasize that the level in which the organization acts in an entrepreneurial way in terms of innovation, risk acceptance and proactivity will be related to the dimensions of strategic management (Ireland et al., 2001).

Ireland et al. (2001) point out those common variables between entrepreneurial and strategic actions, which occur naturally, will help companies to create wealth. These variables are: innovation, networks, internationalization, organizational learning, management teams and governance and growth. In this perspective, the first definition of strategic entrepreneurship is the integration between entrepreneurial action (search for opportunity) and strategic action (search for competitive advantage) for the development and adoption of measures to create wealth (Ireland et al., 2001).

Although useful, the research efforts carried out by Ireland et al. (2001) to explain strategic entrepreneurship through the integration of strategic and entrepreneurial actions, as a single construction, did not adequately describe its various dimensions. To complement the idea of these authors, Ireland, Hitt and Sirmon (2003) developed a

linear and sequential model which is composed of four dimensions: (1) mentality, culture and entrepreneurial leadership; (2) strategic management of organizational resources; (3) application of creativity; and (4) development of innovation. These dimensions integrate several theoretical bases, including resource-based view (RBV), human capital, social capital, organizational learning, and creative cognition.

Ireland, Hitt and Sirmon (2003) argue that the integration between dimensions and the combination of the search for opportunity and competitive advantage will lead to the creation of wealth. For these authors, the entrepreneurial mindset, culture, and leadership are fundamental aspects for strategic entrepreneurship and are intrinsically linked, because they promote and support the continuous search for entrepreneurial opportunities that can be exploited with sustainable competitive advantages.

The second dimension of the model, strategic management of organizational resources, is an essential process for strategic entrepreneurship. Ireland, Hitt and Sirmon (2003) report that resources are the basis of organizations' differentiated performance in value-creating suits. Barney and Arikan (2001) show that the use of idiosyncratic resources by enterprises has a strong influence on performance, rather than the characteristics of the sector. Another important aspect of the model presented by Ireland, Hitt and Sirmon (2003) is the application of creativity that is a vector of wealth creation that grows from the attributes of individuals, going towards the demands of a given market. For Barney and Arikan (2001) and Ireland, Hitt and Sirmon (2003), creativity is increasingly important, especially for organizations operating in markets with multiple opportunities to differentiate their goods and services.

The last dimension, development of innovation, is an essential tool for increasing productivity and competitiveness of the organization, as well as for boosting the economic development of regions and countries. For Tigre (2006), development does not derive from a mere growth in existing economic activities, but it resides fundamentally in a qualitative process of transformation of the productive structure, in the sense of incorporating new products and processes and adding value to production by intensifying the use information and knowledge.

After describing the dimensions of the strategic entrepreneurship model developed by Ireland, Hitt and Sirmon (2003), it is important to highlight that the actions associated with these dimensions are complex and challenging. It is difficult for new enterprises, for example, to obtain and manage resources strategically, mainly to

establish and sustain a competitive advantage. The authors above explain that these firms are more likely to be flexible and entrepreneurial and less likely to have the resources and capacity to build a competitive advantage. Likewise, for companies that are already consolidated in the market, and that already have a competitive advantage, it is difficult to continue to seek and exploit entrepreneurial opportunities.

Based on additional research and critical analysis, Kyrgidou and Hughes (2010) suggest that Ireland, Hitt and Sirmon (2003) model did not have the robustness needed to capture the gestalt of strategic entrepreneurship. For the authors, the previous model contains several limitations and absences that compromise the understanding of how strategic entrepreneurship can be performed to succeed in practice. For example, although strategic entrepreneurship is defined as the pursuit of opportunity and competitive advantage (Ireland; Hitt; Sirmon, 2003), the model is linear and sequential between the concepts of entrepreneurial and strategic activities and lacks a cycle feedback between the two concepts.

In addition, the model is linked to behavior variables, such as the entrepreneurial mindset to identify opportunity; or application of creativity to create innovation, but does not take into account the conditions of the organization's internal environment, which provides a conceptual framework in which these variables are embedded (Kyrgidou; Hughes, 2010). The last critique that Kyrgidou and Hughes (2010) make to the model of Ireland, Hitt and Sirmon (2003) is that the authors do not take into account the dynamic capacities, since in environments of rapid changes the resources that sustain the entrepreneurial and strategic actions deteriorate over time. For Kyrgidou and Hughes (2010), dynamic capabilities favor strategic and entrepreneurial processes and balance the pursuit of opportunity and competitive advantage, leading to wealth creation.

To correct these limitations and absences, Kyrgidou and Hughes (2010) developed an alternative model of strategic entrepreneurship. Although critical, the alternative model developed by Kyrgidou and Hughes (2010) adopts, in its initial structure, the model developed by Ireland, Hitt and Sirmon (2003), but adding bidirectionality to evidence the interactivity between stages, which contributes to the refinement of decision making.

The alternative model of Kyrgidou and Hughes (2010) is almost linear, focusing on the internal organizational environment and top management vision. For the authors, the search for a new opportunity begins with the analysis of the mindset, culture and leadership entrepreneurial of

the company, which then manages the strategic resources and, finally, applies the creativity so that it can develop an innovation. These three steps are intrinsically linked as they promote and support the continuous pursuit of entrepreneurial opportunity, contributing to the development of competitive advantage.

Kyrgidou and Hughes (2010) also considered the feed forward and feedback mechanism to help organizations improve the use of strategic entrepreneurship and thereby create wealth over time. The interaction between the four dimensions occurs when a company and its managers or employees detect a problem, such as the execution of a certain activity that then triggers a review and learning process.

Hitt et al. (2011), supporting the statement of Kyrgidou and Hughes (2010), argue that strategic entrepreneurship is broader and more dynamic than originally conceived. To contribute to the continued development of this young field of research, Hitt et al. (2011) developed a richer model, extended the models created by Ireland, Hitt and Sirmon (2003) and Kyrgidou and Hughes (2010), and incorporating a broader and multilevel domain with the objective of improving the understanding of strategic entrepreneurship.

This new model, encompasses three types of focus: (a) environmental; (b) organizational; and (c) individual and three dimensions: (i) input of resources and factors, (ii) resource orchestration processes, and (iii) outputs of benefits that contribute to the process of pursuit of opportunity and competitive advantage.

The first dimension of the advanced model of strategic entrepreneurship presented by Hitt et al. (2011) emphasizes that munificent and dynamic environments, relationships between companies, individual knowledge, individual and organizational competencies, together with the motivation and passion of entrepreneurs, are important sources of long-term success for an organization to explore opportunities and achieve competitive advantage.

The second dimension of the advanced model of Hitt et al. (2011) is the resource orchestration process. This stage is characterized by gaining competitive advantage in the decision making of the leaders of the organizations and by the control of the valuable and rare resources. For the authors, resource orchestration is concerned with the actions taken by entrepreneurs to facilitate efforts to effectively manage the company's resources. Sirmon, Hitt and Ireland (2007) and Helfat et al. (2007) point out three important actions for an organization to gain competitive advantage, (1) structure the company's resource portfolio; (2) aggregate resources into the organization's capabilities;

and (3) leverage capabilities to create value for customers and wealth for entrepreneurs.

The third dimension of the advanced model of Hitt et al. (2011) indicates that entrepreneurial activity generates wealth creation for entrepreneurs and creates value for clients and can also contribute to the construction of new economic, social, institutional and cultural contexts, providing significant benefits for the entrepreneur, the organization and society.

As described, the advanced strategic entrepreneurship model developed by Hitt et al. (2011) is based on the concept of multilevel where resources can exist and / or be created in the spheres of the individual, organization, and society. The results of entrepreneurial activities, which are creating wealth for entrepreneurs and creating value for clients, can generate benefits for individuals (entrepreneurs, managers, employees, clients, etc.), organizations and society. The authors conclude that there are few studies that cross these levels. They point out that more research is needed to understand the influence of the interaction of individual and organizational attributes on entrepreneurial activities and their outcomes.

The analysis of the three models presented by Ireland, Hitt and Sirmon (2003), Kyrgidou and Hughes (2010) and Hitt et al. (2011) highlight the importance of innovation in the global economy, from entrepreneurial activity to economic growth and the critical value of strategic management to the survival and success of organizations and increase the importance of strategic entrepreneurship.

In short, strategic entrepreneurship allows organizations to apply their knowledge and skills in the current context and explore the opportunities to take advantage of them in the future by applying new knowledge and new and / or advanced skills. To be more specific, strategic entrepreneurship requires companies to strike a balance between the pursuit of opportunity (entrepreneurship) and the pursuit of advantage (strategic management).

Hitt et al. (2011) and Kraus, Kauranen and Reschke (2011) emphasize that, to some extent, entrepreneurship in strategic entrepreneurship requires flexibility and novelty, while strategic management seeks stability and predictability. Achieving this balance is a major challenge because companies have limited resources and are often in highly constrained economic environments. The brief review of the literature presented provides a small base of support and suggests a robust set of opportunities to enrich future research on the effective use of strategic entrepreneurship and its benefits.

## III. METHODOLOGICAL PROCEDURES

To prepare a robust study, it was used the methodology of multiple case studies according to Eisenhardt's (1989) recommendations. The study addressed the reality of four aeronautical SMEs, two Brazilian and two Canadian, and described how these companies identify and exploit new opportunities and create and sustain competitive advantages. For Eisenhardt (1989), the choice of cases is a very important aspect because it defines the characteristics of the research design. In addition, the appropriate choice of the sample to be studied makes it possible to control the external variations and define the limits of consideration of the results for other contexts.

The sample of SMEs who participated in the study is presented in Table 1. The cases were chosen intentionally, based on the contributions they could provide to the study, in other words, the study sample was characterized as theoretical and intentional.

*Table 1. Composition of the Sample of SMEs that Participated in the Study*

| SMEs of Aeronautical Industry (Foundation, Location) | Activities/Products | Interviews and Duration of Interviews |
|---|---|---|
| **Empreendimentos Aeronáuticos (fictitious name)** <br><br> **1998 – São José dos Campos – SP - Brazil (inside the Univap Technological Park)** | Medium company, with 128 employees, specializing in the development of landing gear solutions. The company also designs and manufactures civil and military aircraft. | Interviewed: president of the company and the technical director and co-founder. <br><br> Duration: 2h 42 min. |
| **Aero Brasil (fictitious name)** <br><br> **2005 – São José dos Campos- SP - Brazil (company graduated in Incubaero)** | Small company, with 31 employees, specializing in the development of command, control and intelligence solutions based on Unmanned Aerial Vehicles (UAV). In addition, it develops a family of multi-function displays for | Interviewed: 2 owner-managers. <br><br> Duration: 1st interview lasting 1h15 min and 2nd interview lasting 2h. |
| | air navigation in special applications. | |
| **Altitude Aerospace** <br><br> **2005 – Montreal – Canada** | Small company with 70 employees; specializing in the design, structural analysis and certification for both the development of new aircraft and the maintenance of fleets. | Interviewed: Nancy Venneman, president and founder of the company. <br><br> Duration: 1h 36 min |
| **Mechtronix** <br><br> **1987 – Saint-Laurent – Canada** | Medium company, with 200 employees, with multidisciplinary specialization in design and engineering. | Interviewed: Fernando Petruzziello (president and co-founder) and Thomas Allen (vice president of engineering and co-founder). <br><br> Duration: 3h 15min |

To answer the research question and to elaborate a study of multiple cases, it was adopted as data collection procedure the semi-structured interview, individual and in depth and documentary analysis. In this research, the semi-structured interview has open questions, elaborated from a script that gave the interviewer the flexibility to order and formulate the questions during the interview, which becomes richer given the possibility of deepening the questions from the answers obtained.

The procedure of data analysis occurred in two stages: within-case and across-case. Within-case analysis is the one that describes, understands, and explains what happens in a single, limited context, that is, in a single case (Miles; Huberman, 1994). For Lima (2010), this form of analysis aims to highlight the conceptual contents that are most important to describe and explain a phenomenon, taking each case of the sample separately. On the other hand, the purpose of the across-case analysis is to describe, understand, explain and cross-reference the conceptual contents, processes and results of a given phenomenon in a

multiple-case context, thereby, developing more detailed descriptions of all cases of sample (Miles; Huberman, 1994). Data from the interviews were analyzed and studied using the Atlas-ti software.

## IV. RESULTS

### 5.1 Matrix of the Strategic Entrepreneurship Process in Empreendimentos Aeronáuticos Company

The matrix of strategic entrepreneurship has two dimensions: the search of opportunity in the Y axis and the search of competitive advantage in the X axis. To create long-term wealth, Empreendimentos Aeronáuticos needed to make the best combination of these two dimensions, as explained in Figure 1.
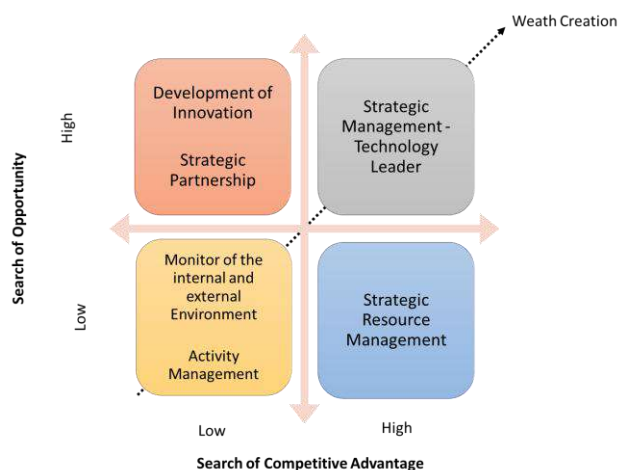


*Fig.1: Matrix of the Strategic Entrepreneurship Process in Empreendimentos Aeronáuticos Company.*

When there is a low search for opportunity and a low search for competitive advantage, the company works to monitor the environment, both internal and external, and for the management of its activities. It is worth mentioning that monitoring the environment helps identify future opportunities and create competitive advantage. In this case, flexibility and efficiency are the values on which their strategic and entrepreneurial actions are based.

Based on the respondents' reports, flexibility is related to the ability of the company to deal with the uncertainties of a changing environment. The efficiency is linked to the reduction of costs, agility in the processes and increase of the productivity of the factors of production. Given the high dependence of the strategic action for being subcontracted to a large company that develops regional aircraft projects, Empreendimentos Aeronáuticos must have high capacity for internal coordination and adaptability to new environments. Its internal

organizational structure therefore allows direct communication between employees and the board, there is little standardization of procedures and owner-managers participate in all activities of the organization.

When there is a high search for opportunity and a low pursuit of competitive advantage, the company focuses on the development of innovation and strategic partnerships. This is the time to explore new opportunities. In this situation, strategic and entrepreneurial actions reveal the owner-managers' concern with the development of an environment of creation and experimentation, which stimulates freedom of initiative for their employees; the amount of investment in R&D and its orientation to solve problems and create novelties; as well as the way it takes advantage of meetings such as fairs and exhibitions, to seek technological innovations or to do business. Within this process, strategic partnerships aim to distribute the risks inherent in the development of innovation and increase the exchange of knowledge between the parties.

When there is a low search for opportunity and a high search for competitive advantage, the company considers more important the management of strategic resources such as financial, human and technological capital. It is evident the creation of competitive advantage by the Empreendimentos Aeronáuticos Company. The management of the strategic resources of this company is related to the agility of the processes, to the establishment of financial goals, to productive restructuring, to the creation and management of knowledge, to the development and valorization of personnel, to creativity and to quality certifications.

When there is high search for opportunity and high search for competitive advantage, the company elaborates strategic management focused on technological leadership, sustaining its competitive advantage. Leading technology companies establish and maintain a competitive position with the development and exploitation of technologies within a given market, which gives them a dominant position in this market (Narayanan, 2001). As already mentioned, technology is the primary instrument for the creation and maintenance of the competitive advantages of the company that seeks the competitive in the technological appropriability.

In short, Empreendimentos Aeronáuticos Company identifies a new opportunity in monitoring the environment, both internal and external, and explores this opportunity by developing innovation and strategic partnerships. At the same time, it creates a competitive advantage with the management of strategic resources and

sustains this advantage by developing strategic management as a technology leader.

## 5.2 Matrix of the Strategic Entrepreneurship Process in Aero Brasil Company

A matrix was elaborated to clarify the search for opportunity and competitive advantage of Aero Brasil Company, as shown in Figure 2.



*Fig.2: Matrix of the Strategic Entrepreneurship Process in Aero Brasil Company.*

The matrix analysis indicates that when there is a low search for opportunity and low search for competitive advantage, the company identifies new opportunities with participation in research groups of the Aeronautical Technological Institute (ITA). The interviewees' reports indicate that when they participate in the ITA Aeronautical Techniques Studies Center, the company is at the frontier of technological knowledge, because the research groups that are part of this nucleus of studies are considered efficient instruments for the exchange of information.

When there is a high search for opportunity and a low search of competitive advantage, the company explores the new opportunities with the development of innovation and strategic partnerships. Based on the data collected, the company encourages employee creativity by stimulating the sense of prosperity that feeds innovative behavior. It also stimulates spontaneous behavior and the continuity of the study of ideas. In relation to strategic partnerships, the company encourages the free exchange of information and honest feedback from all those involved in this partnership.

At the time there is a low search for opportunity and a high search for competitive advantage, Aero Brasil creates a competitive advantage with strategic actions and strategic knowledge. The interviewees explain that before undertaking any strategic action, it undergoes a process of

strategic reflection: it makes a diagnosis of the situation that needs to be changed, then evaluates the alternatives and, finally, makes the strategic choice.

Action, reflection and strategic choice are linked to the strategic knowledge of owner-managers, and encompass knowledge related to planning, description, impact, prediction, evaluation and generation of previous strategies. The reports show that any strategic action must be related to the vision and strategic objectives of the company.

Aero Brasil's strategic vision is to be a Latin American leader with global projection in Intelligence, Surveillance, Monitoring, Navigation, Command and Control solutions. The objectives are: (i) to promote technological innovation linked to business as a way to develop a sustainable and growing company; (ii) be an excellent choice for human and professional development; (iii) be considered by customers and partners the best option in solutions in Intelligence, surveillance, monitoring, navigation, command and control; (iv) be considered by shareholders and investors as the best return in the segment; and, (v) be a strategic company for the country.

When there is high search for opportunity and high search for competitive advantage, the company elaborates a strategic management with a prospective position, thus sustaining its competitive advantage. For Nakano (1997), prospectors continuously seek new products and markets. They are constantly changing, often passing on an idea of inefficiency, although they remain always as a powerful force in the market. This strategic position is evident, since Aero Brasil is seeking new markets, such as in the biotechnology sector.

When the search for opportunity and the search for competitive advantage reaches the highest point of the matrix, it can be said that the company object of study reached the creation of wealth. Based on the interviewees' reports, Aero Brasil presents an increase in financial revenues and, consecutively, an increase in profits, growth of internal knowledge and development of individual and organizational learning.

## 5.3 Matrix of the Strategic Entrepreneurship Process in Altitude Aerospace Company

Just as in previous cases, it is important to explain how Altitude Aerospace Company identifies and exploits a new opportunity and creates and sustains a competitive advantage. For this purpose, a matrix was elaborated to clarify the search opportunity and competitive advantage, as shown in Figure 3.
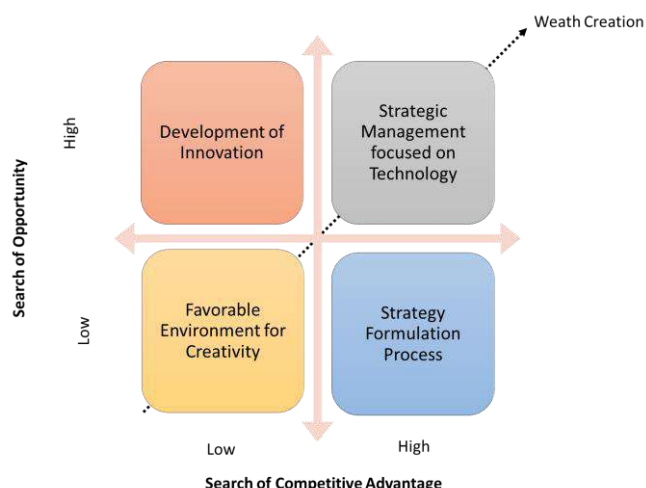
*Fig.3: Matrix of the Strategic Entrepreneurship Process in Altitude Aerospace Company.*

By analyzing the matrix points out that when there is low search of opportunity and low search of competitive advantage the company identifies a new opportunity, promoting a favorable environment for creativity. It is worth emphasizing that creativity is a key factor for innovation and adds value to knowledge to make it progressively more useful. The reports indicate that creativity flourishes when the individual performs activities mobilized by pleasure and satisfaction, not by obligation and duty. The company analyzed stimulates initiative, independence of thought and action, flexibility, persistence, and self-confidence.

The moment there is a high search of opportunity and a low search of competitive advantage, the company explores new opportunities to the development of innovation. Based on the data collected, Altitude Aerospace reveals the concern with the development of an environment of creation and experimentation, which stimulates the freedom of initiative of its employees; the amount of investment in R&D and its orientation to solve problems and create novelties.

When there is low search of opportunity and high search for competitive advantage, Altitude Aerospace creates competitive advantage by developing a strategy formulation process. As already mentioned, the formulation of the strategy is understood as a process of development of the strategic reflection, which results from a strategic plan that involves the analysis of the internal and external environment, the evaluation of the alternatives and the strategic choices. For the interviewee, with a well-structured strategy formulation process, the company gains competitiveness compared to its competitors who are also small and medium-sized. She points out that many of her

competitors have not devised a formalized strategy such as Altitude Aerospace.

At the moment there are high search of opportunity and of competitive advantage, the company draws up an offensive strategic management focused on the technology, supporting thus their competitive advantage. The company's success is therefore in incorporating technology management into strategic management. For Freeman and Soete (1997), technology-oriented offensive strategic management is characterized by the attainment of technological and market leadership by the introduction of new products and services. It is usually intensive in R&D and includes involvement in fundamental research.

When the search for opportunity and for competitive advantage reaches the highest point of the matrix, it can be said that the analyzed company has reached the creation of wealth. Based on the reports, Altitude Aerospace shows an increase in its financial assets (revenue and profit), as well as value gains in its tangible and intangible assets. This value gain is due to the voluntary, creative, and proactive organizational attitude, with collective engagement in all stages of the strategic entrepreneurship process.

## 5.4 Matrix of the Strategic Entrepreneurship Process in Mechtronix Company

In this section, the matrix of the strategic entrepreneurship process of the Mechtronix Company was analyzed to clarify the search for opportunity and competitive advantage, as shown in Figure 4.

The analysis of Figure 4 shows that when there is a low search for opportunity and for competitive advantage, the company identifies a new opportunity to monitor the internal and external environment and the management of information. For the interviewees, the internal environment monitoring corresponds to the analysis of the current situation of the company. The internal factors that cause change in organizational and strategic management are: infrastructure, finances, vision of the future and internal competence.
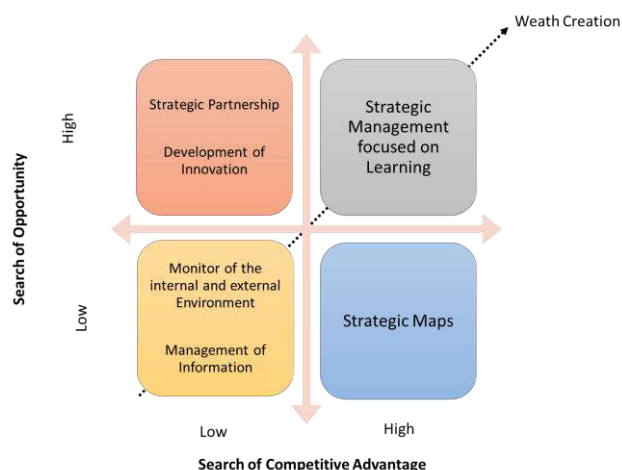
*Fig.4: Matrix of the Strategic Entrepreneurship Process in Mechtronix Company.*

The monitoring of the external environment corresponds to the analysis of macro and micro environment. It is understood macro environment in which the external factors impact Mechtronix are horizontal in nature, not specific to the company's performance, although they are capable of provoking changes in its strategic management. Based on the data collected, the external factors for the company are: political, social, regulatory (International Civil Aviation Organization) and government investments. Regarding the microenvironment, the key focuses are those external factors that are more specific to the field of activity of the company. These factors are: production chain, customers, partnerships and technologies.

Information management, in turn, corresponds to the process of collecting, organizing, processing, and disseminating information. For the interviewees, the information is a good of high added value and needs to be managed in the same way as the human and technological resources of the company and must be equally administered.

At the moment there is a high search for opportunity and a low search of competitive advantage, the company explores the new opportunities with strategic partnerships and the development of innovation. Based on the reports, the strategic partnerships represent the articulating and collaborative capacity of Mechtronix, offering strategic visions and contributing to the creation of wealth. The analysis of the development of innovation indicates that Mechtronix considers innovation as one of the foundations to guarantee a lasting future. An innovative environment for respondents has the ability to articulate and mobilize human, financial and material resources to capture

opportunities and neutralize threats. Based on the data collected, the company has an innovative business philosophy, favoring a work environment that stimulates trust among employees, a business culture tied to a philosophy of tolerance to errors and that the ideas generated are evaluated and implemented.

When there is low search of opportunity and high search of competitive advantage, Mechtronix creates competitive advantage by developing strategic maps. The respondents' reports indicate that these maps assist the owner-managers at the time of the strategic decision. For this, this visual representation of the strategy is formed by five stages that are: (i) formulation of the strategic intention; (ii) definition of the critical factors of organizational performance; (iii) formulation of strategic objectives; (iv) definition of cause and effect relationships between goals; and, (v) definition of strategic indicators.

At the moment of high search for opportunity and high search for competitive advantage, the company elaborates a strategic management focused on learning, sustaining its competitive advantage, so the success of the company is in incorporating learning in strategic management. Mintzberg, Ahlstrand and Lampel (2000), in the book Safari of Strategy, propose ten schools of thought regarding the formulation of the strategy, and one of them is that of learning. For this school, the world is too complex for strategies to be developed at once with clear plans or visions. The strategy should emerge in short steps as the organization adapts or learns. The authors complement that strategies emerge when people, individually or collectively, learn about a situation.

When the search for opportunity and the search for competitive advantage reach the highest point of the matrix, it can be said that the analyzed company reached the creation of wealth, the benefits generated for the company, financial results, and for society, creation of new innovations and generation of qualified jobs.

## V. CONCLUSION

The recognition of the contribution of SMEs to economic development has attracted the interest of studies and research in applied social sciences. However, the complexity generated by the various types of SMEs requires different approaches to understand the numerous sectors and ranges that make up the universe of these companies. About the most dynamic sectors, such as the aeronautics sector, composed of knowledge and technology-intensive SMEs, studies are still recent and require research that seeks to collaborate in understanding strategic management and entrepreneurship.

In this way, this paper was developed with the intention of contributing to the expansion of knowledge about the identification and exploration of new opportunities and the creation and maintenance of competitive advantages in the SMEs of the aeronautical industry, exploring a new field of knowledge called strategic entrepreneurship. Therefore, this study aimed to study how the process of strategic entrepreneurship in SMEs in the Brazilian and Canadian aeronautical sector occurs. With this research, it was verified that the search and use of the opportunities include the identification and exploration of new opportunities through the monitoring of the internal and external environment, participation in research groups, strategic partnership, and innovation development. To emphasize the interactivity between these three elements, bi-directional and feed forward and feedback mechanisms were adopted, which helped Brazilian and Canadian SMEs to refine the use of strategic entrepreneurship and improve the effectiveness of each step over time. It is noteworthy that feedback and feed forward mechanisms are composed of three key factors: (a) exploration and exploitation of skills, (b) entrepreneurial culture (c) collaborative production.

Another aspect identified was that the elements of the search and exploitation of opportunity promote strategic information, the system of strategic information, strategy formulation and strategic management, which is the basis of the search and exploitation of competitive advantage. Consequently, they support the ability of the companies studied to create wealth over time. Strategic management encompasses the actions and choices taken by owner-managers to explore the competitive advantages of their company.

In summary, it was concluded that the companies that participated in the research, through the process of strategic entrepreneurship, obtained a competitive advantage, since they incorporated to the entrepreneurial activity, strategic partnerships and the development of innovation as activities to be developed in a continuous character, identifying the innovative elements of the productive chains where the companies saw a greater potential of gain and, finally, worked together with the clients in the development and improvement of processes and products. This allowed the Brazilian and Canadian SMEs to identify and to explore new opportunities in relation to the greater circulation of tacit and explicit knowledge existing in the productive chain and the execution of R&D as a whole.

It can be said that the study of strategic entrepreneurship in SMEs in the aeronautics industry was quite enriching because it produced results that could be useful both for future research on the subject and for the development of new solutions for the growth of Brazilian and Canadian SMEs. Despite being a pioneer initiative, the study of the strategic entrepreneurship process in SMEs in the aeronautical industry and although the objective proposed in this paper has been achieved, the research carried out has limitations.

The limiting factor that deserves attention is the accessibility of company information was restricted, since some owner-managers were not comfortable in divulging data considered as confidential, mainly concerning the issues of strategy, innovation and financial. Another limitation that deserves to be highlighted is the limited number of selected cases, with information that largely reflects the point of view of the owner-managers, and contemplating companies from a single sector of the economy, the aeronautical industry.

To contribute to the development of the concepts of strategic entrepreneurship in small and medium enterprises, the study left inquiries for future research. That way, some recommendations are presented: (1) the topic of strategic entrepreneurship in SMEs is still a new field in research. The complexity of the topic implies great potential for research. It is interesting to develop an analytical framework that becomes an instrument capable of assisting SME owner-managers in the search for and use of opportunities and competitive advantage; (2) The inclusion of companies from other sectors of the economy could be contemplated in new studies, to verify the possible validity of the models presented by Ireland, Hitt and Sirmon (2003), Kyrgidou and Hughes (2010) and Hitt et al. (2011); (3) the expansion of the number of companies in the sample can bring important information and, therefore, contribute to a better understanding the process of strategic entrepreneurship in SMEs; and (4) another study of relevance is to better understand the facilitators and difficulties for the integration of entrepreneurship and strategic management in both technology-based and traditional SMEs.

## REFERENCES

[1] Acs, Z., & Tarpley, F. (1998). *New American Evolution*: The Role and Impact of Small Firms. NASA.

[2] Agarwal, R., Audretsch, D., & Sarkar, M. B. (2007). The process of creative construction: knowledge spillovers, entrepreneurship, and economic growth. *Strategic Entrepreneurship Journal*, 1(3-4), 263-286.

[3] AMATO NETO, J. (2000). *Redes de cooperação e clusters competitivos*. São Paulo: Atlas.

[4] Barney, J. B., & Arikan, A. M. (2001). *The resource-based view*: Origins and implications. The Blackwell handbook of strategic management, 124-188.

[5] Baron, R. A., & Henry, R. A. (2010). How entrepreneurs acquire the capacity to excel: Insights from research on expert performance. *Strategic Entrepreneurship Journal*, 4(1), 49-65.

[6] Kathleen, E. (1989). Building theories from case study research. *Academy of Management Review*, 14(4), 532-550.

[7] Helfat, C. E., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D., & Winter, S. G. (2009). *Dynamic capabilities*: Understanding strategic change in organizations. John Wiley & Sons.

[8] Hitt, M. A., Ireland, R. D., Camp, S. M., & Sexton, D. (Eds.). (2002). *Strategic entrepreneurship:* Creating a new mindset. Wiley-Blackwell.

[9] Hitt, M. A., Ireland, R. D., Sirmon, D. G., & Trahms, C. A. (2011). Strategic entrepreneurship: creating value for individuals, organizations, and society. *Academy of management perspectives*, 25(2), 57-75.

[10] Ireland, R. D., Hitt, M. A., Camp, S. M., & Sexton, D. L. (2001). Integrating entrepreneurship and strategic management actions to create firm wealth. *Academy of Management Perspectives*, 15(1), 49-63.

[11] Ireland, R. D., Hitt, M. A., & Sirmon, D. G. (2003). A model of strategic entrepreneurship: The construct and its dimensions. *Journal of management*, 29(6), 963-989.

[12] Kraus, S., Kauranen, I., & Reschke, C. H. (2011). Identification of domains for a new conceptual model of strategic entrepreneurship using the configuration approach. *Management research review*, 34(1), 58-74.

[13] Kyrgidou, L. P., & Hughes, M. (2010). Strategic entrepreneurship: origins, core elements and research directions. *European business review*, 22(1), 43-63.

[14] Lima, E. D. O. (2010). A Gestão estratégica de pequenas e médias empresas segundo a abordagem da aprendizagem sistêmica. *Gestão & Planejamento-G&P*, 9(2).

[15] Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*: An expanded sourcebook. Sage

[16] Montoro, G. C. F., & Migon, M. N. (2009). *Cadeia produtiva aeronáutica brasileira*: oportunidades e desafios. Banco Nacional de Desenvolvimento Econômico e Social.

[17] Nakano, D. N. (1997). *Uma comparação entre tipos de estratégia tecnológica de oito empresas brasileiras*. Anais do ENEGEPE.

[18] Narayanan, V. K. (2001). *Managing technology and innovation for competitive advantage*. Pearson Education India.

[19] Sirmon, D. G., Hitt, M. A., & Ireland, R. D. (2007). Managing firm resources in dynamic environments to create value: Looking inside the black box. *Academy of management review*, 32(1), 273-292.

[20] Tigre, P. B. (2006). *Gestão da inovação*. A economia da tecnologia no Brasil. Rio de Janeiro: Editora Campus.

[21] Woolley, J. (2010). Technology emergence through entrepreneurship across multiple industries. *Strategic Entrepreneurship Journal*, 4(1), 1-21.

# The emergence and impacts of home office strategy during the pandemic scenario of COVID-19

Rick Carneiro de Menezes[1], Aline Castro Jansen[2]

[1]Postgraduate Student in Labor Safety Engineering - Estácio de Sá Universities, Brazil.

[2]Doctoral Student in Business Management - Federal University of Rio Grande do Sul – UFRGS, Brazil.

*Abstract*—*The pandemic outbreak of COVID-19 triggered a profound economic crisis of global proportions, due to measures to contain the transmission of the virus causing the disease, being social isolation and, in more severe situations, the complete closure of non-essential activities (lockdown). In order to survive this scenario, many organizations began to adopt remote work as an alternative to continue their activities. However, this new way of working could not be properly structured and planned due to the urgency of such adaptation. Thus, the aim of this study is to discuss the advantages and challenges of the home office emergence due to the pandemic outbreak of Coronavirus. Among the main benefits are the flexibility and digital learning of professionals, and the technological transformation of organizations. The prominent limitations were the lack of infrastructure, the extension of the working day and the tenuous limit between professional and personal life.*

*Keywords*—*Coronavirus, crisis, labor, lockdown, remote work.*

## I. INTRODUCTION

The first months of 2020 demonstrated that the year would be atypical on a global scenario. The current health and economic crisis that has been impacting this year's development has emerged from the rapid spread of Coronavirus, more specifically the evolution of the so called SARS-CoV-2, a highly transmissible virus that causes COVID-19 disease and originated in a live animal market in Wuhan, China [1]. The situation triggered an outbreak of the virus worldwide in a few months, severely affecting countries such as Italy, Spain, Germany, France, England, Iran, the United States, India and Brazil, being declared as a global pandemic by the World Health Organization on March 11, 2020 [2].

Lockdown has been applied in many regions and even in entire countries, with schools, universities, some public services, businesses considered non-essential, events and leisure activities (including games, artistic shows, cinemas, art exhibitions etc.) being totally shut down [3], in order to slow the advances of the disease caused by the Coronavirus and prevent collapses in the health system.

According to the International Monetary Fund [4], the world has plunged into an economic crisis as deep as the financial collapse of 2008, because of the measures taken to contain the transmission of the virus, such as social isolation, which have been affecting not only the daily life of civil society, but also companies of various sectors and sizes all around the world. Illustrating this with some data, in only one month, 22 million people in the United States lost their jobs, unemployment rates more than doubled in Austria [3] and, in Brazil, the number of unemployed workers increased by 10.5% in the first quarter of 2020, when compared to the last quarter of 2019 [5].

To overcome the challenges created by any crises and, in particular, by a global impact event such as what is currently occurring, business organizations must seek to be resilient [6]. As an example of this in the current Coronavirus crisis. It was necessary a rapid adaptation of work activities by employers, managers, subordinates and self-employed workers due to the social isolation measure to stop the spread of COVID-19.

Considering this, a way to lessen the negative impacts on the results of companies and unemployment rates is remote work, thus the professional can continue working from home, without breaking the rules of social isolation imposed by the authorities. Therefore, in the current scenario, working from home emerges as an alternative to maintain the employment of many individuals in the labor market. However, it has its peculiarities that are not so easily overcome and, thus, showing significant and

exhausting challenges, especially for traditional organizations that used face-to-face control as the basis of working relations [7].

It can be highlighted that, in this work, the words home office, remote work and telework are considered synonyms and interchangeable. Thus, they are characterized as a new way of developing work activities, without the need to be physically in the workplace, which is made possible thanks to the evolution of Information and Communication Technologies (ICT), such as computers, smartphones and internet and its entire range of digital possibilities.

In this sense, even with work routines being affected by social isolation measures to contain COVID-19, it is necessary that the decision-making process continues to occur, and the flow of information is not interrupted [8]. For this to happen efficiently, it is essential that professionals know the available digital tools and know how to handle them to have the ability to make the necessary deliveries.

As much as the possibilities of remote work had already been developing in recent years through smartphones, computers and the entire wide range offered by digitalization, it was the emergence of the new Coronavirus and its consequent lockdown to which citizens were submitted that enhanced the adoption of the home office in order to enable certain routines and work activities to have continuity during the pandemic period.

From this scenario described, the following research question emerges: what transforming elements emerged from the instant adoption of the home office in the corporate context due to the health and economic crisis of COVID-19 that erupted in the first half of 2020? Based on this problematic, the aim of this article is to discuss the advantages and challenges of the home office emergency due to the pandemic crisis of Coronavirus. Therefore, to achieve this initial purpose, the work is divided into five sections, the first being this brief introduction. After that, the literature review will be intensified, raising the contributions in the literature about the possibilities and limitations of the home office and the use of digital tools in work activities. The third section will then expose the methodological procedures used to understand the research problem. In the following topic, the data will be explored through their analysis, crossing them with the theoretical framework. And finally, the final considerations of this study will be woven.

## II.   HOME OFFICE AS A PROFESSIONAL STRATEGY

Researches on the economic impact of previous pandemics has shown that countries, industries and companies suffer deeply from the consequences of a global pandemic, due to, in addition to health issues, the simultaneous shock that occurs on both sides, demand and supply of products and services [3]. In times of uncertainty and scarcity, organizations must seek creative and innovative solutions to the problems faced in the market. For this, they need to cultivate the necessary skills to transform, in an agile and dynamic way, their business and management practices oftheir material, financial, marketing, administrative and human resources and their knowledge bases[6].

The current pandemicof COVID-19, due to having social isolation as the main measure of containment of contagion – leading to some economic activities to be temporarily closed or suffer restrictions – has accelerated the spread of the home office. This term is related to the professional activities performed in an alternative space other than the company space, whether it is in the employee's residence [7]. Therefore, the lives of workers have undergone changes in various ways, ranging from job loss to the transformation of their work activity to telework.

To condense references and have a specific definition of the term, the  home office - remote work  and telework will also be used as synonyms in this article - is understood in this study as  the development of work activities outside the physical facilities provided by the employer, being made possible by the use of  digital tools for work [9]. For Brazilian legislation, in Law No. 13,467 of 2017, the expression telework means "the provision of services predominantly outside the employer's premises, with the use of Information and Communication technologies that, by their nature, do not constitute external work" [10].

The first home office records are dated to the 1970s, due to the oil crisis. According to [11], telework was a strategy that sought to reduce the time spent in traffic with commuting to perform work activities in offices. However, according to the authors, only around two decades later, this format of practice of labour activities advanced and reached, mainly in developed countries, a considerable number of followers, mainly due to the influence of the exponential increase in the popularization of digital tools. Currently, due to the pandemic crisis of COVID-19, there is an even greater acceleration of the adoption of remote work at levels that were predicted until recently.

Under ordinary conditions, remote work is adopted by organizations for reasons such as allowing a good balance between work and personal life, increasing flexibility and reducing the waste of time in traveling from home to the office, which also decreases traffic in cities [12; 13]. However, in the current adverse circumstance, employers and employees of all hierarchical levels seek adaptation to remote work in record time, for which there was not enough structuring and planning time [7].

As a result, personal life began to be organized from the centrality of work. To maintain productivity, then, the days go beyond conventional schedules and tasks start to be performed after normal office hours and on weekends, invading the other spheres of the worker's life. Considering this, the greatest challenge is to find the appropriate measure of the distribution and execution of goals and deadlines that compete with family life, household chores and school activities [7].

Previous research has already highlighted the paradox of remote work, as it provides employees with a greater sense of autonomy, on the one hand, and, on the other hand, results in increased organizational control of subordinates and intensification of workload, especially in cultures dominated by competition and performance indicators [14; 15]. In the face-to-face performance in the organizational environment, the superiors, as a rule, control the time and effort dedicated by their subordinates with visual supervision, in addition to the establishment of goals, for example. However, in teleworking, these evaluation methods and their criteria must also be adapted, because monitoring can no longer be done equally, and motivation mechanisms do not work in the same way through virtual means. Reinforcing this, [7, p. 73] emphasize:

In the format based on the achievement of goals, the worker finds himself compelled to reassure the manager, literally taking control of him over his time. Despite the competition that household chores or family life can bring to the time of work effort, the individual remains online and responsive, recording the achievement of goals and deadlines and avoiding any impression of idleness about their hours.

Thus, because they are not under the face-to-face control of their superior, the professionals end up working more and having a more intense workday to deliver a satisfactory productivity. However, with the labour reform in Brazilian legislation for 3 years, the home office worker no longer has the guarantee of overtime pay [10], that is, even if he is submitted to develop his work activities beyond the time of his contracted work day, the professional will not obtain additional financial gains.

Even with remote technologies and the possibility of virtualization of work relationships, the home environment is not structured to favour the productivity of the work activities, which makes it difficult to adapt quickly to the new working environment. In addition, with schools cancelling classes to avoid contagion of individuals by Coronavirus and life partners also working from home, all family members end up being forced to perform, in the same residence, tasks related to work, education, domestic and leisure.

In this context, women end up being more harmed, especially those who have young children, because they have been dedicating most of their time to educate them at home, assisting especially in remote classes, and also performing domestic functions [16], because of the lockdowns imposed. The data on the burden of women with children were deepened and a study done in Brazil by researchers – who are, also, mothers. Regarding being able to work, 15% of the male respondents with children answered that they follow their activities remotely, while only 4% of women in the same condition manage to continue working [16]. Within this universe, according to the researchers, when the analysis is related to the age of children, the disparity increases considerably, because 32% of women with children under 1 year were able to submit scientific articles as planned, compared to 61% of men with the same reality. These results show that the productivity of professionals with small children is affected and that women, in this scenario, end up being the most affected. Therefore, the attention given to these workers and the demanded amount of work to be made to them needs to be rethought, in order to understand the peculiarities of these routines.

Another issue related to remote work is the acceleration of digital transformation. According to [7], this is one of the main difficulties encountered by professionals forced to work remotely, since it emphasizes the urgency of learning new technologies in record time, the establishment of new forms of communication between teams and the new ways of doing their activities. As a result, remote workers need to be always up to date with new technological possibilities, developed in increasingly shorter periods.

Following in their understanding of the challenges and opportunities of teleworking for professionals, [11] listed in their study the greatest difficulties faced by teleworkers, being: lack of commitment, difficulty in having self-discipline, lack of contact with colleagues, inflexible organizational culture and stagnant contract model. On the

other hand, in this same research, the authors also list the main benefits of remote work, such as: agility in the delivery of tasks, increased quality of life, exclusion of regionality for professional work, reduction or extinction of time spent on commuting, possibility of spending more time with the family, greater concentration due to decreased noise from the work environment, greater autonomy and flexibility in activities. Therefore, it is understood that the adaptation, or not, to remote service is an individual issue, being accepted and defended by many, as well as, at the same time, rejected and criticized by others.

In this scenario, a common opinion prevails, as a result of this whole process of immediate adaptation to the pandemic period, the prediction is that organizations will be more open to various flexible forms of work [13] and look for digital tools to assist them in this process. [3], reinforcing this idea, emphasize that external shocks tend to accelerate the processes of innovation and digitization of companies, emphasizing the relevance of flexibility and responsiveness to changes. Consequently, this health and economic crisis resulting from COVID-19 highlighted, even more, the need for the development of digital skills. Therefore, professionals need to keep up with technological developments and adapt to the new post-pandemic socioeconomic context in order to remain competitive in the labour market.

## III. DIGITAL TOOLS FOR REMOTE WORK

In the course of its development, humanity has undergone many changes, some of which have totally changed the way they live, relate and work, also other changes considered an increment, were developed to improve something that already existed. Thus, the human being always sought to improve tools that facilitate the performance of his activities, which greatly helped in the progress of society over time [8].

Information and Communication Technologies, translated into digital tools, have been developed for decades to assist citizens in different tasks, both professional, personal and leisure. The term ICT refers to all technical means used to handle information and assist in communication, including network and computer hardware, as well as their software [17]. Digital solutions support a wide variety of tasks that need to be performed in the routine of individuals.

Among the many benefits that digital technologies can offer to the sectors of a company, we highlight the possibilities of reducing cost and time and increasing productivity, agility, efficiency, flexibility and innovation

[18], due to the greater ease in communication, in the management process and in the development of labour functions.. New ICT often creates new ways to gather the information needed for business management. Thus, organizational processes are shaped by new technologies and, therefore, can reshape the use of technology [12].

ICT has revolutionized the work routine and the way the market operates in the 21st century, offering both new opportunities and new challenges. Although digital tools have really transformed the way in which organizational activities are carried out and remote work is facilitated, the home office is not yet a widespread practice in all segments [9], although the COVID-19 pandemic has accelerated the process of adopting teleworking in several organizations.

For [1], digital transformation is one of the most critical areas in organizations regarding the management of the crisis caused by Coronavirus, along with decision-making processes, the role of leadership and the relevance of the emotional intelligence of employees in this delicate period. However, with the urgency of adaptation to the home office, digitization among companies tends to help superiors in monitoring organizational activities, because these new technologies facilitate the collection and analysis of performance results [12].

[19] highlight the need for learning and adoption of existing digital technologies, emphasizing that there is already a wide range of tools to solve almost all communication problems and access to information, not requiring the development of new solutions for adaptation to the home office. Therefore, telework requires investments by organizations in digital platforms and flexible mechanisms for working hours. Some companies that did not yet use the home office had to establish internal standards for its implementation, in addition to having to invest in digital resources to operate remotely, although many have failed to structure themselves so quickly [7].

The current crisis has resulted in strategic changes in business template and the operational use of their resources in many organizations, as well as in the culture of digitization [3]. In this perspective, it is understood that companies that adapt more rapidly to times of crisis, technological transformations and consumer demands can present better results and achieve a higher level of competitiveness in the market [8].

Following this line of thought, while restrictive measures force work teams to adopt new flows of activities and digital technologies, this forced adaptation allows the opportunity to experience the functionalities of the tools,

which can convince previously resistant professionals of the benefits of digital platforms in work tasks [3]. Thus, despite the negative effects, the pandemic outbreak of 2020 accelerated digital learning and the adoption of telework in many cases around the world [13].

Currently, to master applications and digital mechanisms that facilitate organizational activities, contribute to increased productivity and allow performance in more flexible jobs is an indispensable skill for professionals to work in the labour market. Considering this, then, we highlight the relevance of the competencies that involve 'digital literacy', a term originally created by [20]. Digital literacy, according to the author, is considered as the ability to find, evaluate, understand, create and use information and content using digital tools, encompassing not only the technical skills for this use, but also cognitive aspects of the evaluation of virtually available elements. In summary, it is to understand how applications work and how their possibilities can be explored in personal and professional life [8].

Within this perspective, it is emphasized that the use of the Internet during the period of social isolation increased substantially, according to data collected. In Brazil, this use reached growth rates of more than 40%, according to data provided by the National Telecommunications Agency [21]. At the same time, monthly time spent on mobile apps worldwide grew 39% in the second half of 2020 compared to the same period in 2019 [22]. By the way, some of the most downloaded applications in the world since March, when quarantine began to be implemented in many countries, were precisely those that offer the possibility to make video calls, which are widely used for team meetings that are physically distant, such as Zoom, Google Meet and WhatsApp [23].

To demonstrate how much the use of ICT advanced in Brazil, a decade ago, 84% of the individuals had a cell phone in Brazil, and most of these devices were not smartphones, and 31% had a computer [24]. In that period, notebooks and tablets were not yet counted separately in the research 'ICT Domicílios'. Currently, the proportion of individuals with a cell phone has advanced to 93%, while those with a computer have decreased to 16%, but it is noteworthy that 26% of those surveyed have a notebook and 13% of the population has a tablet [25]. However, although the percentage of people using digital devices is increasing, these data do not necessarily show that individuals know how to use and/or take advantage of the numerous possibilities that these devices offer. At this point, then, the importance of digital literacy is emphasized again [20].

On the other hand, when a critical look is directed at this digital advance, the excessive use of digital technologies or even the frustration caused by the limitations that the individual carries for not being able to use or adapt to new technological tools can cause physical and psychological tensions, known as technostress [26], which tends to cause the reduction of the productivity of individuals. These negative effects of scanning occur, not only by the high load of information and activities offered, but also because of the notifications and alerts that accompany the individual all day long. Seeking to reduce these effects, it is noteworthy that organizations should seek to assist their professionals in the way possible in order to avoid possible negative psychological impacts.

On the other hand, [13] argue that remote work will be the main strategy of resilience of the labour market during and after the Coronavirus outbreak, which further highlights the relevance of digital skills for professionals from all sectors. In this regard, while there are a number of challenges in the use of ICT, there are also many opportunities related to the adoption of data analysis tools, project management, online commerce and social media [1].

Finally, to analyse the positive and negative points of the rapid change in professional work for remote work due to the pandemic crisis of COVID-19, with the need for these workers to adapt to the use of digital tools in the development of their activities, a qualitative approach will be used, which will be detailed in the next section referring to the research method.

## IV.    RESEARCH METHOD

To achieve the objective initially established in this study, which is to analyse the challenges and opportunities of the urgent change of professional activity to the home office due to social isolation measures, a research classified as descriptive was made, which, according to [27], has the purpose is based on the description, recording, analysis and interpretation of the data without their manipulation. The approach defined for this work is qualitative, because it allows to deepen particular issues and explore a level of reality that is difficult to be quantified [27].

### 4.1 Data collection and analysis

Figure captions appear below the figure, are flush left, and are in lower case letters. When referring to a figure in the body of the text, the abbreviation "Fig." is used. Figures should be numbered in the order they appear in the text.Data were collected for this research through deep-

founded interviews, documental analysis and bibliographical research. This type of data collection with multiple sources is advocated by [28] to increase the reliability of the results, especially when the qualitative approach is used in the work. For this paper, therefore, a bibliographical research was made to explore the state of the art on the challenges and opportunities of remote work and on the use of digital tools that allow the home office, thus having references from academic literature to support empirical study.

Regarding the collection of primary data, it was done through eight semi-structured interviews, conducted with workers from different sectors and with different profiles that had to adopt telework urgently in order to maintain professional performance during the period of June 17 from 2020 to August 06, 2020. In search of the definition of the number of interviews, the criterion of saturation sampling was used, which is used in qualitative research in order to delimit the closure of the study sample [29]. As a general criterion for the selection of the interviewees, it was defined that they should be people working in a remote work regime on an exceptional basis due to the restrictions imposed in order to contain the spread of COVID-19 and we sought representatives from various segments of activity. Table 1 presents the profiles of the interviewees in this study:

*Table.1: Profile of respondents for the survey*

| Interviewed | Profile |
|---|---|
| Interviewee 1 | Financial advisor of a large company in the medical equipment industry |
| Interviewee 2 | Small entrepreneur in the graphic business |
| Interviewee 3 | Saleswoman in small clothing store |
| Interviewee 4 | Freelance food professional |
| Interviewee 5 | Teacher with online classes |
| Interviewee 6 | Manager of innovation projects in the public service |
| Interviewee 7 | Communication professional of a medium-sized company in the furniture manufacturing industry |
| Interviewee 8 | Accountant who has his own office |

The interview script was constructed from the initial objectives of this study, bringing the point of view of Brazilians and based on the issues of the themes: challenges and opportunities arising from remote work and digital tools used for work activities. On the other hand, the collection of secondary data, done through documentary analysis, occurred through access to the Eurofound report [9], which condenses data on the positive and negative impacts of the home office in several countries, with the exception of Brazil.

After the literal transcription of the interviews, the analysis of the results was performed, based on the data triangulation, which aims to increase their reliability [30]and offers a more comprehensive understanding of the phenomenon studied. For the treatment of the collected data, content analysis was used, which allows the interpretation of the responses of the respondents' statements [31]. The results of this research will then be discussed in the next topic, where the data obtained in this study will be detailed and explored.

## V.    RESULTS AND DISCUSSION

This section will analyse the data collected in this empirical research from the sources of evidence detailed in the previous chapter. Contextualizing the period in question is essential, because the moment is exceptional due to the pandemic crisis of COVID-19, which interferes in the form of adoption of both remote work and preparation for the use of digital tools that support it.

Regarding the disadvantages of remote work, workers highlighted the tendency to work beyond the predefined hours in the contract, create an overlap between work and personal life, with interference from one another, and result in intensification of work [9]. Another drawback reported by respondents who are subordinates and that does not appear in Eurofound's report is related to the fact that the organizations in which they operate simply transferred the structure costs to the employees. That is, they were assigned to remote work, but without being provided with any structure for this performance, such as digital devices, internet, light, equipment and office furniture, etc.

Within this structural issue, respondents also said that they often have to share digital tools with family members, as their children are taking remote classes and partners are also working in home office format. In addition, apart from cases like the one with the Interviewee 6: "the internet is very slow because we are making video calls all together, my husband is sometimes in a meeting at the same time as me and my son is studying, taking online classes". This question substantiates the study by [7], which states that adaptation had to occur so quickly that there was no time for planning and structuring the teleworking.

Another point that emerges is related to the separation between personal and professional life. In the home office, because employees are not linked to the employer's facilities as a fixed workplace, and because it is feasible to perform work-related tasks anywhere and at any time, the professional is more likely, in order to meet his goals

or by charges from his superior, to extend the hours he dedicates to work activities beyond what is in the contract [9]. On one side, the worker has greater autonomy to carry out his activities, being able to adjust his schedules according to personal needs, but, on the other hand, the individual tends to work longer and at times that would be dedicated to leisure, in other conditions.

To illustrate the increased time dedicated to work activities, the Eurofound's report [9] highlights the difference between the rates of professionals who report working more than 48 hours a week according to the way they work, and around 8% of employees working in the company's office compared to more than 30% of those who provide their services in a home office routine. In addition to these condensed data from several countries, it is emphasized that, within the universe of this empirical study, all interviewees confirmed their performance beyond their work day and the speech of Interviewee 3 illustrates this situation:"Working from home, for me, is much more exhausting than having to be in the store, because before people respected the time we were open and knew that we were online on Instagram, but there was the store for them to visit us. Not now, any time is time to work. If it takes a while, the customer no longer likes it or looks for another profile to make the purchase. So, I have to be online all the time. If I'm awake, I'm with my cell phone, I don't have time to goof around anymore."

The line that separates the professional and personal life of the individual becomes very thin. Interviewee 5 has a 3-year-old son and reports: "(...) he asks at all times to play and is always appearing in my classes. Me and my students think it's funny, but I feel like he wants me to pay more attention to him, because there's no school now, it's just us all day (...)". For her, class preparation and other complementary professional activities are impaired, because they have to be divided between domestic tasks, be present with the child and also work remotely at home, all of this adding, also, to the emotional and psychological issues that emerge in a period of uncertainty such as the pandemic crisis of COVID-19, which qualitatively illustrates the quantitative empirical research done by [16].

One of the factors restricting the adoption of the home office is the culture of the way of working, because the traditional style of management through very strict supervision and control does not allow flexible modes of action [9]. However, according to [12], scanning can help in this monitoring. In addition, other limiting factors include low level of trust between superiors and subordinates, fear of loss of control by managers, needs for interaction in the workplace, and lack of space and

equipment needed at home [9]. The statements of the interviewees in this empirical study also corroborate the data of the other countries described in the report, because both the entrepreneurs surveyed and the employees reported the same adversities related to monitoring.

Another barrier to home office adoption is the complexity and skills needed for the effective use of ICT [1]. Respondents 2 and 8,presenting the point of view of entrepreneurs, confess that they had difficulties to implement telework for two main reasons: first, because monitoring was always done in the traditional way, by face-to-face supervision and control of schedules and development of activities; and then, because they themselves did not have mastery of the necessary tools for this.

In this sense, one point needs to be highlighted: although the skills in digital tools are being more requested than ever, both in the interviews for this study and the Eurofound report [9], it was found that transformation and digital literacy [20] are still gaps in organizations. In quantitative data, only 58% of people in Europe had basic digital skills or above in 2019. On the other hand, the current economic crisis has accelerated digital learning [13] and, although some interviewees have less familiarity in the use of ICT, all indicated that they had increased their knowledge about the possibilities of using them and the use of at least one new software, due to the need to software adapt to remote work..

In this context, in order to adapt to adverse conditions, individuals had to adopt practices that were not part of their routines, such as: meetings per conference experience; sharing documents on drives in the cloud; remote access to other computers; project management in shared programs; digital signature of documents; management of routines and goals through applications. Based on the survey of the digital tools used by the interviewees, Table 2 was elaborated with this condensed information:

*Table.2: Digitals tools used by the interviewees*

| Category | Tool | Description |
|---|---|---|
| Social networks | Whatsapp | Communication tool used in organizations for internal communication between teams and external with consumers and suppliers, and also for business dissemination and marketing |
| | Instagram | Photo and video sharing tool, used for dissemination of products/services and communication with consumers |
| | Facebook | Social media tool used by organizations to communicate with the public and in the dissemination of their products / services |
| Project management | Trello | Tool based on to-do lists and with direct correlation with Kanban |
| | Padlet | Tool for creating a mural or collaborative virtual framework for recording, saving, and sharing content between teams |
| | Asana | Tool to track and manage projects, and can be used for areas such as Marketing, Operations, Sales, Product Development, HR |
| Video conferencing | Zoom | Tool for visual communication, allows the exchange of instant messages and sharing of the screen |
| | Google Meet | Video calling tool, allows instant messaging and screen sharing |
| | Microsoft Teams | Multifunctional tool, which allows video conferences; storage and sharing of files; team management; project management |
| Design Platforms | Canva | Graphic design tool that allows you to develop social media graphics, presentations, flowcharts, posters, among others, integrating various types of images, fonts, templates and illustrations |
| | Miro | Collaborative online tool for simultaneous construction of mind maps, business modelling, diagrams and boards with notes |
| Remote access | Teamviewer | Tool for remote access, desktop sharing, online conferencing and cross-computer file transfer |
| | AnyDesk | Tool that provides remote access to personal computers running the host application |
| Task Organizer | FocusList | Tool for organizing and performing tasks through the pomodoro technique |
| | Any.Do | Task manager tool and activity lists, allowing you to insert new notes by typing or voice |
| Creating, Editing, and Storing Documents in the Cloud | Google Drive | File storage and synchronization tool, which allows you to upload any type of program or file |
| | OneDrive | Microsoft cloud storage tool, where you can store and host any file type |
| | Dropbox | Cloud file storage tool |
| Data collection | Survey monkey | Tool for the development of quantitative and qualitative research based on online data collection |
| | Google Forms | Tool for creating online forms, mainly used for data collection and satisfaction survey, and can assist in the decision-making process |
| Electronic signature | D4sign | Electronic signature tool that allows the generation of documents and creation of templates with form for the individual to fill out |
| | Adobe Sign | Document signature management tool |

This evidence of the use of new tools due to social isolation measures in the Coronavirus pandemic shows individuals' recent learning about other ICT possibilities and the search for digital transformation, confirming the statement made by [3] that external shocks force companies to accelerate their innovation processes.

Regarding the benefits of teleworking, Interviewees 1 and 6 agreed that having more flexibility in their work and not having to waste time in traffic are the main privileges of the home office. Interviewee 2 pointed out that the possibility of being able to spend more time with the family is what has stood out in this scenario for him. These advantages, as well as greater agility in the deliveries of activities, increased quality of life, exclusion of regionality for professional performance l, greater concentration by reduction of noise from the work environment and greater autonomy in the execution of tasks, were listed in the results of the study by [11] as the benefits pointed out by professionals in remote work. In addition to this, the [9] also points to the positive effect of teleworking, in addition to these, increased productivity [9].

A relevant point stands out here, employers with experience in the adoption of remote work observe its advantages more than individuals who have not yet experienced this experience, which suggests that there may be a certain prejudice against this form of execution of the service [9]. The Interviewee 7 agrees on this issue, stating that, in his opinion, the ideal scenario is a mixed model, in which he would develop his activities in the work environment during some days of the week and, in other periods, would work from home. [9]highlights similar results, emphasizing that satisfaction rates vary mainly, depending on whether the home office completely replaces the face-to-face work in the office or complements it. In addition, other variables also influence the approval of remote work, such as familiarity in the use of ICT, the workplace, the definition of the limits of professional life and the characteristics of each productive sector.

Finally, when asked if they intend to follow a home office regime after the end of the pandemic period, the professionals did not give similar answers. Interviewees 3 and 4 stated that they intend to continue working on a teleworking basis, because they are managing to obtain higher financial returns, since they are self-employed professionals, they can answer to their customers at any time and do not need to spend on the rental of a physical space. Interviewee 1 was the only one who replied that he would like to return to his work schedule at the office, highlighting: "In my apartment I do not have a suitable space to work. And as a matter of fact, I don't even want to. For me, home is to rest and to be with my family." The other five Interviewees stated that they plan to work on a mixed basis, alternating days in remote work and others complying with the schedule in the organizational environment. Concluding, at this point, the analysis of the results, the following section will point out the final considerations of this article, in order to contribute to the advancement of academic literature.

## VI. CONCLUSION

At the current stage, the rapid spread of COVID-19 has led decision makers around the world to adopt prevention measures to reduce the contagion of the disease, which include social isolation and, in many cases, total restriction of non-essential activities. Because of this, companies had to seek solutions on an emergency basis in

order to survive this health and economic crisis. One of the most widespread strategies to overcome these limitations was the adoption of remote work, which has many challenges, but also numerous opportunities. It is also noteworthy that the emergence of the home office, in this case, differs from the scenario in which the form of remote action is planned and structured, because the need for rapid adaptation to this regime, in most cases, occurred in an ungoverned manner.

As positive points of remote work, we highlight the increase in flexibility and autonomy in the execution of activities, the reduction of time spent commuting to the work environment, digital transformation, increased productivity and the possibility of spending more time with the family. On the other hand, the biggest challenges of the home office were the added working hours without their financial reward, the intervention of professional life in the person, the urgent adoption of new digital tools, the transfer of infrastructure costs to the employee and the forms of control.

This transformation of the way of working, using digital tools as support for the home office, is occurring more because of the need and, if perpetuated, will have a direct relationship with the change of mentality and not with technology, because the necessary technological mechanisms have been around for some time, not needing to be developed. In any case, in the data collection of this research, we observed the digital tools most used by the interviewed professionals and a list of them was made to support the development of tasks by teams that are working in a teleworking regime.

The reflection on this phenomenon of imposition of telework and acceleration of the use of digital tools so that work activities can be carried out at home is being carried out since the first weeks in which social isolation measures were taken. However, this is still a very recent discussion in the academic literature and it is necessary to move further, especially by analysing, at the end of the pandemic period, which transformations will be perpetuated and which will have been only punctual.

## REFERENCES

[1] Cortez, R. M. & Johnston, W. J. (2010). The coronavirus crisis in B2B settings: crisis uniqueness and managerial implications based on social exchange theory. Industrial Marketing Management, 88, 125-135. http://dx.doi.org/10.1016/j.indmarman.2020.05.004

[2] WHO - World Health Organization. (2020). WHO Director-General's opening remarks at the media briefing on COVID-19. Retrieved from https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020.

[3] Kraus, S. et al. (2020). The economics of COVID-19: initial empirical evidence on how family firms in five European countries cope with the corona crisis. International Journal of Entrepreneurial Behavior & Research.http://dx.doi.org/10.1108/IJEBR-04-2020-0214

[4] IMF - International Monetary Fund. (2020). The IMF and COVID-19 (Coronavirus). Retrieved from https://www.imf.org/en/Topics/imf-and-covid19.

[5] IBGE - Brazilian Institute of Geography and Statistics. (2020). PNAD Continuous - National Continuous Household Sample Survey. Rio de Janeiro.

[6] Liu, Y. & Lee, J. M., Lee, C. (2020). The challenges and opportunities of a global health crisis: the management and business implications of COVID-19 from an Asian perspective. Asian Business & Management, 1.http://dx.doi.org/10.1057/s41291-020-00119-x

[7] Brant, R. &Mourão, H. C. (2010). Desafios do teletrabalho na pandemia COVID-19: quando o home vira office. Caderno De Administração, 28(Edição E), 71-75. https://doi.org/10.4025/cadadm.v28iEdição E.53637

[8] Hermogenes, R. et al. (2020). A importância das digital skills em tempos de crise: alguns aplicativos utilizados durante o isolamento social devido à pandemia do COVID-19. *Revista Augustus*, *25*(51), 198-218.

[9] Eurofound. (2020). Telework and ICT-based mobile work: flexible working in the digital age, new forms of employment series, Publications office of the European Union, Luxembourg.

[10] Brazil. Law No. 13.476 of July 13, 2017, Art. 75-b. Retrievedfrom http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/lei/l13467.htm.

[11] Haubrich, D. B. & Froehlich, C. (2020). Benefícios e desafios do home office em empresas de tecnologia da informação. RevistaGestão&Conexões, 9(1), 167-184.https://doi.org/10.13071/regec.2317-5087.2020.9.1.27901.167-184

[12] Miele, F. &Tirabeni, L. (2020). Digital technologies and power dynamics in the organization: A conceptual review of remote working and wearable technologies at work. Sociology Compass, 14(6), 2795.http://dx.doi.org/10.1111/soc4.12795

[13] Zamfir, A. M. &Aldea, A. B. (2020). Digital skills and labour market resilience. Postmodern Openings, 11, 188-195.http://dx.doi.org/10.18662/po/11.1sup2/151

[14] Sewell, G., Taskin, L. (2015). Out of sight, out of mind in a new world of work? Autonomy, control, and spatiotemporal scaling in telework. Organization Studies, 36(11), 1507–1529.http://dx.doi.org/10.1177/0170840615593587

[15] Wood, A. J., Graham, M., Lehdonvirta, V. & Hjorth, I. (2019). Good gig, bad gig: Autonomy and algorithmic control in the global gig economy. Work, Employment and Society, 33(1), 56–75.http://dx.doi.org/10.1177/0950017018785616

[16] Staniscuaski, F. et al. (2020). Impact of COVID-19 on academic mothers. Science, 368(6492), 724-724.http://dx.doi.org/10.1126/science.abc2740

[17] Eurostat. (2018). Information and Communication Technology (ICT). Retrieved from https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Glossary:Information_and_communication_technology_(ICT).

[18] Sordi, J. O. (2003). Tecnologia da Informação aplicada aos negócios. São Paulo: Atlas.

[19] Xie, B. et al. (2020). When going digital becomes a necessity: ensuring older adults' needs for information, services, and social inclusion during COVID-19. Journal of Aging & Social Policy, 1-11.http://dx.doi.org/10.1080/08959420.2020.1771237

[20] Gilster, P. (1997). Digital literacy. New York: Wiley Computer Pub.

[21] ANATEL - National Telecommunications Agency. (2020). Anatel Data Dashboards. Retrieved from https://www.anatel.gov.br/paineis/acessos/panorama.

[22] Kristianto, D. (2020). Mobile apps usage reached an all-time high amidst stay-at-home measures due to COVID-19 pandemic. App Annie. Recuperado em: 20 de julho, 2020, de https://www.appannie.com/en/insights/market-data/mobile-app-usage-surged-40-during-covid-19-pandemic/.

[23] Rank my app. (2020). App categories and user needs. Retrieved from https://www.rankmyapp.com/mobile-marketing/as-categorias-de-apps-e-as-necessidades-dos-usuarios/.

[24] Cetic.BR - Regional Center for Studies for the Development of the Information Society (CGI.br/NIC.br). (2011). ICT Households 2010: Research on the use of Information and Communication Technologies in Brazilian households. Retrieved from https://cetic.br/pesquisa/domicilios/indicadores.

[25] . Cetic.BR - Regional Center for Studies for the Development of the Information Society (CGI.br/NIC.br). (2020). ICT Households 2019: Research on the use of Information and Communication Technologies in Brazilian households. Retrieved from https://cetic.br/pesquisa/domicilios/indicadores.

[26] Daruwala, N. A. (2020). Generation lockdown: exploring possible predictors of technology phobia during the Coronavirus self-isolation period. Aloma: Revista de Psicologia, Ciències de l'Educació i de l'Esport, 38(1).

[27] Minayo, M. C. S. (2013). Pesquisa Social: teoria, método e criatividade. 33 ed. Petrópolis: Vozes.

[28] Creswell, J. W. (2016). Reflections on the MMIRA:the future of mixed methods task force report. Journal of Mixed Methods Research, 10(3), 215–219.https://doi.org/10.1177/1558689816650298

[29] Fontanella, B. J. B., Ricas, J. &Turato, E. R. (2008). Amostragem por saturação em pesquisas qualitativas em saúde: contribuições teóricas. Cadernos de Saúde Pública, 24(1), 17-27.

[30] Yin, R. K. (2015). Estudo de caso: planejamento e métodos. 5 ed. Porto Alegre: Bookman Editora.

[31] Bardin, L. (2016). Análise de conteúdo. São Paulo: Edições 70.

# Food Security as a Fundamental Human Right

Bruno Cezar Silva, Lucia Marisy Souza Ribeiro de Oliveira

Universidade Federal do Vale do São Francisco, Rua Rio de Janeiro, 32 João xxiii Juazeiro BA CEP 48900 330
Universidade Federal do Vale do São Francisco, Praça da República, 33. Bairro Dom Tomaz, CEP 48907-180 Juazeiro – Bahia

*Abstract— The objective of this article is to identify and evaluate public policies for Food and Nutritional Security in the country, establishing the relationship between them and policies aimed at family farming, based on their effects on the development of the most vulnerable populations and their fixation on the field. The search for information included national and foreign authors who are experts on the topic, as well as annual reports from 2016 onwards, from international organizations such as FAO, IFAD, IFAD; WFS;UNICEF, WORLD BANK and others, who keep the safety assessment on their agenda. food and nutrition in the world, detecting advances and setbacks, to suggest to nations, policies and action strategies capable of correcting dysfunctions. The conclusions point Brazil out of the world map of extreme hunger, however it indicates the increase of people in situation of food risk in the country, for not having the economic conditions sufficient to have a healthy diet.*

*Keywords— Food Security, Family farming, Public policy, Law 13.345.*

## I. INTRODUCTION

Although the concept of food security may vary from country to country, given that factors such as food culture, education, type of housing, health concept and others, strongly influence this formulation, the definition adopted by Law 11.345 that creates the National System of Food and Nutritional Security - SISAN, explains in Art.3 "the food and nutritional security consists in the realization of the right of everyone to regular and permanent access to quality food, in sufficient quantity, without compromising access to other essential needs, having as a basis, health-promoting food practices that respect cultural diversity and are socially, economically and environmentally sustainable. " (Organic Law on Food and Nutritional Security, art. 3, 2006). Therefore, this Law places the State as responsible for the food well-being of its population. Reinforcing the State's commitment to the quality of life of the population, the Federal Constitution of 1988, in its art. 6th says: "Education, health, food, work, housing, leisure, security, social security, maternity and child protection, assistance to the helpless are social rights, in the form of this Constitution. " (Brazil, 2010). Despite the existing legislation in the country to ensure a decent life for all, and to be Brazil one of the largest world producers of food and, even if there is not an explicit situation of hunger, approximately 46 million individuals live in a situation of risk, as their income is insufficient for them to be able to eat in the recommended quantities and with the necessary quality and regularity (FAO, 2020)

The concept of Food Security emerged from the First World War (1914-1918), when in Europe the term was linked to the notion of national security and with the capacity of each country to produce its own food, so as not to be vulnerable in embargoes, boycotts or for political or military reasons (GALEAZZI, 1996). It returned to the surface, in the Second World War, when the devastated European countries, with their physical and material structures destroyed and their population without the necessary means to produce their own food, started to discuss the matter, putting the need to create a multinational organization, to encourage agriculture and food, which, regardless of wars, calamities, natural weather, would guarantee all peoples access to food, in quantity, quality and regularity. At the same time, the implementation of the UN - United Nations Organization and the IMF - International Monetary Fund (GALEAZZI, 1996) was being discussed, to create policies and funds capable of restructuring world economies. After a wide debate, in 1945 the FAO - Food and Agriculture Organization of the United Nations is created, whose purpose is to fight hunger and poverty, promote agricultural development, improve nutrition, seek food security and the access of all people, at all times, to the foods necessary for an active and healthy life (BELIK, 2003).

However, not with this terminology, but with the same essence, since the eighteenth century this topic was addressed by the English economist and demographer

Thomas Robert Malthus (1798), whose theory he defended supported the idea that demographic growth would exceed capacity the land, generating hunger and misery. This theory served as the basis for the Conservative Modernization of the Green Revolution that changed the way of planting and harvesting between the 1930s and 1980s of the 20th century worldwide.

In Brazil, the Green Revolution, despite increasing the productivity of crops, especially commodities, did not reduce hunger as promised, because its cause was never the lack of food, but a set of elements such as the lack of access to land to produce ; the lack of money to buy food and the ignorance of the technologies generated by research bodies for the people of the countryside to make appropriate choices for each geographic context. This scenario is decisive for the social injustice that has been affecting the poorest since colonization. In addition, the Green Revolution left a legacy of soil erosion and compaction, especially in the northeast; reduction of water resources, since so-called modern agriculture is responsible for 70% of the consumption of existing fresh water; flooding and salinisation of irrigated land; contamination of soils and workers with agrochemicals, with a relevant impact on the health of the population (LAZZARINI, 2018).

In the post modern concept of food security, in addition to the availability in quantity, quality and regularity of food, since the 2nd National Conference on Food and Nutritional Security, held in March 2004 in the city of Olinda - Pernambuco, it has been advocated that each people has the right to define policies that guarantee the preservation of traditional production and food practices of each culture, carried out on an environmentally, economically and socially sustainable basis. From then on, Brazil adopted the following concept:

> "(...) Food and Nutritional Security consists in realizing the right of everyone to regular and permanent access to quality food, in sufficient quantity, without compromising access to other essential needs, based on health-promoting food practices that that respect cultural diversity and that are environmentally, culturally, economically and socially sustainable "(Law 11.345).

This understanding was reaffirmed in the Organic Law on Food and Nutrition Security, approved by the National Congress and sanctioned by the President of the Republic on September 15, 2006, a legal instrument that constitutes an advance for considering the promotion and guarantee of DHAA as the objective and goal of the Policy Food and Nutritional Security (BELIK, 2003).

The initial idea on Food Security, which was guided by food production, only remained until the 1st World Food Security Conference promoted by FAO, in 1974. In 1996, more than 180 nations participated in the World Food Summit, and there have pledged to halve, by 2015, the rate of malnourished people in the world. This commitment was renewed in Rome, on June 11, 2002, by the same 182 signatory countries of the previous declaration (BELIK, 2003).

Referring to the issue of hunger and food production, Amartya Sen (2000), states Malnutrition, chronic hunger and collective famines are influenced by the functioning of the entire economy and society as a whole - not just the production of food and agricultural activities [...] food is not distributed in the economythrough charity or any other means. automatic sharing system. The potential to buy foodhas to beacquired. [...] people go hungry when they cannot establish their "entitlement" on a sufficient amount of food (SEN, 2000).

Thus, it can be observed that the concept of food security is constantly changing, always incorporating new elements in its understanding, such as, safe food, one free from chemical or biological contamination; food quality, incorporating nutritional aspects; balancing the diet; cultural and other aspects, which subsidized the International Conference on Nutrition, promoted in 1992 by the UN and FAO, with the presence of 159 countries and the leaders of the European Economic Community. At this event, the World Declaration on Nutrition was drafted, where all participants declared that hunger and malnutrition are unacceptable and that access to nutritionally adequate and safe food is a right of every person. The World Food Summit met in Rome in 1996, addressing the issue and highlighting: "Poverty is an important cause of food insecurity, and sustainable progress in its eradication is fundamental to improving access to food" (WORLD DECLARATION OF ROME,

1996). In early 2002, FAO organized a new Conference with the name "Summit + 5", in which it was found that the 2015 target was very far from being reached.

Referring to the issue of hunger and food production, Amartya Sen (2000), states:

> "Malnutrition, chronic hunger and collective famines are influenced by the functioning of the entire economy and society as a whole - not just the production of food and agricultural activities [...] food is not distributed in the economy through charity or any other means. automatic sharing system. The potential to buy food has to be acquired. [...] people go hungry when they cannot establish their "entitlement" on a sufficient amount of food" (SEN, 2000).

Thus, it can be observed that the concept of food security is constantly changing, always incorporating new elements in its understanding, such as, safe food, one free from chemical or biological contamination; food quality, incorporating nutritional aspects; balancing the diet; cultural and other aspects, which subsidized the International Conference on Nutrition, promoted in 1992 by the UN and FAO, with the presence of 159 countries and the leaders of the European Economic Community. At this event, the World Declaration on Nutrition was drafted, where all participants declared that hunger and malnutrition are unacceptable and that access to nutritionally adequate and safe food is a right of every person. The World Food Summit met in Rome in 1996, addressing the issue and highlighting: "Poverty is an important cause of food insecurity, and sustainable progress in its eradication is fundamental to improving access to food" (WORLD DECLARATION OF ROME,

## II.     FOOD SECURITY IN BRAZIL

In Brazil, the fight against hunger is not recent. In the postwar period, the Brazilian physician Josué de Castro mapped hunger in Brazil and "his ideas were decisive for the institution of the minimum wage, which established a basket of 12 foods, which would compromise 50% of the salary estimate and would meet 100% of the recommendations for calories, proteins, minerals and vitamins "(BATISTA FILHO, 2003). In Geography of Hunger, Josué de Castro (1980), defines as an objective of his study, to carry out an ecological survey on the phenomenon of hunger in Brazil, guided by the geographic principles of location, extension, causality, correlation and land unity. It innovated by introducing in the work the concepts of food areas, areas of endemic hunger, areas of epidemic hunger, areas of malnutrition, Brazilian food mosaic, in order to draw the first map of hunger in the country.

By food areas, the author understood, a region that had typical resources, a habitual diet based on certain regional products and with its inhabitants reflecting, in their biological and socio-cultural characteristics, the marked influence of the diet. Endemic famine areas were those in which at least half of the population had permanent nutritional deficiencies, while in epidemic hunger, the nutritional deficiencies of half the population are transitory. Malnutrition areas, in their classification, include small groups in a given region. Finally, it defines regional and ethnic food diversity as the Brazilian Food Mosaic (CASTRO, 1980).

In the methodology used, Josué de Castro, divided the country into five food areas:

1. Amazon area, covering the states of Amazonas, Pará, Mato Grosso, Goias, Maranhão, Amapá and Rio Branco (the last two, at the time, were territories).

2. Northeastern sugar, covering the entire northeastern coast.

3. Sertão Nordestino, comprising the central lands of the states of Piaui, Ceará, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe and Bahia.

4. Midwest, comprising the states of Minas Gerais, Goias and part of Mato Grosso.

5. Extreme South, at the time covering the states of Guanabara, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul (CASTRO, 1980).

The food consumed in each of these areas was defined by the culture of its population. For example, in the Amazon area, the diet consisted of manioc flour, fish, beans and rapadura, which were the components of indigenous food, seasoned with plenty of pepper. Chestnuts, açaí and buriti, although nutritionally rich, were little eaten at the time, making the population's diet very poor. In the sugar northeast, the diet was rich in protein and mineral salts,marine foods (fish, molluscs and crustaceans). In addition to these, there were coconut, cashew, cocoa and jerky, which made the coastal population's diet nutritionally balanced (CASTRO, 1980).

In the case of the Sertão Nordestino, the diet was the most varied and rich, with Portuguese and Arab colonizers as the main influence. The population fed on corn and its derivatives, such as mush, hominy, couscous; mugunzá; angú; bean; beef, mutton; buchada; sarapatel; flesh of the sun; beef jerky; rapadura; milk; curd; cheese; butter; pumpkin; gherkin; okra; sweet potatoes, which made the diet of this population both in quantity and in complete quality, meeting all nutritional needs. This balance was only broken in prolonged periods of drought, when the population was experiencing nutritional deficit, the lack of water to plant and to give water to animals. In the prevalence of this situation for a long time, the sertanejo started to feed on roots, seeds, rustic plants and wild animals, as a survival strategy (CASTRO, 1980).

In the Midwest, the basic diet was corn, beans, corn flour and bacon. Although high in calories, from a nutritional point of view it was to be desired. However, this diet was supplemented with fruits, bananas, oranges, papayas, avocados and vegetables. In the area of the Far South, the region most developed in industry, agriculture and commerce, the diet was complete. Rice, bread, potatoes, meats, vegetables, legumes, fruits, the result of the influences of the colonizers: Italians, Germans, Poles, Japanese, Lithuanians, forming an immense food mosaic (CASTRO, 1980).

In 1948 the Universal Declaration of Human Rights (UDHR) was signed, which internationally enshrined food as a fundamental human right. In Brazil, despite the social inequality that separates rich and poor, in terms of food and nutrition conditions, there are significant advances, with repercussions on reducing extreme poverty. Between 1990 and 2008, while the Brazilianpopulation grew from 141.6 to 186.9 million, thepopulation in extreme poverty decreased from 36.2 to 8.9 million people (IBGE,

2010). It is worth mentioning that Brazil is the only country in the world that has a specific law in the field of food security and the right to food. Law nº 11.346, places Brazil in a position of global protagonism in this matter, even as an alert for government officials less committed to the citizenship of its population, by stating in Art.2 that "adequate food is a fundamental human right of the human being, inherent in the dignity of the human person and indispensable to the realization of the rights enshrined in the Federal Constitution, and the public power must adopt the policies and actions that are necessary to promote and guarantee the food and nutritional security of the population ". It also emphasizes in Art. 3 that "it is the duty of the public power to respect, protect, promote, provide, inform, monitor, inspect and evaluate the realization of the human right to adequate food, as well as guarantee the mechanisms for its enforcement". This text makes it evident that having an adequate diet is not kindness, sensitivity or charity of the governors who exercise it in their management for the poor, but a legal obligation of the State, as a representation of society. Law 13.415 is based on the following guidelines:

a.The promoting the intersectorality of governmental and non-governmental policies, programs and actions;

b. decentralization of actions and articulation, in collaboration, between the spheres of government;

c. monitoring of the food and nutritional situation, in order to subsidize the cycle of management of policies for the area in the different spheres of government;

d. conjugation of direct and immediate measures to guarantee access to adequate food, with actions that expand the population's autonomous subsistence capacity;

e.and. articulation between budget and management;

f. encouraging the development of research and the training of human resources.

These guidelines were drawn up with the participationof society through social movements, hence reflecting the concerns of the population. Food insecurity is disrespect for human rights and directly affects the right to life. Food sovereignty favors the economic, political and cultural sovereignty of peoples.

In Mali, in 2007, at the World Food Sovereignty Forum, the traditional peoples present or represented there (indigenous, quilombolas, riverside dwellers, fishermen, farmers, people of African origin and others), reformulated the then concept of Food Security, adding other

components to the text, in order to feel contemplated. They state:

> "Food sovereignty is the right of peoples to decide their own food and productive system, based on healthy and culturally appropriate foods, produced in a sustainable and ecological way, which places those who produce, distribute and consume food at the heart of systems and policies above the demands of markets and companies, in addition to defending interests and including future generations."(WORLD FORUM FOR FOOD SOVEREIGNTY, 2007).

What changes in this conception, according to Via Campesina (2003), an important movement of rural workers, is the valorization of those who produce, including:

• Agrarian Reform, so that workers have access to land, water, seeds, agricultural inputs, to produce under competitive conditions.

• Priority of national products, avoiding that imported products that are too cheap, due to the subsidies they received from their governments, may harm local farmers, especially family members.

• The participation of farmers in the definition of agrarian and agricultural policies.

• The recognition of peasant women who play an essential role in agricultural production and food.

• The appreciation of the local food culture, both for those who produce and those who consume.

• Encouraging family farming, free of agrochemicals (VIA CAMPESINA, 2003).

These are the guidelines that qualify Brazilian family farming.

## III. MAIN PUBLIC POLICIES FOR FAMILY AGRICULTURE THAT STRENGTHEN FOOD AND NUTRITIONAL SECURITY IN BRAZIL

Public policies aimed at the agricultural sector have been an important tool for the development of regions and countries in recent decades. However, as discussed above, agricultural policy in Brazil, from the post-war period, was focused on the capitalized rural company, which has large tracts of land, focusing on the modernization of its productive structures, privileging the increase in productivity through technological advances and government subsidies (SILVA, 2008). Only from 1999, with the intense mobilization of social movements in the countryside, PRONAF - National Program for Strengthening Family Farming was created, an important tool of financial increase for family farmers, because in addition to reducing poverty and social inequalities among the urban and rural population, it provides movement of capital in the countryside, boosting the local market and reducing the rural exodus.

Established by Decree 1.946 / 1999, it was organized to operate in three different lines: credit; municipal infrastructure and services and training, whose sources of financing are the general budget of the union, the workers' support fund and cooperative banks and constitutional funds (SILVA, 2008). It covers the following lines of credit:

• Pronaf Agroindustry - aimed at processing and future commercialization.

• Pronaf Cota-Parte - aimed at members of cooperatives.

• Pronaf Custeio - aimed at financing production.

• Pronaf Floresta - aimed at agroforestry projects.

• Pronaf Jovem - aimed at young people working in agriculture.

• Pronaf Mais Alimentos - aimed at improving the production infrastructure.

• Pronaf Mulher - aimed at women working in agriculture.

Since its implementation, the program has undergone changes to adjust to legal and market requirements. Given its national relevance, it now includes a set of programs to support family agricultural production, such as:

• National Policy for Technical Assistance and Rural Extension (PNATER), created in 2003 with the objective of restructuring the technical assistance system in Brazil, focusing on family rural properties;

• Food Acquisition Program (PAA), which allows the public purchase of products from family farmers at prices established by the National Supply Company (CONAB), for donation to social assistance organizations, school lunches or stock building;

• National School Feeding Program (PNAE), which, according to article 4 of Federal Law No. 11,947, aims to contribute to the growth and biopsychosocial development, learning, school performance and the formation of healthy eating habits of students, for through actions of food and nutrition education and the provision of meals that cover their nutritional needs during the school year. Article 14 of the aforementioned law establishes that of the total financial resources transferred by the FNDE, within the scope of the PNAE, at least 30% (thirty percent) must be used in the acquisition of foodstuffs directly from family farming and the rural family entrepreneur or their organizations, giving priority to agrarian reform settlements, traditional indigenous communities and quilombola communities. Coelho (2012), states that PNAE is currently considered the largest dietary supplementation program in Latin America, considering the length of activity, continuity, universal character, the number of students served and the volume of investments made.

• National Land Credit Program, facilitates the financing of rural properties, for those who have not yet had access to land, and can pay the financing in up to 25 years, with a grace period of 36 months.

• Unified Animal Health Care System (Elesa), aims to ensure the health quality of food, decentralizing the process of monitoring good practices for states and municipalities.

• Land Registration and Land Regularization Program, which aims to provide legal certainty to small landowners and rural property owners targeted for regularization.

• National Program for the Production and Use of Biodiesel (PNPB), created in 2004 to encourage the production of biodiesel, energy from renewable sources. Oil extraction can be castor, sunflower, soy, palm, peanut and others.

All of these programs have a positive impact on rural families, however, the public policy that has brought the greatest benefits to the rural population is Rural Social Security, through pensions and pensions, which have transformed the quality of life of the elderly population, when wear and tear due to the expenditure of energy in hard work for the production of food, would not allow him the deserved rest. It was the 1988 Constitution, complemented by Laws 8,212 (Costing Plan) and 8,213 (Benefit Plans), of 1991, which determined universal access for the elderly and disabled of both sexes in the rural sector to social security, in a special regime, provided that they prove the situation of rural producer, partner, sharecropper and tenant, garimpeiro and artisanal fisherman, as well as respective spouses who carry out their activities in a family economy regime, without permanent employees. (BRUMER, 2002).

In Brazil, family farming plays an important role in food and nutrition security, in protecting the environment, in generating employment and income and in local development. The term family farming proposes several nuances of meaning in its definition. Law No. 11,326 of July 24, 2006, characterizes family farming as "that developed on rural properties with up to four fiscal modules, where family work predominates over the total labor of the establishment". The value of the "fiscal module" unit is fixed by INCRA, and varies from municipality to municipality, based on the criteria of art. No. 4 of Decree 84.685 / 80 (BIANCHINI, 2005). However, as Altafin (2005) states, "Brazilian family farming is an evolving concept, with significant historical roots and linked to traditional peasant production". For Chayanov (1974), "family farming is one that does not hire outside labor, that owns a certain extent of land and its own means of production, and that, at times, is forced to continue to employ part of its workforce in other activities outside the property".

Public policy is being considered "the field of knowledge that seeks, at the same time, to put the government into action and / or analyze this action and, when necessary, propose changes in the direction or course of these actions" (SOUZA, 2006). For Cunha and Cunha (2002), "public policies have been created by the State as responses to the demands that emerge from society and from within, representing the public commitment to act in a given area in the long term". According to Lima and Pitaguari (2005), public policies that include public spending capable of reducing production costs and making the productive sector viable improve the structural conditions for growth and development of the local economy. Summarizing the importance of public policies, (Cornwall & Brock, 2005; Cabral, Favareto, Mukwereza, & Amanor, 2016), they say that policies guide the conduct of public managers for the relationship of the State with Society, being formulated through laws, norms, decrees or

even programs for its effective application, providing improvements in the quality of life of all its citizens.

Although it is possible due to the evaluations made by international organizations, such as FAO (2016; 2017; 2019) and the World Bank 2016; 2017; 2019), to note advances in agricultural and agrarian policies aimed at rural populations, with regard to family farming with a view to food and nutritional security, serious deficiencies in the State's performance can be identified, such as the low participation of workers in the definition of these policies; the marginalization and worsening of the social situation, with loss of rights and omission in the application of the law for offenders; unequal food distribution, formation of an economically strong employer category to the detriment of the family productive sector, in addition to irreversible environmental problems (GUEDES PINTO, 1995; BUAINAIN, 1999; PESSANHA, 2002). But rural workers have resisted, and the consolidation of the ideal of equality and social justice is gradually taking place. More recently, this productive segment has sought to implement agroecology in its production processes, from the perspective of environmental sustainability, the preservation of biodiversity and the commitment to life. The agroecological model of production proposes the production of safe food without the use of agrochemicals, based on traditional knowledge and methods of environmental management and management produced over many generations, in a meeting between human beings and nature. (ANA, 2010; NAVOLAR et al., 2010; PACHECO, 2010).

## IV.   METHODOLOGY

This research is exploratory and descriptive, whose objective was to identify with the national and international organizations that address the theme of Food and Nutritional Security the policies implemented in the country by the State and its relationship with the guidelines of Family Agriculture, verifying that Brazil is the only country in the world that has a specific law to ensure the quality of food for its population. Authors from the areas of health and social sciences who stand out as scholars of the subject were sought, but the basis of the information was the reports developed by the United Nations Food and Agriculture Organization (FAO), by the International Fund for Agricultural Development ( IFAD), the World Health Organization (WHO), the World Food Program (WFP), and the United Nations Children's Fund (UNICEF), on the State of Food and Nutrition Security in the World (2016; 2017; 2018 These documents inform that Brazil in Latin

America has the best position in the implementation of policies to combat poverty and hunger, having already fully achieved the targets set for 2015 and many of the SDGs - Sustainable Development Goals recommended in the Agenda 2030, without disastrous State actions being recognized as obstacles to development.

## V.   FINAL CONSIDERATIONS

The creation and application of incentive programs for food and nutrition security in order to provide improvements in the quality of life for family farmers,hascontributed to promote the socioeconomic development of rural communities as a whole in Brazil.The democratization of public policies represents a promising way to build a new social reality, with a view to reducing inequalities.

Brazil has been employing strategies that combine income transfer programs and support for production, supply and access to food, which contribute to the improvement of food and nutritional security indices, and in the expansion of conditions of production, supply, distribution and consumption of food. adequate and healthy, even at that moment lived around the world with COVID 19, where hunger started to increase, with unemployment and the restrictions imposed on social interaction, making poorer those who survive informal jobs.

The Emergency Aid given by the federal government, has already directly and indirectly benefited 125.4 million people in the pandemic, guaranteed some food for families (Ministry of Citizenship, 2020).Data released by FAO on July 15, 2020 in the Report "The State of Food and Nutritional Security in the World", reveal that Brazil remains outside the World Hunger Map, however, according to the entity, 37.5 million people lived a situation of moderate food insecurity in the country in the period between 2014 and 2016, between 2017 and 2019 this number reached 43.1 million. In percentage terms, the number also rose, from 18.3% to 20.6%.The document says that, although Africa is the region where the highest levels of total food insecurity are observed, it is in Latin America and the Caribbean that food insecurity is increasing most rapidly: it grew from 22.9% in 2014 to 31, 7% in 2019, and also a cause for alarm, the fact that it is in that part of the world where the cost of the diet that meets the minimum energy needs per day, is 34% more expensive in the world, US $ 1.06. This means that for that amount, more than 104 million people cannot afford a healthy diet.

A relevant fact in Brazil was the approval of Law 14,016, enacted in June 2020, which provides for

combating food waste. The text authorizes establishments that operate with food production and supply, including fresh, industrialized products and ready meals, to donate the surplus that has not been commercialized, but that is still fit for human consumption, guaranteeing the poor intake necessary for poor families. maintaining health.

The document infers that the food security and nutritional status of the most vulnerable population groups will deteriorate further due to the health and socioeconomic impacts of the pandemic caused by Covid-19 and ends with the discussion of policies and strategies to transform food systems, the in order to ensure affordable healthy diets as part of the efforts needed to end hunger and all forms ofmalnutrition. It signals the significant challenges that remain in the fight against hunger, food insecurity and malnutrition in all its forms, and calls for action on two fronts:

1) Safeguard food and nutrition security through economic and social policies that help to neutralize the effect of economic slowdowns or contractions;

2) Address existing inequalities at all levels through multisectoral policies that make it possible to eradicate food insecurity and malnutrition.

## REFERENCES

[1] ABRAMOVAY, R. Combate à pobreza: chegou a hora da qualidade. Valor Econômico, São Paulo, 2006.

[2] ALTAFIN, Iara. Reflexões sobre o conceito de agricultura familiar. Disponível em: http://mstemdados.org/sites/default/files/ pdf. Acesso em: 25/08/2020.

[3] ANA– Articulação Nacional de Agroecologia. **Soberania e Segurança Alimentar na construção da Agroecologia**. Sistematização de Experiências, 2010. Disponível em http://www.agroecologia.org.br/publicacoes/agroecologia.pd f Acesso em: 20 de agosto de 2020.

[4] BARROS, Ricardo Paes de. **Desigualdade de renda no Brasil**. Brasília: IPEA, 2007.

[5] BATISTA FILHO, Malaquias. Da fome à Segurança Alimentar retrospectiva e visão prospectiva. *Revista Saúde Pública*, Rio de Janeiro, v. 19, n. 4, p. 872-873, jul./ago. 2003.

[6] BELIK, Walter. Perspectiva para Segurança Alimentar e Nutricional no Brasil. Saúde e Sociedade, V.12 No 1, p. 12-20, jan-jun, 2003.

[7] BIANCHINI, V. O universo da agricultura familiar e sua contribuição ao desenvolvimento rural. Rio de Janeiro, 2005.

[8] BRASIL. Lei nº 11.947 de 16 de junho de 2009. Dispõe sobre o atendimento da alimentação escolar e do Programa Dinheiro Direto na Escola aos alunos da educação básica. Diário Oficial da União, 2009.

[9] BRASIL. Lei Orgânica de Segurança Alimentar e Nutricional - Lei 11.346 de 15 de Setembro de 2006.

[10] BRASIL. CONAB. Programa de Aquisição de Alimentos. Resultados das Ações da Conab em 2012.

[11] BRASIL. Banco Central do Brasil. FAQ – Programa Nacional de Fortalecimento da Agricultura Familiar – PRONAF. Disponível em: http://www.bcb.gov.br/pre/bc_atende/port/PRONAF.asp#1. Acesso em: 25 de agosto de 2020

[12] BRASIL. Ministério do Desenvolvimento Social. Programa de Aquisição de Alimentos – PAA. Disponível em: http://www.mds.gov.br/segurancaalimentar/aquisicao-e-comercializacao-da-agricultura-familiar. Acesso em: 25/08/2020.

[13] Brasil. Emenda Constitucional n. 64, de 4 de fevereiro de 2010.Altera o art. 6º da Constituição Federal, para introduzir a alimentação como direito social. *Diário Oficial da União,* fevereiro de 2010.

[14] BRASIL. Fundo Nacional de Desenvolvimento da Educação (FNDE). Programas, Sobre o PNAE. Disponível em: http://www.fnde.gov.br/programas/alimentacao-escolar. Acesso em: 25/08/2020.

[15] BRASIL. Casa Civil. Lei nº 11.326 de 24 de julho de 2006. Estabelece as diretrizes para a formulação da Política Nacional da Agricultura Familiar e Empreendimentos Familiares Rurais. Diário Oficial da União, 2006.

[16] BRUMER, Anita. Previdência social rural e gênero. Sociologias, Porto Alegre, ano 4, nº 7, jan/jul, p. 50-81, 2002.

[17] BUAINAIN, A. M. **Trajetória recente da política agrícola brasileira**. 326 p. Tese (Doutorado em Ciências Econômicas) - Instituto de Economia, Universidade de Campinas, 1999.

[18] CASTRO, Josué de. Geografia da fome: o dilema brasileiro, entre o pão e o aço. 10. ed. São Paulo: Brasiliense, 1967.

[19] CHAYANOV, Alexander V. La organización de la unidad económica campesina. Buenos Aires: Ediciones Nueva Visión, 1974.

[20] COELHO[, Maria do Socorro Martinho. Inter-relações entre a agricultura familiar e o programa nacional de alimentação escolar no município de Machado – MG. 2012. Dissertação (Mestrado em Política Social) – Escola de Serviço Social, Universidade Federal Fluminense. Niterói, Rio de Janeiro. 2012.

[21] CONSELHO NACIONAL DE SEGURANÇA ALIMENTAR E NUTRICIONAL – CONSEA. Princípios e Diretrizes de Uma Política de Segurança Alimentar e Nutricional. Gráfica e Editora Positiva. Brasilia – DF, 2004.

[22] CUNHA, Edite da Penha; CUNHA, Eleonora Schettini M. Políticas públicas sociais. In: CARVALHO, Alisson; et al. (Org.) Políticas Públicas. Belo Horizonte: Editora UFMG, Proex, 2002.

[23] CORNWALL, A., & BROCK, K. (2005). What do buzzwords do for development policy? A critical look at "participation","empowerment" and "poverty reduction". *Third world quarterly*, *26*(7), 1043-1060.

[24] Lei n. 11.947, de 16 de junho de 2009 (2009). *Atendimento da alimentação escolar e do Programa Dinheiro Direto na Escola aos alunos da educação básica e dá outras providências.* Brasília-DF.

[25] DECLARAÇÃO MUNDIAL DE ROMA. Disponível em: <www.feedingminds.org/level3/lesson3/WFSdecl_pt.htm>. Acesso em: 25/08/2020.

[26] FAO/OMS/OPAS. Panorama Segurança Alimentar e Nutricional da América latina e o Caribe: sistemas alimentares sustentáveis para acabar com a fome e a má nutrição. Santiago – Chile, 2017.

[27] FAO. Methods for estimating comparablerates of food insecurity experienced by adults throughout the world. Rome, 2016. (also available atwww.fao.org/3/a-i4830e.pdf

[28] FAO, IFAD, UNICEF, WFP & WHO. 2017. The State of Food Security and Nutrition in the World 2017: Building resilience for peace and food security. Rome, FAO.(also available at www.fao.org/3/a-I7695e.pdf).

[29] FAO, IFAD, UNICEF, WFP & WHO. 2018. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO.(also available at www.fao.org/3/I9553EN/i9553en.pdf).

[30] FAO. 2020. COVID-19 global economic recession: avoiding hunger must be at the centre of the economic stimulus. Rome. (also available at www.fao.org/3/ca8800en/CA8800EN.pdf).

[31] FAO, IFAD, UNICEF, WFP & WHO. 2017. The State of Food Security and Nutrition in the World 2017: Building resilience for peace and food security. Rome, FAO. (alsoavailable at www.fao.org/3/a-I7695e.pdf).

[32] FREITAS, Eduardo de. "Thomas Malthus"; *Brasil Escola*. Disponível em: https://brasilescola.uol.com.br/geografia/thomas-malthus.htm. Acesso em 27 de agosto de 2020.

[33] GUEDES PINTO, L. C. Reflexões sobre a política agrária brasileira no período de 1964-1994. **Reforma Agrária**.Campinas, v. 25, n. 1, p. 65-92, 1995.

[34] International Monetary Fund (IMF). 2020. World Economic Outlook, June 2020: a crisis like no other, na uncertain recovery. Washington, DC. (also available at www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020).

[35] LAZZARINI, Sergio G. Capitalismo de Laço. Bei Editora, 2018.

[36] MATTEI, L. Programa de aquisição de alimentos da agricultura familiar (PAA): antecedentes, concepção e composição geral do programa. Sociedade e Desenvolvimento Rural, Brasília, v. 1, n. 1, p. 1-12, 2007.

[37] NAVOLAR, T.S.; RIGON, S.A.; PHILIPPI, J.M.S. Diálogo entre agroecologia e promoção da saúde. Revista Brasileira de Promoção da Saúde 23(1): 69-79, 2010.

[38] PESSANHA, L. D. R. *Pobreza, Segurança Alimentar e Políticas Públicas:Contribuição ao Debate Brasileiro.*(texto apresentado no Seminário "SistemasLocais de Segurança Alimentar" realizado no Instituto de Economia da Unicamp

em novembro de 2002. 1: Estimativa de Beneficiários de Programas de Combate à Fome, 2001.

[39] PITAGUARI, S. O.; LIMA, J. Ferrera de. As idéias keynesianas e o crescimento do produto nas economias locais. Interações: Revista Internacional de Desenvolvimento Local, Campo Grande, v. 6, n. 10, p. 11-20, 2005.

[40] SEN, Amarya. *Desenvolvimento como liberdade*. São Paulo: Companhia das Letras, 2002.

[41] SOUZA, Celina. Políticas Públicas: uma revisão da literatura. Sociologias, Porto Alegre, ano 8, nº 16, jul/dez. 2006, p. 20-45

[42] UNICEF, WHO and International Bank for Reconstruction and Development/World Bank.2020. *UNICEF-WHO-The World Bank: Joint child malnutrition estimates – Levels and trends* (March 2020 edition) [online]. data.unicef.org/topic/nutrition.www.who.int/nutgrowthdb/estimates,data. worldbank.org.

[43] TURPIN, M.E SEN, Amarya. A alimentação escolar como vetor de desenvolvimento local e garantia de segurança alimentar e nutricional. 2008. Dissertação (Mestrado) – UNICAMP, Campinas, 2008. 176 f.

[44] WFP. New digital map shows terrible impact of COVID-19 on school meals around the world. In: *WorldFood Programme* [online]. Rome.2020. www.wfp.org/news/new-digital-map-shows-terrible-impactcovid-19-school-meals-around-world.

[45] WFP. 2017. *Fill the Nutrient Gap El Salvador: summary report*. Rome. (also available at https://docs.wfp.org/api/documents/WFP-0000023738/download/?_ga=2.192387818.1174494151.1587721921-9809492.1584029776).

# Reflective portfolio as evaluation and self-assessment instrument in the teaching process learning: Experience report

Selma Kazumi da Trindade Noguchi[1], Diego João de Lima Arrais[2], Enderson Vasconcelos de Lima[3], Juliana de Oliveira Bezerra[4], Giovanna Farias de Sousa[4], Gabrielle Santiago Costa Neves[4], Beatriz Pinheiro Bechir[4], Josinete da Conceição Barros do Carmo[5], Leane dos Reis Costa[5], Danielle Rêgo Gonçalves[5], Suane Priscila dos Santos Antunes[5], Clédia Maria Gomes Moraes[5], Bruna Massane de Moura Loiola[5], Jonatas Bezerra Tavares[6], Widson Davi Vaz de Matos[7], Liliane Souza Soares Cerqueira[8], Juliana de Souza Lima Coutinho[9], Adams Brunno Silva[10], Alex Miranda Franco[11], Gisela Pereira Xavier Albuquerque[12], Elyade Nelly Pires Rocha Camacho[13], Thamyris Abreu Marinho[14], Eimar Neri de Oliveira Junior[15], Marcio Almeida Lins[15], Robervânia Ferreira da Costa[15], Jaqueline Cardoso Marcena[15], Lucilena Estumano Almeida[15], Danielle Oliveira Maciel[16], Hermana Rayanne Lucas de Andrade Bender[5], Darllene Lucas de Andrade[17], Maicon de Araujo Nogueira[18*], Weslley do Vale Maia[19], Cinthya Lorena Bezerra Sarmanho[20], Isadora Menezes Franco[21], Tiago Nolasco dos Anjos Leão[22], Amanda Carolina Silva de Aviz[22], Mayco Tadeu Vaz Silva[22], Talita Lima dos Santos[22], Isadora da Costa de Souza[22], Letícia Lôide Pereira Ribeiro[22], Gabrielle Reis de Nazaré[22], Ediane dos Anjos Leão Franco[23], Renata Di Karla Diniz Aires[24], Alda Helena dos Santos Carvalho[25], Luciene Maria dos Reis[26], Pamela Nery do Lago[27], Joana Katia de Mendonça Flexa Monteiro[28], Maria José Cruz de Souza[29], Karine Honorato dos Santos[30], Elcilane Gomes Silva[31], Alfredo Cardoso Costa[32], Simone Aguiar da Silva Figueira[33], Jofre Jacob da Silva Freitas[34], Renato da Costa Teixeira[35], Antonia Margareth Moita Sá[36]

[1]Physiotherapist, Master in Health Education in the Amazon, Doctoral Student, Stricto Sensu Postgraduate Program, Professional Doctorate in Health Education in the Amazon, Pará State University. Professor at the Esamaz, Belem, Para, Brazil.
[2]Nurse, Master's student at the Stricto Sensu Postgraduate Program, Master in Nursing, Federal University of Pará (UFPA), Belem, Para, Brazil.
[3]Nursing Student, Estácio Castanhal Faculty, Castanhal, Para, Brazil.
[4]Nurse, State University of Para (UEPA), Belem, Para, Brazil.

[5]Nurse, University of Amazon (UNAMA), Belem, Para, Brazil.

[6]Nurse, Palmas School of Public Health Foundation, Tocantins, Brazil.

[7]Resident Nurse, Oncology Nursing Residency Program, Federal University of Para (UFPA), Belem, Para, Brazil.

[8]Nurse, Brazilian Hospital Services Company (EBSERH), Clinical Hospital of the Federal University of Minas Gerais (UFMG), Minas Gerais, Brazil.

[9]Resident nurse in elderly health, Federal University of Minas Gerais (UFMG), Minas Gerais, Brazil.

[10]Nurse, Ophir Loiola Hospital (HOL). Master degree student, Nursing Master Degree Program, State University of Para (UEPA), Belem, Para, Brazil.

[11]Nurse, Master in Health Education in the Amazon (ESA), State University of Para (UEPA), Belem, Para, Brazil.

[12]Nurse, João Barros Barreto University Hospital (HUJBB), Federal University of Para (UFPA), Belem, Para, Brazil.

[13]Master in Nursing, Federal University of Pará (UFPA). PhD in Tropical Diseases, Postgraduate Program in Topical Diseases (PGDT), Nucleus of Tropical Medicine (NMT / UFPA), Belem, Para, Brazil.

[14]Nurse, Post graduate. Stricto Sensu Graduate Program in Nursing, Federal University of Para (UFPA), Belem, Para, Brazil.

[15]Nurse, Metropolitan University Center of the Amazon (UniFAMAZ), Belem, Para, Brazil.

[16]Nurse, João Barros Barreto University Hospital (HUJBB), Federal University of Para (UFPA), Belem, Para, Brazil.

[17]Nursing Student, Integrated Faculty of Brazil Amazon (FIBRA), Belem, Para, Brazil.

[18]Nurse, Master in Health Education in the Amazon, PhD student, Stricto Sensu Postgraduate Program, Professional Doctorate in Health Education in the Amazon (ESA), State University of Pará (UEPA). Professor at Escola Superior da Amazônia (ESAMAZ), Belem, Para, Brazil. *E-mail: profmaiconnogueira@gmail.com

[19]Nurse, Federal University of Para (UFPA), Belem, Para, Brazil.

[20]Nurse, Master in Health Education in the Amazon, Stricto Sensu Post Graduate Program, Professional Master degree in Health Education in the Amazon (ESA), State University of Para (UEPA). Professor at University Center of Amazon (UniFAMAZ), Belem, Para, Brazil.

[21]Nursing Student, State University of Para (UEPA), Belem, Para, Brazil.

[22]Nursing Student, University of Amazon (UNAMA), Belem, Para, Brazil.

[23]Nurse, Ophir Loiola Hospital (HOL), Belem, Para, Brazil.

[24]Nurse, Master. Professor at the State University of Ceara (UECE), Ceara, Brazil.

[25]Nurse, Clinical Hospital of the Federal University of Minas Gerais (UFMG), Minas Gerais, Brazil.

[26]Nurse, Faculty of Science and Technology of Unai (FACTU), Minas Gerais, Brazil.

[27]Nurse, nursing coordinator of the specialized medical clinic at Clinical Hospital of the Federal University of Minas Gerais (UFMG / EBSERH), Minas Gerais, Brazil.

[28]Nurse, Master's Student, Academic Program in Health Care Sciences, Fluminense Federal University (UFF), Rio de Janeiro, Brazil.

[29]Nurse, Federal University of Amapa (UNIFAP), Amapa, Brazil.

[30]Nursing Student, Escola Superior da Amazônia (ESAMAZ), Belem, Para, Brazil.

[31]Doctor. PhD student, Stricto Sensu Graduate Program, Professional Doctorate in Health Education in the Amazon (ESA), Universidade do Estado do Pará (UEPA). Professor at the UEPA, Belem, Para, Brazil.

[32]Biologist. PhD student, Stricto Sensu Graduate Program, Professional Doctorate in Health Education in the Amazon (ESA), Universidade do Estado do Pará (UEPA). Professor at the UEPA, Belem, Para, Brazil.

[33]Nurse, Master in Health Education in the Amazon, PhD student, Stricto Sensu Graduate Program, Professional Doctor degree in Health Education in the Amazon (ESA), State University of Para (UEPA). Professor at the State University of Para (UEPA), Campus Santarem, Para, Brazil.

[34]Biomedic. PhD in Cellular and Tissue Biology in the University of Sao Paulo. Full professor in undergraduate course in medicine and professional master's and doctorate courses in health education in the University of Para State (UEPA), Belem, Para, Brazil.

[35]Physiotherapist, PhD in Education. Assistant Professor IV, State University of Pará (UEPA). Permanent member of the faculty in the Stricto Sensu Postgraduate Program, Master and Professional Doctorate in Education and Health in the Amazon (ESA), State University of Para (UEPA), Belem, Para, Brazil.

[36]Nurse, PhD in Nursing, Federal University of Rio de Janeiro (UFRJ). Permanent member of the faculty in the Stricto Sensu Postgraduate Program, Master and Professional Doctorate in Education and Health in the Amazon (ESA), State University of Para (UEPA), Belem, Para, Brazil.

*Abstract— Objective: to describe the experience of professors and students of the undergraduate nursing course in the use of reflective portfolio as instrument of assessment and self-assessment in the teaching-learning process. Method: experience report, with participatory observation of professors and students of the undergraduate nursing course at the University of the Amazon (UNAMA), Belém, State of Pará, Brazil, regarding the use of active methodologies in the construction of teaching in Urgency and Emergency, in the period from August 6 to December 22, 2019. Result: in this teaching-learning process, using active teaching*

*methodologies and formative evaluation, through the reflective portfolio, teachers played a fundamental role, acting as facilitators, emphasizing self-directed and student-centered learning. Such experiences provided the actors involved, teachers, students and managers, to see teaching as a privileged space, which allows constant interaction at the moment of integrating theory learned in the classroom with practice. Conclusion: the use of active teaching methodologies and consequent evaluation through the assessment tool, online portfolio, contributes to increase the self-confidence, self-knowledge and reflexive competence of students throughout the training process, in addition to providing theoretical-practical dialogue aimed at the profile of the professional that it aims to form.*

*Keywords— Teaching. Reflective portfolio. Active methods. Evaluation.*

## I. INTRODUCTION

In the current context of university education, the traditional models of teaching, learning and evaluation are put in check, which start from linear and verticalized premises, opening space for proposals that bet on a new approach to training, which increases a dialogical education among the actors involved , teachers, students and higher education managers[1].

The use of the portfolio in this process is a relatively current topic, which has been frequently and increasingly improved in different contexts and by researchers from different professional categories, a relevant fact for the real transformation of education in the health area[2].

Where collaborative learning is privileged, the autonomy of students, the processes of evaluation and self-evaluation, based on teaching proposals with creative activities and the partnership between students and teachers, among other elements that guide the process of teaching and learning, is not to cause strangeness that, more and more, teachers and managers of higher education are betting on assessment instruments that are also dynamic and reflective, that allow a meaningful teaching-learning, having the student as the main focus of the teaching-learning process[3].

In this perspective, the reflective portfolio falls within the context of training by skills and formative assessment, whose learning is based on constant and continuous feedback between teacher and student, and student-student. The results should focus on the process of building knowledge in a dialogical and creative way, transcending the cast and crystallized, punctual and classificatory paradigm used in the evaluations present in traditional teaching models[1].

Portfolio is recognized as both an instrument and an evaluation methodology. As a methodology, it requires teachers and students to assume a posture committed to a pedagogical practice based on the transformation and overcoming of adversities and challenges. In this perspective, the triad: critical about the construction of new

knowledge, renewed synthesis of the knowledge plan and action in relation to the new synthesis elaborated. As an instrument, it fulfills the purposes of collecting and registering information, transcending the instrumental aspect, given that, under this focus, it gives rise to reflection on the relationship between theory and practice [3].

The evaluation in the teaching process must be permanent and planned, taking into account all the dynamics of the path that the student goes through during the learning process. In this context, there are conflicts with care situations, the perception of the world of work, inherent challenges to communication, requiring the exercise of listening and permanent reflection. The student is evaluated regarding their commitment, participation, motivation, capacity for reflection and critical thinking, which are the main factors for assessing academic performance. The subjectivity of interpersonal and intrapersonal relationships, and measurements between peers and groups are fundamental aspects that must also be considered in the evaluation field[4].

In this context, assessment instruments emerge, which are records of different natures, such as: tests, tests, works, scientific, intellectual and artistic productions of the students, based on the assumption that only what was taught could be evaluated[4].

Among different teaching assessment instruments present in university education, the reflective portfolio stands out as an innovative method, capable of leading students to pan and collect their opinions, doubts, difficulties, reactions to the contents, the studied texts and the techniques of teaching, feelings and situations experienced, offering subsidies for the evaluation of the student, the educator, the contents and the teaching and learning methodologies planned and implemented. In education, the portfolio presents several possibilities, with the main contribution to learning being built by the student himself, or group of students. Gradually, throughout the school semester, the student organizes his productions,

which show the trajectory of his knowledge construction process[1].

Evaluation of the training process concerns the accompaniment of teaching and learning and, therefore, works as a mediating tool in this process, that is, it mediates the relations between teaching and learning, between teacher and student, and not least, the management of teaching. When carrying out the evaluation process, as a mediating and formative action, the teacher becomes a facilitating, reflective and guiding agent, monitoring the student's performance and analyzing his own work[4]. Thus, the portfolio allows the teacher to experiment with diversified alternatives. and reflect on the possibility of future use in their own professional practice[3], confirming the role of the university, to develop, in students, cognitive, metacognitive, social, emotional, affective, motivational, technological and instrumental skills, enabling these competences become the priority object of the training apparatus.

In the meantime, the exercise of skills provided by the reflective portfolio stimulates the autonomy, the critical, reflective, creative and citizen spirit of the actors in training[1], and it is on this theme that the present experience focuses. Thus, the objective of this work was to describe the experience of professors and students of the undergraduate nursing course in the use of the reflective portfolio as an instrument of assessment and self-assessment in the teaching-learning process.

## II. METHOD

Report of experience with participative observation of professors and students of the Nursing Undergraduate course at the University of the Amazon (UNAMA), Belem, State of Para, Brazil, from August 6 to December 22, 2019.

The approach describes aspects related to the experience of academics in the seventh period of the undergraduate nursing course, with an emphasis on the activities developed in the curricular component "Nursing Care in Emergency and Trauma".

The institution's nursing course works with guiding principles in the curriculum that aim to develop attitudes and skills essential to health work. These axes intend to guide the training of nurses to meet the needs of the world of health work, prioritizing the profile of the nursing professional with critical-reflexive capacity and who can intervene on the locoregional health reality. It is guided by the nurse profile recommended in the National Curriculum Guidelines (DCN) of the Undergraduate Nursing Course, National Education Council, Higher Education Chamber,

Resolution CNE / CES, of November 7, 2001, whose Article 3 points out how profile of graduate / professional traineeNurse, with generalist, humanistic, critical and reflective training. Qualified professional for the practice of Nursing, with scientific and intellectual rigor and guided by ethical principles. Able to know and intervene on the most prevalent health-disease problems / situations in the national epidemiological profile, with an emphasis on their region of activity, identifying the spiritual biopsychological and social dimensions of their determinants. Trained to act, with a sense of social responsibility and commitment to citizenship, as a promoter of the integral health of human beings[5].

The curricular component "Emergency Nursing Care and Trauma" makes up the seventh semester of the course, has a theoretical-practical character, with a workload of 80 hours, seeks to develop in the student the skills and competences for nursing care for high-risk patients in urgency and emergency, in order to provide nursing assistance in pre-hospital, hospital and home emergencies, in addition to performing nursing procedures in the main emergency situations, using the nursing care instruments based on the assessment of the health status of the patient. individual, promoting clinical reasoning, through experiences in health institutions where the Nursing Process and Nursing Care Systematization can be applied, in order to understand health work. It is based on ethical, political, economic, cultural and social determinants for the recognition of health professionals as transforming care agents.

As it is a curricular component thought and dynamically structured, its evaluation requires instruments that can account for the construction of skills and competences necessary for the nurse's performance in this context, and that are not limited to classify or quantify the proposed and implemented activities.

We believe that when methodologically and reflexively formulating the evaluation process to be worked on, it is necessary to consider the programmatic contents, the bibliographic material, the laboratory practices, the experiences in the health services, the teaching supervision, the apprehension of skills and competences, the building academic identity with the course, breaking paradigms and understanding the role of the academic as an active subject in the teaching-learning process.

The choice to use the portfolio as an instrument for evaluating the discipline was due to the fact that in it, activities of analysis and reflection are proposed, all thought from problem situations arising from the practice,

built by the faculty, which requires students communication skills and critical analysis.

In this process, with the use of active methodologies, it assumes that the student's assessment must value the dynamism that involves the training, in an integral way; allowing the monitoring, mutual exchange and growth of everyone involved in the teaching-learning process.

Among assessment instruments that use reflection and the development of critical thinking, we identified the portfolio, as it is an instrument that presents an opportunity to build from a dialogical relationship between educator and student. It enables the apprehension of personal and interpersonal information and meanings, which mediate knowledge, dialogue with the various actors involved and allow meaningful learning[1-4].

Portfolio enables questioning, criticism, reflection, formulation and reformulation. It is not ready, it is unfinished and in constant construction, welcoming criticism and reframing of impressions. It presents flexibility and dynamism, because it always seeks to expand the possibilities of formulations and reframings, and when it presents a chronology it must allow to accompany personal / professional growth and with it identify needs, weaknesses and inaccuracies, allowing them to be corrected in time, so that learning is in fact significant[1].

We believe that this instrument stimulates reflective thinking, allowing the recording and documentation of the learning itself. It provides guidelines for reformulations that respond to the objectives of the curricular component, indicating new paths and possibilities, allowing the exchange between peers, new perspectives on the same activity, enabling the understanding of the diversity of interpretations and multiple understandings under the same aspect of health training work.

In elaborating the evaluation process of the discipline, we sought to apprehend the essence of the development of each student in their training process, allowing the expression of subjectivity and the search for knowledge constructed, apprehended and reframed by the academic, in a growing spiral of involvement and technical-scientific development. The product of this evaluation process is characterized by significant learning, that is, one that makes sense and has theoretical and practical applicability.

In this experience, the teachers initially taught an integrated class with the explanation of ideas of how to make a portfolio and build a blog, as well as the step by step of inserting publications in the Virtual Learning Environment. It is reiterated that in this stage there was the active participation of students, through the teaching strategy Brainstorming.

During the classes, the students synthesized the contents taught, being directed to research content considered important to foster the construction of knowledge in the context of nursing care in urgency and emergency from the literature evidence, guided by the teaching plan of the discipline.

When the period of practical classes started, technical visits were made: one took place in an Emergency Unit and the other in a municipal Emergency Room. On the occasion of the referred visit, it was possible to observe the routine of care offered by these services. Observation continued during the semester, during supervised practices.

The contents were organized and inserted according to the schedule of classes, these were evaluated by peers and teachers, with an emphasis on relevance, scientificity, compliance with scientific consensus, respect for ethics, property and intellectual rights. It is reiterated that all the content inserted in the online portfolio / blog followed the recommendations of citation and referencing, giving due credit to the authors of origin in compliance with ethical precepts.

In addition to the practical activities carried out during supervised practices and laboratories, which served as a starting point for research and inclusion of content in the online portfolio, all activities carried out in the classroom were also part of the discipline's records. and images were added to the blog and served as a subsidy for building the portfolio.

At the end of the academic semester, there was a culmination moment, when the students presented their experiences, inserted in the blog, bringing their reflections, self-evaluation and evaluation in the groups, allowing collective feedback.

## III.    RESULTS AND DISCUSSION

The findings of this experience made it possible to show that the configuration of the teaching and learning evaluation process proposed and implemented, as it was agreed between teachers and students, allowed them to assume a committed and co-responsible posture, with transparency throughout the process, which allows us to infer by identifying positive manifestations from students that this proposal was recognized as a legitimate instrument to be applied, considering the needs of students and having the involvement of these and teachers, from the experience in the construction and orientation of portfolios,

resulting in a process meaningful and motivating assessment.

These results are in line with other studies, where the expectation in using the portfolio was to be able to mobilize the student's personal responsibility over their learning process, favoring the analysis of the singularities and peculiarities of each one's development[6,7].

Such finding was evidenced from the students' speeches, where we observe reports that the portfolio makes it possible to connect the contents studied in the classroom with the real world, the professional world and everyday life. As students are encouraged to pay attention to the events around them and to think about them, actively seeking content published in the databases and means of scientific dissemination, a critical and reflective practice is instituted and, concomitantly, a commitment to the best health practices, the light of evidence, the exercise of citizenship and with the current health system, Unified Health System (SUS).

We emphasize that the criteria used in the evaluation were transparent and clear, explained and agreed upon since the beginning of the academic semester, facilitating the student's visualization of his / her training process in a continuous and procedural way. We reiterate a positive apprehension in this experience, given that, there was the development of comprehension and interpretation skills, which we believe to be a facilitating element in the decision-making process about the contents, with effective exercise of oral and written communication.

The results of this experience are in line with the results of other studies[1,7] by demonstrating that the evaluation instrument is not presented as a simple intuitive innovation, but that, based on a theoretical-conceptual framework associated with a previous reflection on the pertinent literature proved to be an excellent didactic and evaluation possibility, pointing to the different probabilities of using the portfolio.

We found that students, while building an opportunity, guided by teachers attentive to the competencies established in the teaching plan, made reflections on learning and progress.

In this perspective, the online portfolio proved to be an assessment tool with potential for use in the teaching-learning process, where the feedback, by the teachers, was not only through oral communication, there was written registration, helping in the process of self-evaluation and evaluation, thus making the culmination and evaluation moments an excellent opportunity for growth and mutual learning.

We believe that there was the development of the student's responsibility for his own learning, given that the reflective activity was made explicit both in the portfolios as a document, as well as in the evaluations and self-evaluations carried out at the end of the school semester. assessment in addition to the analysis of earnings (summative assessment), providing reflection on one's own thinking and the work carried out, allowing the detection of mistakes made, the valuation of learning and evolution, in addition to the valuation of the level of personal satisfaction (formative assessment).

We understand and propose the use of the portfolio as the individual record of all the knowledge developed by the student, organized based on their reflections and activities guided by the teacher, as well as comments on classes and experiences.

During the construction of this important tool, informative links, videos, images with relevant information on the theme, contents that were part of the classes taught and the activities developed during the semester were inserted according to the respective effective dates.

The contents were organized according to the curriculum component schedule and the activities carried out during the school term, always following a chronological sequence. As a final product, we built a portfolio and presented it to classmates and teachers, showing in great detail everything that was planned, elaborated and developed during the construction of the curriculum component.

During the preparation period, it was observed that the portfolio / blog is an important methodological resource for assessment, both in teaching and in learning, because when organized in a portfolio format, it allows students the opportunity to learn in a practical, dynamic way and interactive. In addition to providing Internet users with new sources of knowledge, it innovates the educational methodology and ratifies the triple research, teaching and extension proposed by educational institutionse[1,7].

The use of the reflective portfolio in this experience made the evaluation of the teaching learning process dynamic, diversified, different and attractive, which was based more on the execution path than on the results, on the processes than on the products, in line with the ways of working located in scenarios as close to the real ones as possible.

It is emphasized as a contribution to the educational practice, that the critical, reflective and active action carried out by nursing students, through the reflective portfolio, has the potential to allow the future professional to experiment with a new teaching, learning, assessment

and self-assessment strategy, so that, in the future, it can be applied with practical experience[7]. Furthermore, the experience allowed to know the weaknesses and potential of the strategy, so that teachers can plan its use effectively, according to the context and also with the group of students with whom the teacher / facilitator will interact and the profile of the student desired egress.

Finally, we believe that the objective set was achieved, and although we have not obtained results different from those already available in the scientific community, this study reiterates the reflective portfolio as a promising strategy for formative assessment.

## IV. CONCLUSION

The use of active teaching methodologies and consequent evaluation through the assessment tool, online portfolio, contributes to increase the self-confidence, self-knowledge and reflexive competence of students throughout the training process, in addition to providing theoretical-practical dialogue focused on the profile of the professional who aims to form.

An evidence pointed out by the speeches on evaluation days and in conversations at the end of classes, is that students identify with this new evaluation possibility, which, at first, seems strange and causes discomfort, but which, with the development of the discipline, materialized and allowed each student to accompany their formative process.

As knowledge is built, students begin to apply their critical and reflective skills in a practical way; and as you return to the portfolio, through the exercise of writing, there is the construction of a story.

We believe that in the perspective of this formative assessment methodology, more than an assessment and self-assessment exercise, there is a construction of identity with the profession, in a more critical, reflective and above all attitudinal way.

We reiterate that such an experience is not challenging and full of mishaps only for students, in terms of overcoming the traditional paradigm with application of tests; reflect, write, and build the portfolio, invited us as teachers to reformulate our practices, our methodologies and to look for other ways of teaching-learning-teaching, in a dynamic that understands to evaluate the process and no longer the final result.

It is understood that it is necessary to learn to evaluate, to face this moment as something that enhances learning, in the sense of integrating, proposing trajectories to be followed, but not the path with crystallized goals, established without space for discussions.

The achievements are unquestionable, however there is still a lot to try to understand and pan in these teaching relationships; such search for instruments, methods with the potential to offer students favorable space to learn, learn, live and live together must be goals pursued by all higher education teachers and managers.

A certainty pointed out is the certainty that we should always encourage students to read and record activities as a way to support scientific development. Much more than technicians, manufacturers, we want to train citizens aware of their social potentials and critical subjects capable of identifying problems, with the capacity to cope with the search for solutions.

## REFERENCES

[1] Cotta RMCM, Costa GD. Instrumento de avaliação e autoavaliação do portfólio reflexivo: uma construção teórico-conceitual. Interface Comunicação Saúde Educação. [Internet]. 2016; [Cited 2020 Jul 08] 20(56):171-83. Available: https://www.scielosp.org/pdf/icse/2016.v20n56/171-183/pt

[2] Pinheiro AKC et al. O portfólio como instrumento de avaliação na graduação em enfermagem. Anais do 13º Congresso Internacional da Rede Unida. [Internet]. 2018. [Cited 2020 Jul 08]; 4(1). Available: http://conferencia2018.redeunida.org.br/ocs2/index.php/13CRU/13CRU/paper/view/1873

[3] Vilarinho LRG et al. O Portfólio como instrument de Avaliação: uma análise de artigos inseridos na base de dados e-AVAL. Meta: Avaliação, Rio de Janeiro. [Internet]. maio/ago. 2017; [Cited 2020 Jul 08]; 9(26): 321-336. Available: http://revistas.cesgranrio.org.br/index.php/metaavaliacao/article/view/1456/pdf

[4] Rodrigues DB et al. Avaliação da aprendizagem no ensino médio: as concepções dos professores de física sobre o uso da observação e dos registros para avaliar. Educação em Debate, Fortaleza. [Internet]. anos 35-38 - n. 66-71 jul/dez. 2013, jan./jun., jul/dez. 2014, jan./jun., jul/dez. 2015, jan./jun. 2016; [Cited 2020 Jul 08]. Available: http://repositorio.ufc.br/bitstream/riufc/21269/1/2016_art_db rodrigues.pdf

[5] Resolução CNE/CES Nº 3, de 7 de novembro de 2001. Institui Diretrizes Curriculares Nacionais do Curso de Graduação em Enfermagem. Conselho Nacional de Educação. Câmara de Educação Superior. [Internet]. [Cited 2020 Jul 08]. Available: http://portal.mec.gov.br/cne/arquivos/pdf/CES03.pdf

[6] Otrenti E et al. Portfólio reflexivo como método de avaliação na residência degerência de serviços de enfermagem. Semina: Ciências Biológicas e da Saúde, Londrina. [Internet]. jan./jun. 2011; [Cited 2020 Jul 08]; 32(1): 41-46.

Available:
http://www.uel.br/revistas/uel/index.php/seminabio/article/viewFile/3482/8809

[7] Cesário JB et al. Portfólio reflexivo como estratégia de avaliação formativa. Revista Baiana de Enfermagem, Salvador. [Internet]. jan./mar. 2016; [Cited 2020 Jul 08]; 30(1): 356-364. Available:
https://portalseer.ufba.br/index.php/enfermagem/article/view/14500/pdf_34

# Non-parametric Inference Applied to Damage Detection in the Electromechanical Impedance-based Health Monitoring

Quintiliano Siqueira Schroden Nomelini[1], Jose Waldemar da Silva[2], Carlos Alberto Gallo[3], Roberto Mendes Finzi Neto[4], Karina Mayumi Tsuruta[5], Jose dos Reis Vieira de Moura Jr[6]

[1,2]Mathematics School, FAMAT, Federal University of Uberlandia, UFU, Uberlandia-MG, Brazil
[3,4,5]Mechanical Engineering School, FEMEC, Federal University of Uberlandia, UFU, Uberlandia-MG, Brazil
[6]Department of Mathematics and Technology, IMTec, Federal University of Goias, Catalao-GO, Brazil

*Abstract— The electromechanical impedance-based structural health monitoring is a non-traditional vibration technique that compares a pristine signature to a damaged one. However, in order to compare a complete frequency response function to another, it is necessary to create a virtual index called damage metric, which indicates how far the investigated structure states from the initial condition. The most used index is the RMSD (Root Mean Square Deviation) to have a quantitative measurement of the monitored structures but CCD (Correlation Coefficient Deviation) is more robust to temperature changes. Thus, this contribution focuses on thisCCD damage metric for simulated damages (mass addition) of Al beams in a 2x5 factorial design. The first factor considered was the pristine or damage condition. The second factor was the environmental temperature of the specimen, during the signature gathering, for five levels: -10 ºC, 0 ºC, 10 ºC, 20 ºC and 30 ºC. According to the references, temperature is a very important aspect to be considered because some changes in the signature can be promoted, and for this purpose a temperature chamber was used in the study. Several statistical evaluations were performed and this contribution illustrates the median of the damage metrics are greater than the baseline ones. Also, although the temperature level creates shifts of the damage metrics, this not caused false positives, enabling the technique to differentiate the damage to the pristine conditions.*

*Keywords— **Impedance-based SHM, Non-parametric inference, False positive removal.***

## I. INTRODUCTION

The maintenance function is one of the most important aspects of production management today due to the straight effects in repair costs, spare parts and production losses.Then, maintenance has replaced the corrective maintenance of critical items for predictive maintenance. In this development, new supervision mechanisms have emerged, such as SHM (Structural Health Monitoring).The electromechanical ISHM (impedance-based SHM) method is one of the most promising approaches, presenting several research contributions over the last three decades [6-7, 11, 13-17, 19].

ISHM is a methodology that allows damage detection by comparing a pristine condition, related to a baseline signature,to a new condition under investigation. This impedance signature is gathered from a PZT patch bonded on the surface of the structure under investigation and an impedance analyzer store this information. The real part of the impedance is considered for the monitoring purposes due to its relation to structural features while the imaginary part, related to the PZT patch, it is not used in this study[11, 13-14].

Impedance signatures are measured over a frequency range (domain) and structural changes in stiffness and mass due to incipient damage cause changes in shape and peaks of the function.Thus, it is necessary to create a quantitative approach for evaluating the changes that occurred in the signature throughout the monitoring process.This summary is made using damage metrics that make it possible to verify the damage hypothesis in relation to the initial condition (baseline).

However, in addition to structural changes, environmental temperature is a factor that can affect damage metric because it has an important effect on impedance signature [16-17]. Thus, this variable must be

considered in the monitoring process in order to avoid mistakes.

There are several damage metric definitions due to the ability of some specifics to be more robust to interference such as temperature itself, even though it cannot completely eliminate its influence.In this contribution, it is used the most appropriate metric for the damage detection with temperature changes through statistical tests such as Kruskal-Wallis and Wilcoxon-Mann-Whitney [1-5, 8-10, 12, 18].

First most used metric in ISHM is the RMSD (Root Mean Square Deviation) and is described in Eq. (1)[13-14].

$$RMSD = \sqrt{\sum_{i=1}^{n} \left( \frac{\left( Re(Z_{1,i}) - Re(Z_{2,i}) \right)^2}{n} \right)}$$

(1)where $Re(Z_{1,\ i})$ is the real part of the baseline impedance measurement at frequency $i$, $Re(Z_{2,\ i})$ is the real part of the impedance measurement under investigation at a frequency $i$, and $n$ is the total number of frequency points.

However, the damage metric most robust and considered in this contribution is the CCD (Correlation Coefficient Deviation) described by Eq. (2) [7, 17].

$$CCD = 1 - CC$$

(2)

where CCD is the deviation from the correlation coefficient and CC is the correlation coefficient given by Eq. (3).

$$CC = \frac{1}{n} \sum_{i=1}^{n} \frac{\left( Re(Z_{1,i}) - Re(\bar{Z}_1) \right)\left( Re(Z_{2,i}) - Re(\bar{Z}_2) \right)}{S_{Z_1} S_{Z_2}}$$

(3)

where $S_{Z1}$ is the standard deviation of the baseline signature and $S_{Z2}$ is the standard deviation of the impedance signature under investigation. Correlation coefficient 1 means 100% both signatures are fully correlated. The greater the difference between signatures, the lower the CC value. The CC value is also used to compare and quantify admittance signals [17]. On the other hand, the greater the difference between them, the greater the CCD value.

Regarding the statistical tests used, the Wilcoxon-Mann-Whitney Test is applied in the comparison of two independent groups in order to verify whether the samples provide enough evidence to support the hypothesis that both belong to the same population.It is an alternative to the t-test, a parametric test for equality of means, since it does not require any hypothesis about population distributions.

The Kruskal-Wallis test is an extremely useful test to decide if $k$ independent samples ($k>2$) come from the same population. This test is applied for small samples or if assumptions required to perform the analysis of variance are seriously compromised. This test is an extension of the Wilcoxon-Mann-Whitney test, and therefore uses ranks assigned to the observed values.The test also determines that the variable under analysis is measured on a scale at least ordinal and, therefore, applies to the damage metrics determined from the electromechanical impedance.

In this study and for applied purposes, it is very important the analysis of the damage detection based on comparison of the baseline with cases under investigation. However, there is a paramount importance in the use of the values of the metrics for classification in true positive or true negative events.

The false positive classification can lead to the mobilization of teams and financial resources to repair the false damage.On the other hand,a false negative rating can lead to serious safety problems and subsequently high maintenance and compensation values.

A proposed methodology for classifying the values of the metrics is based on statistical quality control in which the threshold for the decision rule is determined by Eq. (4).

$$PZT_{threshold} = \mu_{max} + 3\sigma_{max}$$

(4)

where $\mu_{max}$ and $\sigma_{max}$ are respectively the upper limits of the confidence intervals for the mean and for the standard deviation in the baseline [17].

## II. EXPERIMENTAL PROCEDURE

In this case study, two aluminum beams of 500x38x3.2 mm were used. In each one a 1 mm thick and 20 mm diameter PZT(Lead Zirconate Titanate) patch was glued to 100 mm from one end.

Five levels for environmental temperatures and two levels of damage were considered.

Baseline measurements were made without adding mass while other damage levels were caused by addition of concentrated mass at the opposite end of the sensor in the structure: B = baseline, D = 0.6g. Fig. 1 illustrates both specimen during the measurements in a bi-supported condition inside the chamber.



*Fig.1: Two beams with PZT patches and mass additions.*

A climate and temperature control chamber (Platinous EPL-4H series) was used to control the temperature effect. It was considered five environmental temperature levels: -10 ºC, 0 ºC, 10 ºC, 20 ºC e 30 ºC.This chamber is installed in the Structural Mechanics Laboratory (LMEst) of the School of Mechanical Engineering (FEMEC) at the Federal University of Uberlandia (UFU).

## III. RESULTS AND DISCUSSION

In this contribution the Kruskal-Wallis test is justified to compare the temperature/damage levels since the assumptions of normality of residues and homogeneity of variances, necessary for the correct application of parametric tests, were not satisfied according to Table 1.

*Table 1: p-values of Shapiro-Wilk and Levene Tests for CCD damage metric.*

| PZT Patch | p-value | |
|---|---|---|
| | Shapiro-Wilk | Levene |
| 1 | $1.1 \times 10^{-18}$ | $8.5 \times 10^{-18}$ |
| 2 | $5.3 \times 10^{-21}$ | $1.2 \times 10^{-13}$ |

As presented in Table 1, this finding is verified through the p-values of the Shapiro-Wilk and Levene tests, which were less than 0.05 for both PZT patches. It should be noted that if only one of the assumptions is not met, the use of parametric analysis of variance is incorrect. In this case, both normality of residues and homogeneity of variances assumptions were not met. Therefore, the Kruskall-Wallis test is a good alternative. Due to the lack of a test for homogeneity of variance in experiments with more than one factor, the temperature and damage levels were arranged, thus forming a single factor composed of 10 levels.

Also, according to Table 2, the comparison of the combined levels of temperature and damage using the Kruskal-Wallis test, show that despite the temperature effect, the test is sensitive to the detection of damage regardless of which PZT patch is. In all metrics, the first five groups (levels) differ from the last five, in other words, the baselines (B) at any of the temperatures differ from conditions with damage (D) at any temperature level.

*Table 2: Median and comparison of CCDs by Kruskal-Wallis test.*

| Temp/Damage | PZT patch 1 | PZT patch 2 |
|---|---|---|
| -10ºC - B | 0.0016 a | 0.0009 a |
| 0ºC - B | 0.0016 b | 0.0006 b |
| 10ºC - B | 0.0006 c | 0.0006 c |
| 20ºC - B | 0.0005 d | 0.0006 d |
| 30ºC - B | 0.0005 e | 0.001 d |
| -10ºC - D | 0.8492 f | 0.8439 e |
| 0ºC - D | 0.8617 g | 0.8651 e |
| 10ºC - D | 0.8565 h | 0.8763 f |
| 20ºC - D | 0.831 hi | 0.8873 fg |
| 30ºC - D | 0.818 i | 0.8439 g |

*B: Baseline; D: Damage.*

On the other hand, blocking the baseline (B) or the damaged (D) cases, there are differences between the temperatures, which confirms the temperature effect in the metrics.

A pattern of the temperature effect can be observed, in which all temperatures differ in groups of two in the baseline versus the damaged condition. Regarding damage at temperatures 10 and 20ºC and likewise at 20 and 30ºC, there was no significant difference (p-value> 0.05) with the other pairs being significantly different (p-value <0.05). Thus, it is observed that the temperature effect influences the impedance signature since the signals should coincide at the different temperature values and this does not occur. This fact is observed in the baselines of the PZT patch 1 (Fig.2a) as well as in PZT patch 2 (Fig.2c). The same occurs in both cases with damage for the two PZT patches (Figs.2b and 2d). As the damage is the same by changing only the temperature parameter, then the impedance values should match. This observation must be made by specific PZT patch since each sensor has its particularities and, therefore, there will be a variation from patch to patch. Consequently, it was decided to present in each plot (Fig.2), the average impedance for the 30 impedance signatures, by temperature, due to the variations between signatures or repetitions. Only part of the frequency range is shown here to visually demonstrate the temperature effect on the impedance.
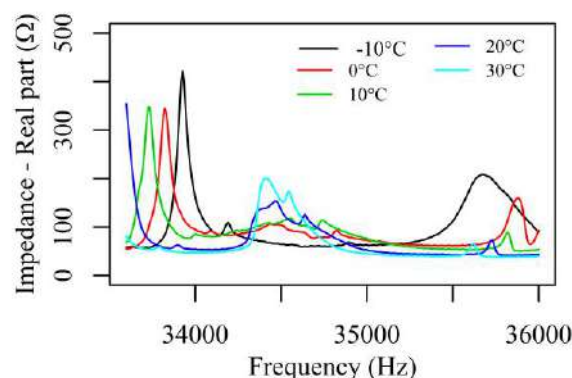


a) PZT patch 1 – Baseline
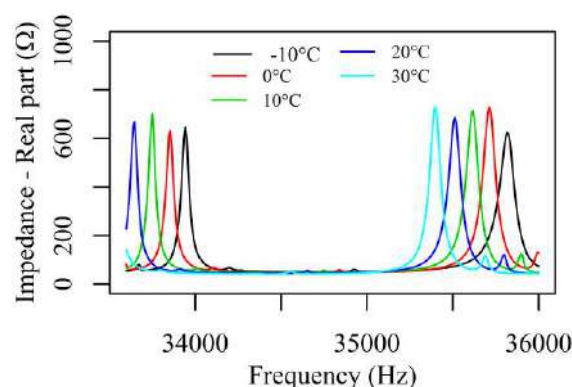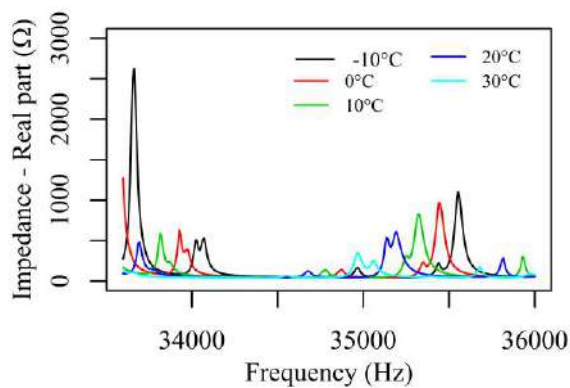


b) PZT patch 1 – Damage

c) PZT patch 2 – Baseline
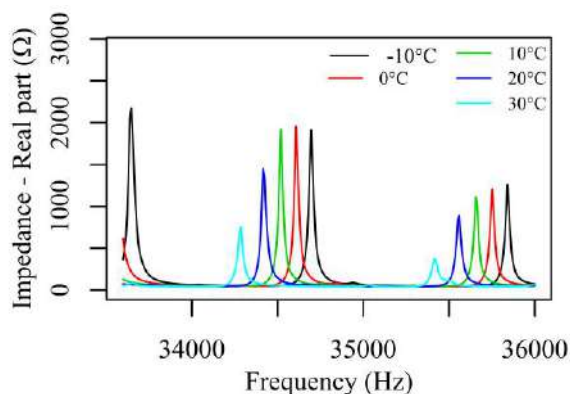


d) PZT patch 2 – Damage

*Fig.2: Avg impedance signatures vs Temperature levels*

According to the method's premises, the impedance signature is expected to be significantly different in the damaged condition compared to the baseline in some frequency range. The impedance signatures obtained in the two conditions may not differ in all frequency points, but, if there is damage, the difference between their values will be noticeable in some frequency sub-range. Thus, it is not convenient to observe or directly compare the impedance values across the monitored frequency range. The large number of frequency points that are not sensitive to damage could lead to mistaken decisions about the presence or absence of damage. To consider this aspect, damage metrics are used, which aim to summarize all information of the impedance signature in a single quantitative scalar value. In general, this damage metric illustrates how different the baseline signatures are from the supposed damaged condition.

ISHM has developed several damage metrics. Some of them are addressed to minimize impacts as such as temperature effects. However, it is observed as shown in Fig.3 that the temperature effect also significantly affects the damage metric.Results of the effect of temperature on the CCD damage metric are shown in Fig.3.



a) PZT patch 1 – Baseline



b) PZT patch 1 – Damage



c) PZT patch 2 – Baseline



d) PZT patch 2 – Baseline
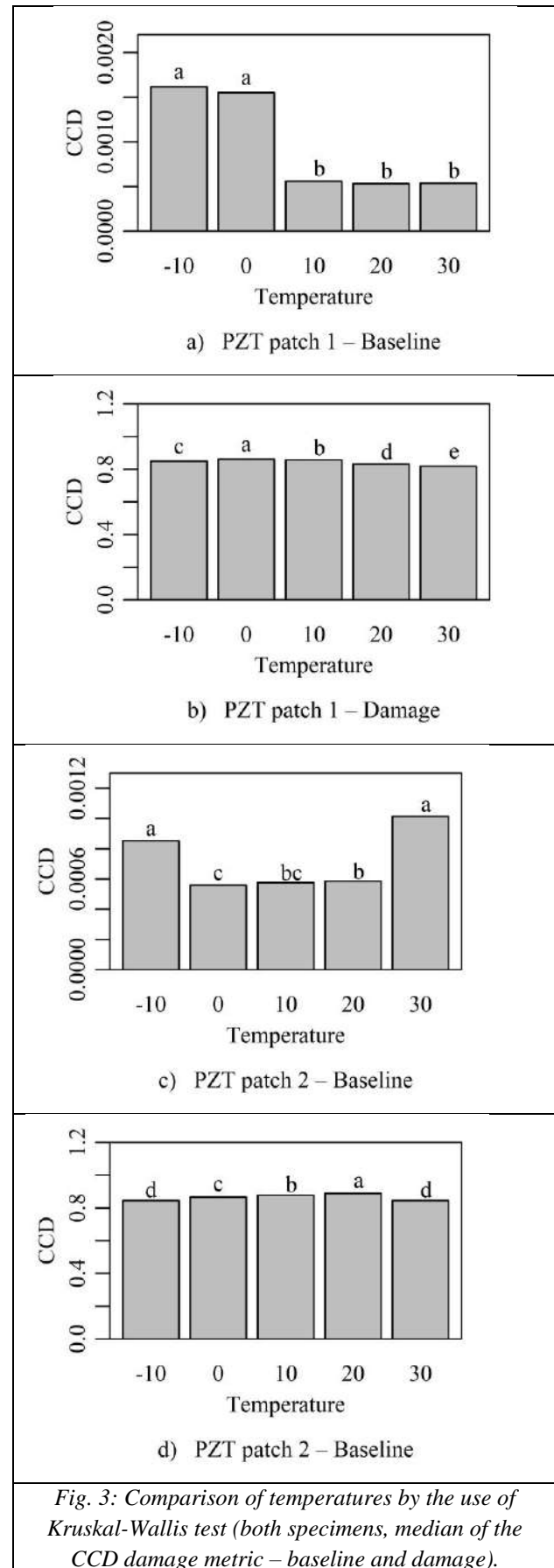
*Fig. 3: Comparison of temperatures by the use of Kruskal-Wallis test (both specimens, median of the CCD damage metric – baseline and damage).*

In each figure, temperatures with same letter at the top of the column indicate that they do not differ significantly according to the Kruskall-Wallis test (p-value> 0.05).It is observed in Figs.3a-d that there are differences in all cases. The patterns of differences in both PZT patches are not the same in both pristine and damage cases indicating that temperature changes on the damage metric depends on the case.For the CCD damage metric of the pristine conditions in PZT patch 1, the temperatures -10ºC and 0ºC do not differ as well as the temperatures 10ºC and 20ºC, but -10ºC differs from 10ºC and 20ºC from 30ºC. In the damage condition of the same PZT patch,all temperatures differ.

Considering the possibility of a distinguished effect of temperature on the CCD damage metric for pristine and damage conditions, in each PZT patch, as observed descriptively in Fig.3, it is acceptable to compare the two states, with damage and baseline, by temperature.

Since the temperature parameter affects the impedance signature, each case was compared with a baseline under same temperature. Results of the Wilcoxon-Mann-Whitney test presented in Table 3 indicate the efficiency of this test in the damage detection for this specific experiment. For all temperature levels and PZT patches, the test was highly significant with p-values lower than $10^{-10}$indicating that the damage was detected.It should be noted that the application of the Wilcoxon-Mann-Whitney test is conducted by use of thedata ranks and the median, which is the most suitable indicator to summarize the set.

The Wilcoxon-Mann-Whitney test's lack of sensitivity to extreme values is an advantage because it reduces the possibility of detecting a damage when it does not existor the non-detection of the damage in the opposite condition.These two possibilities are called false positive and false negative, respectively.

*Table 3: Wilcoxon-Mann-Whitney test for damage detection at each temperature and PZT using the CCD metric.*

| PZT Patch | Temp. (ºC) | Condition (median) | | p-value |
|---|---|---|---|---|
| | | *Baseline* | *Damage* | |
| 1 | -10 | 0.00161727 | 0.84915706 | $3.016 \times 10^{-11}$ |
| | 0 | 0.00155151 | 0.86167958 | $1.691 \times 10^{-17}$ |
| | 10 | 0.00055904 | 0.85650092 | $3.016 \times 10^{-11}$ |
| | 20 | 0.00053254 | 0.83104712 | $1.691 \times 10^{-17}$ |
| | 30 | 0.00053703 | 0.81802007 | $1.691 \times 10^{-17}$ |
| 2 | -10 | 0.00085333 | 0.84387215 | $3.018 \times 10^{-11}$ |
| | 0 | 0.00055869 | 0.86514823 | $1.691 \times 10^{-17}$ |
| | 10 | 0.0005758 | 0.87634048 | $3.018 \times 10^{-11}$ |
| | 20 | 0.00058458 | 0.88732282 | $1.691 \times 10^{-17}$ |
| | 30 | 0.00101233 | 0.84387215 | $1.691 \times 10^{-17}$ |

Despite the difference of effects of temperature for both conditions, damage and baseline (Fig.3), it is desirable that the methodology is able to identify the damage regardless the temperature. Tables 2 and 3 show the results of comparisons of all possible cases considering temperature and damage (D / B) in which codes D and B reference to the condition with damage and baseline, respectively. The damaged condition differs from the baseline signature in any temperature level. This fact shows that in this experiment, in spite of the temperature effect, the methodology was robust to detect the damage.

Table 4 presents the temperature-independent results for damage detection for the CCD metric. It can be remarked that, regardless of the temperature, damage condition was identified (p-values> 0.001).

*Table 4. Temperature-independent Wilcoxon-Mann-Whitney test for damage detection for both PZT patches (Medians).*

| PZT Patch | *Baseline* | *Damage* | *p-value* |
|---|---|---|---|
| 1 | 0.0006 | 0.8492 | $1.08 \times 10^{-50}$ |
| 2 | 0.000602 | 0.865148 | $1.08 \times 10^{-50}$ |

Tables 5 and 6 show the proportions of false negatives and false positives identifications for both PZT patches by the use of CCD metrics. It is considered in this experiment, a baseline for each temperature and each PZT patch.

A threshold for each specific PZT patch was determined from the baseline, considering each temperature. For a such measurement, a damage metric value below the threshold is classified as false negatives and adamage metric value above the threshold is defined as false positive.

The hypothesis of data normality for the CCD damage metric was not achieved. Bootstrap methodology is applied for building confidence intervals becauseit is more general than the parametric approach. This feature is because there is no need for normality and then can be used in this specific case study. Thus, the confidence intervals were chosen via Bootstrap technique.

Tables 5 and 6 show the existence of false positives in the CCD damage metric, since the occurrence of the damage metrics above the threshold should be zero for values obtained from the baselines. On the other hand, there are no values classified as false negatives. This number of false positives can be caused due to the existence of discrepancy points inside the damage metrics.

*Table 5. Proportions of false negatives for the CCD damage metric in PZT patches 1 and 2.*

| PZT Patch | Thres.(B) | False Negative (D) | | | | |
|---|---|---|---|---|---|---|
| | | -10ºC | 0ºC | 10ºC | 20ºC | 30ºC |
| 1 | -10ºC | 0 | 0 | 0 | 0 | 0 |
| | 0ºC | 0 | 0 | 0 | 0 | 0 |
| | 10ºC | 0 | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 20ºC | 0 | 0 | 0 | 0 | 0 |
| | 30ºC | 0 | 0 | 0 | 0 | 0 |
| 2 | -10ºC | 0 | 0 | 0 | 0 | 0 |
| | 0ºC | 0 | 0 | 0 | 0 | 0 |
| | 10ºC | 0 | 0 | 0 | 0 | 0 |
| | 20ºC | 0 | 0 | 0 | 0 | 0 |
| | 30ºC | 0 | 0 | 0 | 0 | 0 |

*Table 6.  Proportions of false positives for the CCD damage metric in PZT patches 1 and 2.*

| PZT | Thres.(B) | False Positives (D) | | | | |
|---|---|---|---|---|---|---|
| | | -10ºC | 0ºC | 10ºC | 20ºC | 30ºC |
| 1 | -10ºC | 0 | 0 | 0 | 0 | 0 |
| | 0ºC | 0.133 | 0 | 0 | 0 | 0 |
| | 10ºC | 0.733 | 0.6 | 0 | 0 | 0 |
| | 20ºC | 0.8 | 0.7 | 0 | 0 | 0 |
| | 30ºC | 0.766 | 0.7 | 0 | 0 | 0 |
| 2 | -10ºC | 0 | 0 | 0 | 0.066 | 0.166 |
| | 0ºC | 0 | 0 | 0 | 0.066 | 0.166 |
| | 10ºC | 0.066 | 0.033 | 0 | 0.066 | 0.166 |
| | 20ºC | 0 | 0 | 0 | 0 | 0 |
| | 30ºC | 0 | 0 | 0 | 0 | 0 |

## IV.    CONCLUSIONS

Damage detection using non-parametric tests as Kruskal-Wallis and Wilcoxon-Mann-Whitney is a suitable approach for damage detection in SHM methods since they do not need to satisfy statistical assumptions compared to parametric techniques. In this contribution, both tests were efficient for detecting damage but it is important to remark that each experiment and case study can have different impedance signature patterns.

Nonparametric tests were also effective for detecting damage even in temperature-dependent conditions as the electromechanical impedance-based SHM.

Nonparametric tests were also more efficient in damage detection in relation to the threshold technique since there were no false positive problems.

However, the temperature effect can induce false positives, detecting damages in absence of them. Based on this finding it suggests new studies considering a smaller difference between the temperature levels in order to investigate false positives. If such false positives do not happen at smaller temperatures, any measured condition along the monitoring can be compared to the baseline signature.

Other damage severities are also a suggestion for future contributions since this parameter is temperature-dependent. The hypothesis of interest in this case would be to investigate the boundaries which temperature would interfere in the damage detection.

## REFERENCES

[1] Banzatto, D. A. andKronka, S. N. (1995). Experimentaçãoagrícola. *3 ed. Jaboticabal: Funep*, 247 p.

[2] Bartlett, M. S. (1937). Properties of sufficiency and statistical tests. *Proceedings of the Royal Statistical Society A*, [S. l.], v. 160, p. 268–282.

[3] Conover, W. J. (1999). Practical Nonparametric Statistics, John Wiley & Sons. INC, New York.

[4] Durbin, J.and Watson, G. S. (1950). Testing for Serial Correlation in LeastSquaresRegression, *I. Biometrika*, London, v. 37, p. 409-428.

[5] Efron, B.andTibshirani, R. (1986). Bootstrapmethods for standard errors, confidenceintervals, andothermeasuresofstatisticalaccuracy. *StatisticalScience* , v. 1, n. 1, p. 55–77.

[6] Giurgiutiu, V. and Rogers, C. A. (1998). Recent Advancements in the Eletro-Mechanical (E/M) Impedance Method for Structural Health Monitoring and NDE. In: *5th Annual International Symposium on Structures and Materials*, 1998, San Diego. Proc. SPIE 3329 536-47.

[7] Giurgiutiu, V. andZagrai, A. (2005). Damage detection in thin plates and aerospace structures with the electro-mechanical impedance method. *Structural Health Monitoring*, 4(2), 99-118.

[8] Keyes, T. K. and Levy, M. S. (1997). Analysis of Levene's test under design imbalance. *Journal of Educational and Behavioral Statistics*, v.22, p.227-236.

[9] Montgomery, D. C., Peck, E. A. and Vining, G. G. (2001). Introduction to linear regression analysis. 3rd ed. New York: Wiley.

[10] Morais, A. R. (2001). Curso de Estatistica Experimental: umaintroduçãoaosdelineamentos e análise de experimento. Lavras: Ed. UFLA, 197 p.

[11] Moura Jr, J.R.V. and Steffen Jr, V. (2006). Impedance-based Health Monitoring for Aeronautic Structures using Statistical Meta-modeling. *Journal of Intelligent Material Systems and Structures*, v. 17, p. 1023-1036, 2006.

[12] O'Neill, M. E. and Mathews, K. L. (2002). Levene tests of homogeneity of variance for general block and treatment designs. *Biometrics*, 58:216-224.

[13] Palomino, L.V., Tsuruta, K. M., Moura Jr, J.R.V.,Rade, D. A., Steffen Jr, V. and Inman, D.J. (2012). Evaluation of the influence of sensor geometry and physical parameters on impedance-based structural health monitoring. *Shock and Vibration*, v. 19, p. 811-823.

[14] Palomino, L.V., Moura Jr, J.R.V., Tsuruta, K.M.,Rade, D. A. and Steffen Jr, V. (2011). Impedance-based health monitoring and mechanical testing of structures. *Smart Structures and Systems (Print)*, v. 7, p. 15-25, 2011.

[15] Park, G.,Sohn, H.,Farrarand C. R.,Inman, D. J. (2003). Overview of Piezoelectric Impedance Based Health Monitoringand Path Forward. *The Shockand VibrationDigest*. V.35, Issue 6. p. 85-92.

[16] Park, G., Kabeya, K., Cudney, H. H. and Inman, D. J. (1999). Impedance-based structural health monitoring for temperature varying applications. *JSME International Journal Series A Solid Mechanics and Material Engineering*, 42(2), 249-258.

[17] Rabelo, D.S.,Tsuruta,K.M.,Oliveira,D.D., Cavalini Jr,A.A.,Finzi Neto,R.M. andSteffen Jr, V. (2017). Fault Detection of a Rotating Shaftby Using the Electromechanical Impedance Method and a Temperature Compensation. *Approach. J NondestructEval*.

[18] R Development Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/

[19] Tseng, K.K-H. and Naidu, A. S. K. (2002). Non-parametric damage detection and characterization using smart piezoceramic material. *Journal Smart Material and Structures*. V.11, p. 317- 329.

# The use of wood particles in cementitious materials in order to make them more sustainable as greenhouse gas emissions

José de Almendra Freitas Jr[1], Marienne R. M. Maron da Costa[2], Carlos Frederico Alice Parchen[3], Barbara T. Villas Boas[4], Setsuo Iwakiri[5]

[1,2,3,4]Civil Construction Department, Federal University of Paraná, Curitiba, Brazil
[5]Forest Engineering Department, Federal University of Paraná, Curitiba, Brazil

*Abstract*—*Cement building materials are quite aggressive to the environment because of their manufacture causing large amounts of greenhouse gas (GHG) emissions, such as cement and steel. Wood-based materials are great in this respect, as they generally consume less energy for their production and wood stocks carbon in their structure, neutralizing CO2 emissions, the main GHG. But for various reasons, it is not always possible to apply purely wood materials. This work shows two cementitious building materials, concrete blocks and closing panels, which were developed in researches at the Federal University of Paraná (UFPR - Brazil), which contains wood particles in its composition. These materials, in substitution of the corresponding traditional materials, mitigate GHG emissions by the construction works, without causing technical losses. The materials developed in the cited researches are produced with Portland cement, lime and wood particles. The carbon fixed by the wood plus the CO2 absorbed from the air by the carbonation of the lime during the first years of useful life neutralizes the majority of the GHG emissions of its production.*

*Keywords*— *Construction materials, Greenhouse gases emissions, Concrete blocks, Closing panels.*

## I. INTRODUCTION

Within this context, many developed countries (or individual cities) have shown concerns about the emissions of greenhouse gases (GHG) generated by the production of buildings, because of the growing environmental challenges facing society nowadays. The problem of the greenhouse effect and the increase of $CO_2$ concentrations in the atmosphere are becoming increasingly relevant.

Countries in Europe, USA, Australia and Canada have been implementing regulations specifically designed to control buildings' carbon emissions, both for their use time and for their construction time. The current challenge for the construction industry in these nations is to achieve the goal of producing "carbon neutral" buildings from 2020, which means achieving a balance between the quantities of carbon emitted and sequestered or stored. Brazil, although it has not yet reached this level of actions, have concerned about this problem and have taken some actions to minimize their emissions.

In 2008 Nemry et al. published an article under the Joint Research Center (JRC) that presented recommendations for new constructions. The article emphasizing that significant environmental improvement can only be achieved by replacing "conventional" construction products (concrete, steel, bricks, etc.) by wood products. Wood products usually causes less GHG emissions by their production process than other materials and can work as a complement to the forest after the wood was harvested, storing the carbon during its useful life (Hetsch 2008).

It should be noted that from 40 to 45% of the wood mass is composed of carbon and since this element represents only a fraction of the $CO_2$ molecule, therefore each unit of carbon mass fixed in the wood represents the non-emission of 3.67 mass units of $CO_2$ (Oliveira et al. 2011).

This work shows that some conventional constructions material can be replaced by wood-based materials, which are more environmentally friendly in the context of GHG emissions. The wood products emit less GHG for their

production, besides storing carbon in their structure, minimizing the balance of emissions to the atmosphere.

The stored carbon neutralizes part of the $CO_2$ emissions resulting from the construction of the works and in the developed countries, following the recommendations of the international standards ISO 14025:2006, ISO 14040:2006 and ISO 14.044:2006. The UN Intergovernmental Panel on Climate Change (IPCC) allows for the accounting of carbon stored in wood products of certified origin, but not carbon of fossil origin, as recommended by ISO 14.044:2006.

The major building materials such as steel and Portland cement emit large amounts of GHG for their production. It is because of the consumption of fossil fuels and the treatment of raw materials. For example, the Portland cement manufacture is responsible for approximately 7% of the world's $CO_2$ emissions. It occurs because of the decarbonation of limestone and consumption of fossil fuels (Mehta 2001).

The substitution of the usual materials, which are great cause of emissions of GHG, by other wood-based materials allows significant reductions in GHG emissions. It is important to note that wood particles can be used in the composition of mortars and concrete used in the manufacture of various pre-cast construction products. The proper use of these particles enables reductions in the consumption of cement and aggregates, making the products lighter and environmentally friendly from the point of view of GHG emissions.

Within this context, two wood-based building materials are being developed at the Federal University of Paraná (UFPR) in Brazil: a cementiceous block for walls and a cement panel for closures. Both are characterized to have in their composition wood particles replacing the aggregates and minimizing the consumption of Portland cement. As they contain significant amounts of wood in its composition, the carbon stored neutralizes great part of GHG emissions from its production. The wood particles were immersed in a water lime suspension to prevent the wood extractives liberation. These extractives change negatively the important hydration reactions in the cementiceous composition. The hardening of the lime also captures $CO_2$ from the air collaborating with wood particles in the function of carbon storage.

The objective of this work is to show two alternatives of cementiceous building materials, a block and a closing panel, which are more environmentally friendly from the point of view of GHG emissions, which can replace traditional materials that are widely used. The use of these blocks and panels can become interesting alternatives to

achieve the target of 2030 of to built "carbon neutral" buildings.

## 1.1. THE CEMENTICEOUS MATERIALS WITH WOOD PARTICLES

The first wood-based building material is a cementiceous block with wood particles developed by Villas Bôas experimentally produced in UFPR (Villas Bôas 2016). The block contains *Pinus spp* particles with dimensions between 4.75 mm and 2.36 mm sieve. The block is hollow and has the external dimensions of 14x19x39 cm and it has adequate mechanical characteristics for non-structural walls. Figure 1 shows the block details.



*Fig. 1: The cementiceous block with wood particles (Villas Bôas,2016).*

The materials used for the block production, in addition to the wood particles, is Brazilian Portland cement type CP II-Z, lime (CV) and water. In the beginning of the production, the wood particles are submitted for a pre-treatment in a water lime suspension. This action removes the possible inhibitory effects from the extractives of the wood to the hardening reactions of Portland cement (Parchen et al. 2015).

In the sequence the cement is added with water (water/cement ratio 0.20) to the suspension of lime already mixed with the wood particles. The mixture was mixed in a horizontal mixer. The blocks were molded and compacted in an automatic industrial hydraulic vibro-press, usable for the production of concrete blocks.

The hardened density of the blocks has mass around 4.645 kg. The material consumption per block for its production was: 2.264 kg of Portland cement; 1.184 kg of *Pinus spp* particles; 0.2652 kg of lime and 1.372 kg of water. The block has approximately 25.5% of its mass in wood particles of *Pinus spp*.

It is important to emphasize that the addition of wood particles decreases the weight of the block and improves their thermal insulation properties. Similar conventional concrete blocks similar are traditionally used in civil construction for erecting non-structural walls, are produced with common aggregates of sand or crushed rock and has a mass of approximately 10 kg.

The second material is a cementiceous closing panel produced with a mixture of Portland cement, lime and wood particles. The panel was developed and experimentally produced in UFPR in a research project by Parchen (2012). The panel has 25 mm of thickness and adequate mechanical characteristics for use in internal walls. The mass content of wood particles (*Pinus spp*) is 37%. Figure 2 shows the panel in a bending test.



*Fig. 2: The cementiceous closing panel with wood particles in a bending test (Parchen 2012).*

The materials used in the panels were, the wood particles, Brazilian Portland cement type CP II-Z, lime (CV) and water. For the same reasons, the wood particles are pre-treated with lime and water reaching a final water/cement ratio of 0.33. The mixture was made in a mixer. The molding and compacting of the panels were done in a concrete vibrating table. The material consumption per production of m2 of panel is: 8.750 kg of Portland cement; 7.875 kg of *Pinus spp*. particles; 1.425 kg of lime and 2.855 kg of water. The weight of this panel is 18.5 kg/$^{m2}$. Conventional cementiceous panels weigh varies from 14 to 43 kg/m$^2$, depending of their thickness and density. The presence of the wood particles and the increased thickness has the vantage to provide better thermal insulation to the panel. Figure 3 shows the cementiceous closing panel in a thermal insulation test.

The addition of the wood particles in the blocks and panels provides improvements in characteristics such as thermal insulation and weight, but due to the cost of

implementing the production, its initial costs should be 20% greater than the traditional options.



*Fig. 3: The cementiceous closing panel in a thermal insulation test (Parchen, 2012).*

## II. MATERIAL AND METHODS

With the purpose of evaluating the environmental performance, more specifically $CO_2$ emissions and carbon storage of the cementiceous block and panel with wood particles; it was carried a comparative analysis with some similar products commercially produced. These products have not produced industrially yet, because of that it was not possible to develop a LCA, but it was feasible to estimate the $CO_2$ emissions caused by their production.

The comparative analysis was done firstly by raising the $CO_2$ emissions by the production, the storage and the capture of carbon by researched products. The emissions were calculated through the sum of the emissions of raw materials, the estimated emissions by the transport of these to an industrial unit and the emissions by the process of manufacturing. The intention was simulate a LCA for considering the limits of "cradle-to-gate".

The calculation of the carbon stored in the mass of the products was estimated based on the amount of wood and the carbon content of the wood. In addition to the carbon storage, the researched products contain lime in their composition. The lime captures $CO_2$ from the air (carbonation process) during its hardening process.

In order to set up the information base for the comparisons of the products with other similar industrialists, were raised the amounts of $CO_2$ emissions by the production of several ones manufactured commercially in Brazil and abroad. The information for the comparison of emissions with Brazilian products was taken from LCA or from industrial emission survey procedures. The international industrial products were based on some

European and North American industries publish the Environmental Product Declaration (EPD). An EPD is a document based on ISO 14025/2006 and ISO/TS 14067/2013.

### 2.1. THE EMISSIONS CAUSED BY THE RAW MATERIALS OF THE PRODUCTS

The most important raw material for the production of cement matrix blocks and panels in terms of $CO_2$ emissions is Portland cement.

To obtain the EF of Portland cement was considered a LCA developed in Brazil for concrete blocks CBCS (2014), in which the EF of Portland cement was based on the average value for the production of one ton in five years, 2008 to 2012, published by the WBCSD (2013). The EF for CP II-Z cement was estimated from 0.600 to 0.804 $kgCO_2e$/kg, with an average of 0.702 $kgCO_2e$/kg. To the estimatives of this article, the last value was used.

To obtain the EF of the lime, the production systems of the local industries of this material were analyzed. The lime is produced in kilns at temperatures of 700 to 1000°C. Carbon dioxide emissions mainly occur in the extraction of the carbon of the limestone and burning the fuel. The EF of the lime depends on the temperature and the residence time in the furnace. In order to estimate lime EF and emissions by the mixture work, was used the conservative EF estimated by Costa (2012), which is 1.184 $kgCO_2$/kg. This value was the EF used by the lime industries close to City of Rio de Janeiro (similar conditions to the Region of UFPR, Curitiba, Brazil).

For the production of the wood particles only the emissions from the consumption of electric energy were considered. It was considered that because the wood particle industries uses thermal energy from the burning of biomass of certified origin, residues of the industry itself, as Hetsch (2008) recommends. The emissions from the electric energy used in the process were based on Costa (2012), with the EF for this step being considered at 0.0600 $kgCO_2$/kg of particles.

The transport emissions of the raw materials from their place of production to the production facility were estimated, considering a distance of 50 km. Simulating transport using semi-heavy trucks, using the Diesel consumption factor of 0.196 L/t/km of Costa (2012), and the EF of 3.3 $kgCO_2$/L of Diesel also used in CBCS (2014), we reached an EF for transport each cement block with 0.0150 $kgCO_2$/block.

For the production of the researched block, the emissions by the mixture and the vibro-densification work, was based on the emissions calculated for the LCA of concrete blocks CBCS (2014). With this information was estimated EF in 0.030 $kgCO_2$/block. For the production of the panel, considering the mixture, the densification and the molding, this work also based on the emissions resulting from the electric energy calculated in Costa (2012), estimated the EF for this step the value of 0.00006 $kgCO2$/kg. The table 1 shows the $CO_2$ emission factors of raw materials used and energy sources.

*Table 1 Emission factors and sources of the information.*

| Input | Emission factor (EF) | Source |
|---|---|---|
| Diesel | 3.3 $kgCO_2eq$/L | CBCS (2014) apud Wang et al. (2004) |
| Electricity | 0.06 $kgCO_2eq$/kWh | MCTI (2013) – avg. of years 2011/12/13 |
| Cement CP II-Z | 0.702 $kgCO_2eq$/kg | WSBD (2013) |
| Lime | 1.18 $kgCO_2$/kg | Costa (2012) |
| Wood particles | 0.06 $kgCO_2$/kg | Costa (2012) |

### 2.2. THE $CO_2$ UPTAKE IN THE WOOD AND IN THE LIME

For the calculation of the carbon stored by the wood, is necessary knows the mass quantity of the wood particles and the carbon content for the species used were used. In Oliveira et al. (2011), the carbon content (Tc) was found for *Pinus spp*., with Tc being 0.41. The lime absorbs $CO_2$ from the air during its hardening process, when the calcium and magnesium hydroxides are converted into carbonates.

Equation (1) allows to estimate the total mass of $CO_2$ that can be absorbed by the lime. The equation estimates the masses of $CO_2$ that are absorbed by the hydroxides of calcium and magnesium present.

$C = CL.(F_{CaO}.M_{CO2}/M_{CaO} + F_{MgO}.M_{CO2}/M_{MgO})$ kg/block (1)

At where:

CL = Consumption of lime;

$F_{CaO}$ = The CaO mass fraction in the lime;

$F_{MgO}$ = The MgO mass fraction in the lime;

M = Molar weight of oxides

(CaO=56, MgO=40 and CO2=44);

Therefore:

$M_{CO2}/M_{CaO} = 44/56$ e $M_{CO2}/M_{MgO} = 44/40$

The considered values for the CaO and MgO oxide masses for lime were 63.9% and 30.8%, respectively (Mattana,2013).

The potential masses of $CO_2$ uptake by lime were estimated considering 92% of the total potential, which is the value generally used in LCA, as mentioned in Eleni et al. (2014). For the lime the absorption or sequestration potential was calculated based on the average values of the percentages of oxides obtained by Mattana (2013) for lime already hydrated, disregarding the masses of water present.

## III. THE RESULTS CARBON EMISSIONS AND UPTAKE

The next sub-items show the calculations of emissions and carbon uptake for the cement block and cementiceous panel with wood fibers.

### 3.1 THE CEMENT BLOCK WITH WOOD FIBERS

With the consumption of the materials and services, as well as the EF selected, the calculation was carried out to simulate the production emissions of the researched block. The table 2 presents the raw material emissions and the production steps; at the end it shows the EF per block (14x19x39cm).

*Table 2 Raw and production emissions per block.*

| Block | Consume per block | EF kgCO$_2$/kg | Emissions kgCO$_2$ | % |
|---|---|---|---|---|
| Cement CP II Z | 2.264 kg | 0.7021 | 1.5896 | 78.7 |
| Lime | 0.265 kg | 1.1840 | 0.3140 | 15.5 |
| *Pinus* $_{spp}$ partic. | 1.184 kg | 0.0600 | 0.0710 | 3.5 |
| Water | 1.372 kg | - | - | - |
| Raw transport | 1 unit | 0.0150 | 0.0150 | 0.7 |
| Product. Proces. | 1 unit | 0.0300 | 0.0300 | 1.5 |
| Emission Factor per block (kgCO$_2$): | | | 2,0196 | 100 |

The $CO_2$ uptake or stored in the wood was obtained using the Tc value of 0.41 and the consume 1.184 kg of wood particles per block, was obtained the total carbon stored of 0.485 kg of carbon per block. Therefore this carbon storage represents the non-emission, or neutralization of 1.780 kgCO$_2$ per block. It is important to note that the storage period will be the life of the wall, this means practically the same period of life of the building.

The $CO_2$ uptake by the lime was obtained using equation (1), that allows to estimate the total mass of $CO_2$ that can be absorbed by the lime. With the equation this work estimates the masses of $CO_2$ that are absorbed by the hydroxides of calcium and magnesium in 0.208 kgCO$_2$.

The values of the emissions, uptake or storage and carbon balance for the block are presented in table 3. It can

be observed in these numbers that the carbon stored by the wood particles represents approximately 90% of the total.

*Table 3 CO$_2$ uptake and emissions per block.*

| CO$_2$ uptake and emissions | kg.CO$_2$ |
|---|---|
| Total CO$_2$ emissions by raw and production | 2.020 |
| CO$_2$ uptake by wood particles (25.5 % of total mass) | 1.780 |
| CO$_2$ uptake by lime | 0.208 |
| Balance (CO$_2$ emissions - CO$_2$ uptake) | 0.031 |

For comparisons with some commercially produced blocks, this work has raised production emissions and carbon storage by some blocks of characteristics and similar to the one studied in this work. For international products the information has been withdrawn, EPD published by manufacturers.

To allow comparison between blocks, in the table 4 are presented some physical characteristics (weight, volume and dimensions) and emissions per block (in $CO_2$ equivalent or $CO_2$e).

For comparison to block B, that is massive and in Imperial measures system, its dimensions had to be adjusted to the same ones of the Brazilian blocks. This was possible because in its EPD the emissions are by weight, as well as by blocks. The same was not possible for the international blocs (B and C), which were slightly higher than the others.

Observing the net emissions of the blocks, it is verified that the UFPR block, due to its content of wood fibers, emits very few carbon than the commercial ones.

*Table 4 Carbon net emissions by various blocks*

| Prod. | Block | | KgCO$_2$e emissions | | |
|---|---|---|---|---|---|
| | Weight (kg) | Dim. (cm) | Blk. | Kg | wall m$^2$ |
| **Rch** | **4.64** | **14-19-39** | **0.03** | **0.007** | **0.39** |
| A | 13.97 | 15-19-39 | 3.35 | 0.240 | 41.88 |
| B | 4.49 | 14-19-39 | 1.99 | 0.442 | 24.83 |
| C | 10.43 | 15.2-20.3-40.6 | 1.61 | 0.154 | 18.17 |
| D | 12.00 | 14-19-39 | 2.81 | 0.234 | 35.15 |
| E | 10.25 | 14-19-39 | 0.60 | 0.063 | 8.12 |

Legend:

Rch is the researched block.

A) Czech Rep., a structural concrete block (KB-BLOK 2009);

B) Europe, a lightweight aerated concrete block (Ruuska 2013);

C) USA (California), a structural concrete block (ANGELUS 2013);

D) Brazil, a non-structural concrete block (QUANTIS 2012);

E) Brazil, a structural concrete block (CBCS 2014).

## 3.2 THE CEMENTICEOUS PANEL WITH WOOD FIBERS

To the panel (25 mm thick), with the consumption of the materials and services, as well as the EF selected, the calculation was carried out to simulate the production emissions of the researched panel. The table 5 presents the raw material emissions and the production steps, at the end it shows the $CO_2$ emission factor per $m^2$ of panel.

*Table 5 Raw and production emissions per m2 of panel (25 mm thick).*

| . Raw material | Consum per $m^2$ | EF r kgCO$_2$/kg | Emissions kgCO$_2$/$m^2$ | % |
|---|---|---|---|---|
| Cement CP II Z | 8,750 | 0.702 | 6.143 | 66.5 |
| Lime | 1,425 | 1.184 | 1,687 | 18.3 |
| *Pinus* spp particles | 7,875 | 0.060 | 0.472 | 5.1 |
| Water | 2,855 | - | - | 0.0 |
| Raw transport | 1 unit | 0.015 | 0.314 | 3.4 |
| Product. process | 1 unit | 0.030 | 0.627 | 6.8 |
| Emission factor per $m^2$ (kgCO$_2$): | | | | 100 |

The $CO_2$ uptake or stored in the wood was obtained using the Tc value of 0.41 and the consume 7.875 kg of wood particles per $m^2$ of panel, was obtained the total carbon stored of 3.23 kg of carbon per $m^2$ of panel. Therefore this carbon storage represents the non-emission, or neutralization of 11.84 kgCO$_2$ per $m^2$ of panel.

The $CO_2$ uptake by the lime was used the equation (1) to estimates the masses of $CO_2$ that are absorbed by the hydroxides of calcium and magnesium was calculated an uptake of 1.118 kgCO$_2$ per $m^2$ of panel.

The values of the emissions, uptake or storage and carbon balance for the panel are presented in table 6. It can be observed in these numbers that the carbon stored by the wood particles represents approximately 91% of the total.

*Table 6 CO$_2$ uptake and emissions per m$^2$ of panel.*

| CO$_2$ uptake and emissions per m$^2$ | kg.CO$_2$ |
|---|---|
| Total CO$_2$ emissions by production | 9.24 |
| CO$_2$ uptake by wood particles (37.7 % of total mass) | 11.84 |
| CO2 uptake by lime | 1.12 |
| Balance (CO$_2$ emissions - CO$_2$ uptake) | -3.71 |

For comparisons with some commercially produced panels, this work has raised production emissions and carbon storage by some panels of characteristics and similar to the one of the UFPR research. For international products the information has been withdrawn, EPD published by manufacturers.

To allow comparison between the panels, in the table 7 are presented some physical characteristics (density and thickness), their percentage of mass of cellulose or wood fiber, emissions and carbon uptake per $m^2$ of panel (in $CO_2$ equivalent or $CO_2$e).

*Table 7 Carbon emissions and uptake by various panels.*

| | Panel | | | Emissions | | |
|---|---|---|---|---|---|---|
| Product | Thick (mm) | Density (kg/m³) | Cellulose or wood % | Product (kgCO$_2$e/ m$^2$) | Uptake (kgCO$_2$/ m$^2$) | Net (kgCO$_2$/m$^2$) |
| **Rch** | **25** | **0.74–0.65** | **37.7** | **9.24** | **12.95** | **-3.71** |
| E | 24 | ≥1.65–1.80 | 23.0 | 35.81 | 17.84 | 17.97 |
| F | 16 | 1.39 | 8.0 | 12.61 | 2.88 | 9.73 |
| G | 8 | 1.58 | 0 | 8.08 | - | 8.08 |
| H | 12.5 | 1.15 | 0 | 5.13 | - | 5.13 |
| I | 10 | ≥170 | 10.0 | 12.31 | 2.00 | 10.30 |

Legend:

Rch is the researched panel.

E) Germany, a panel produced with cement and wood fibers (Bossenmayer, 2008);

F) Malaysia, a panel produced of fibrocement with cellulose (Bossenmayer, 2014);

G) Belgium, a panel produced with cement and expanded shale (Bossenmayer, 2013a);

H) Germany, a panel produced of fibrocement (Bossenmayer, 2013b);

I) Denmark, a panel produced of fibrocement with cellulose (Bossenmayer, 2012).

Observing the net emissions of the panels, it is verified that the UFPR panel, due to its high content of wood, absorbs more carbon than it emits, with a favorable balance. All other panels emit more than they absorb.

## IV. CONCLUSIONS

This study proved that the use of wood particles in some cementiceous materials, like blocks and panels is very interesting for future constructions, with great potential to allow the construction industry to approach the goal of building "carbon neutral". The addition of wood particles to the cementiceous products reduces their net GHG emissions. The work also demonstrates the potential of products with wood to neutralize part of the $CO_2$ emissions of the construction industry due to the property that the wood uptake carbon in its structure. It is also interesting to note that mixing wood particles in cementiceous materials; it is possible to produce other products that can replace traditional materials collaborating a lot in the reduction of $CO_2$ emissions by the construction works.

## REFERENCES

[1] ANGELUS (2013) Environmetal Procuct Declaration - Angelus Block Concrete Masonry Units. Angelus Block Co., Inc. Sun Valley, California, USA.

[2] Bossenmayer, H. J. (2008) EPD-ETE-2008311-E - Duripanel Baseboard - Eternit AG. Institut Bauen und Umwelt e.V. Königswinter, Deutschland.

[3] Bossenmayer, H. J.( 2012) EPD-CEM-2012111-E – Fibre Cement Flatboard Products - Cembrit Holding A/S. IBU - Institut Bauen und Umwelt e.V. Königswinter, Deutschland.

[4] Bossenmayer, H. J. (2013a) EPD-ETE-2013711-E - EQUITONE TECTIVA Eternit nv. IBU- Institut Bauen und Umwelt e.V. Königswinter, Deutschland.

[5] Bossenmayer, H. J. (2013b) EPD-USG-20130023-IAA1-EN - AQUAPANEL® Cement Board Indoor / Outdoor - Knauf USG Systems GmbH & Co. KG. IBU- Institut Bauen und Umwelt e.V. Königswinter, Deutschland.

[6] Bossenmayer, H. J. (2014) EPD-HUM-20130186-IAD1-EM- PRIMA Fibre Cement Board. Institut Bauen und Umwelt e.V 25. Königswinter, Deutschland.

[7] CBCS (2014) Projeto Avaliação de Ciclo de Vida Modular de Blocos e Pisos de Concreto. CBCS - Conselho Brasileiro de Construção Sustentável.

[8] QUANTIS (2012) Análise comparativa do ciclo de vida de paredes construídas com blocos cerâmicos, com blocos de concreto e concreto armado moldado in loco. Quantis Canada, Montreal, Quebec.

[9] Costa, B. L. C. (2012) Quantificação das emissões de CO2 geradas na produção de materiais utilizados na construção civil. Rio de Janeiro, 190 p. Dissertação de Mestrado COPPE – UFRJ, Rio de Janeiro.

[10] Eleni, D.; Thomas, S.; Aurela, S.; Frederik, V. (2014) Literature study on the rate and mechanism of carbonation of lime in mortars. Universidade do Minho, Escola de Engenharia, 9th International Masonry Conference 2014 in Guimarães, Portugal.

[11] Hetsch, S. (2008) Proceedings of the Workshop on Harvested Wood Products in the Context of Climate Change Policies 9-10 September 2008. United Nations Palais des Nations, Geneva, Switzerland.

[12] KB-BLOK (2009) Environmetal Procuct Declaration- Walling Concrete Blocks of KB-BLOK system, ltd. KB-BLOK System, s.r.o., Masarykova, Czech Republic.

[13] Lagerblad, B. (2005) Carbon dioxide uptake during concrete life cycle – State of the art. Cement och Betong Institutet - CBI, Stockholm, Sweden.

[14] Lawrence, R. M. H. (2006) A study of carbonation in nonhydraulic lime mortars. Thesis for the degree of PhD, University of Bath, Faculty of Engineering and Design, Department of Architecture and Civil Engineering.

[15] Nemry, F. ; Uihlein, A.; Colodel, C. M.; Wittstock, B.; Braune, A.; Wetzel, C.; Hasan, I.; Niemeier, S.; Frech, Y.; Kreißig, J.; Gallon, N. (2008) Environmental Improvement Potentials of Residential Buildings (IMPRO-Building) EUR 23493 EN - 2008. JRC - Joint Research Centre, Institute for Prospective Technological Studies, European Commission. Luxembourg.

[16] Oliveira, E. O.; Nakajima, N. Y.; Chang, M.; Haliski, M. (2011) Determinação da quantidade de madeira carbono e renda da plantação florestal. Embrapa Florestas. Colombo PR.

[17] Mattana, A. Jr. Estudos de cales hidratadas de mercado - caracterização química, física e comportamento reológico da pasta. 2013. Dissertação do Programa de pós-graduação em engenharia de construção civil – PPGECC, UFPR, Curitiba.

[18] Mehta, P. K. (2001) Reducing the Environmental Impact of the concrete. Concrete International, ACI - American Concrete Institute.

[19] MCTI (2013) Estimativas anuais de emissões de gases de efeito estufa no Brasil. Ministério da Ciência, Tecnologia e Inovação, Brasília.

[20] Parchen, C. F. A. (2012) Compósito madeira cimento de baixa densidade produzido com compactação vibro dinâmica. Tese de Doutorado. Programa de Pós-Graduação em Engenharia Florestal, Setor de Ciências Agrárias, Universidade Federal do Paraná. Curitiba.

[21] Parchen, C. F. A., Iwakiri, S., Zeller, F., Prata, J. G. (2015) Vibro-dynamic compression processing of low-density wood-cement composites. Holz als Roh- und Werkstoff 74(1).

[22] Ruuska, A. (2013) Carbon footprint for building products. ECO2 data for materials and products with the focus on wooden building products. VTT Technology 115. 126 p. +

app. 2 p. VTT Technical Research Centre of Finland. Espoo, Finland.

[23] Villas Bôas, B. T. (2016) Utilização de Cimento Portland e Resíduos de *Pinus* spp para Fabricação de Blocos Vazados de Baixa Densidade. Tese de Doutorado, Programa de Pós-graduação em Engenharia Florestal, UFPR, Brazil.

[24] WBCSD (2013) Protocol Spreadsheet. WBCSD Cement Sustainability Initiative (CSI)/ECRA GmbH Cement $CO_2$ and Energy Protocol.

# Entrepreneurial Intention of Undergraduate Students from a Municipal Public University of the State of São Paulo - Brazil

## Marcela Barbosa de Moraes, José Luis Gomes da Silva, Francisco Kenedy Quinderé Aquino, Venusa Delgado Rego

Department of Management and Regional Development, University of Taubaté (UNITAU), Taubaté, Brazil

*Abstract*— *The central proposal of this paper is to to study the entrepreneurial intention of undergraduate students, both beginners and those in the process of completing, at a Municipal Public University in the State of São Paulo - Brazil. Therefore, the research method used a quantitative approach, using a closed questionnaire with a Likert scale, developed by Liñan and Chen (2009) called the Entrepreneurial Intention Questionnaire. The data analysis was divided into 2 stages: the reliability analysis by Cronbach's α and the exploratory factor analysis. As a result of the research, it was found that the entrepreneurial career is perceived as favorable by the students of management, economics, and accounting sciences from different periods, being more attractive than formal work. However, pursuing an entrepreneurial career is not necessarily a positive alternative in the opinion of those around the survey respondents to the point of being encouraged by families, friends, and colleagues. Finally, students consider that their knowledge about the mechanisms to support entrepreneurial practice is limited within the analyzed institution.*

*Keywords*— *Entrepreneurial, Entrepreneurial Intention, Undergraduate Students, Entrepreneurial Intention Questionnaire.*

## I. INTRODUCTION

Economic development and job creation are directly related to the intensity of entrepreneurial activity in a country or region. Dornelas (2005) points out that the existence of support and incentives for new ventures is a way to increase economic growth and reduce the unemployment rate. Entrepreneurial activity, in turn, is recognized as an attractive option, though arduous. Finally, it is the driving force of the capitalist economy (Schumpeter, 1997).

Entrepreneurship can mean economic, personal, and social transformations (Camozzato et al., 2018). Given this transformation, an appropriate place for verifying the latent desire to undertake are universities, especially those focused on management such as: accounting, and economic sciences.

With the growing need to change concepts and methodologies in teaching, and the preparation of professionals for the future, rapid changes in societies have been discussed in academia. There is evidence that most universities in Brazil do not prepare their students to be entrepreneurs (Moraes et al., 2016).

In this perspective, the ideal would be a harmony between professors and universities, preparing students, both in theory and in practice, so that they can create companies that develop new products and services, and come to contribute to the growth of the economy. In this way, each university has the responsibility to sow the entrepreneurial culture, and to develop skills that lead students to compete for space in a very competitive market, leaving them to develop the profile of these new professionals.

In order to disseminate the entrepreneurial culture, studies and discussions on entrepreneurial intention have gained greater relevance in the academic sphere since the last decades of the 20th century, such as, among others, the works of Shapero and Sokol (1982), Bird (1988, 1992), Krueger (1993), Lee and Wong (2004), Liñán (2004), Kristiansen and Indarti (2004), Carvalho and González (2006), Liñán and Chen (2009), Teixeira and Davey

(2010), Lima et al. (2011), Nabi et al. (2018) and Hueso et al. (2020).

In view of the above, this paper aims to analyze the entrepreneurial intention of undergraduate students in the management, economics, and accounting sciences courses of a Municipal Public University of the State of São Paulo, Brazil. Therefore, the entrepreneurial intention questionnaire (EIQ) developed by Liñán and Chen (2009) was used, which will be explained below.

## II. ENTREPRENEURIAL INTENTION AND THE ENTREPRENEURIAL INTENTION QUESTIONNAIRE FROM THE PERSPECTIVE OF LIÑÁN AND CHEN

In the perception of Filion (1991), an entrepreneur is an individual who imagines, develops and realizes visions, that is, the vision is an image projected in the future, from the place that the entrepreneur aspires for the solidity of his product and / or service in the environment market, that is, vision refers to where and how the entrepreneur wants to conduct his enterprise.

Complementing Filion (1991), Liñán and Chen (2009) argue that before deciding to be or not an entrepreneur, it is necessary to analyze the entrepreneurial intention involved in the process of creating a company. Bird (1988) explains that entrepreneurial intention can be seen as a state of mind in which the person's attention is directed to a certain situation, with a view to achieving a certain goal.

Carvalho and González (2006) considers that the idea of creating a new company is preceded by the intention, which, in turn, can be planned for a certain period of time, however, in some cases the intention is formed in the moment before if the idea materializes, and in other cases, the intention never coincides with the realization of the behavior. Thereby, Davidsson (1995) shows that the analysis of entrepreneurial intention can help to predict, albeit imperfectly, a certain behavior of an individual in relation to creating his own company.

In view of the above, Shapero and Sokol (1982), Ajzen (1991) and Carvalho (2004) contributed theoretically with theoretical models that dealt with the entrepreneurial intention of individuals in the process of creating a company.

The model developed by Shapero and Sokol (1982) consists of three fundamental theoretical constructors which determine the entrepreneurial intention. They are perception of desirability, erection of viability and propensity to act. The perceived desirability construct refers to the individual's interest in starting a certain

business, whereas the perception of viability is the level of perception that the agent believes is capable of starting a business and the propensity to act would be the impulse by which it would generate the act of undertaking.

Carvalho (2004), on the other hand, proposes the analysis of an entrepreneurial intention taking into consideration a future choice. The model proposed by him was developed based on studies of entrepreneurial skills, personal history of entrepreneurs and entrepreneurial intentions.

Ajzen's (1991) contribution to the area of knowledge of entrepreneurial intention was with the model of Theory of Planned Behavior (TPB), which is the basis of the entrepreneurial intention questionnaire developed by Liñan and Chen (2009). This questionnaire will be explained below.

This theory has the purpose of being able to explain the human behavior before the act of undertaking. TPB predicts that behavior and the intention to act result from three elementary attitudes, namely: personal attitude, the subjective norm, and the perceived behavioral control (Ajzen, 1991).

The author argues that personal attitudes refer to the attitude towards a behavior, and that it corresponds to a favorable or unfavorable analysis that the individual does of the behavior. On the other hand, the case of the subjective norm deals with the influence of the social environment on the individual's behavior, that is, it represents the "social pressure" to adopt a certain behavior. And the perceived behavioral control, refers to the individual's perception of his ease or difficulty in performing a certain task, conditioning his intention.

Based on Ajzen's TPB model (1991), Liñan and Chen (2009) developed the entrepreneurial intention questionnaire (EIQ) which aims to test the entrepreneurial intention model, measuring that intention and the variables that influence it. Figure 1 shows these variables and their relationships.
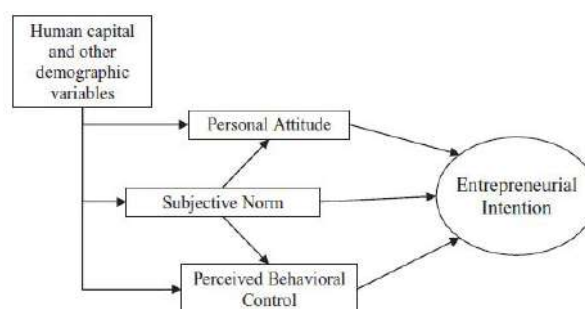


*Fig.1: Entrepreneurial Intention Model*
*Source: Liñan e Chen (2009, p. 597)*

The variables that determine entrepreneurial intention can be described, as follows:

- **Personal Attitude (PA):** refers to the positive or negative impression that the individual has about being an entrepreneur.

- **Subjective Norm (SN):** refers to social pressure exercised about the individual to become or not an entrepreneur, coming from the social circle in which he lives.

- **Perceived Behavioral Control (PBC):** refers to the individual's perception of the ease or difficulty of becoming an entrepreneur and his ability to undertake.

Liñan and Chen (2009) explain that in addition to these variables, the entrepreneurial intention model also highlights the human capital, which are the individual skills, capabilities, and dexterity that individuals have and develop for the purpose of professional and personal growth; and other demographic variables that indirectly influence the formation of entrepreneurial intention, such as the individual's experience and education.

Based on the model presented in Figure 1, Liñan and Chen (2009) developed the EIQ which is formed by five sections. The first to fourth sections are directly related to the elements of the entrepreneurial intention model (personal attitude, subjective norm, perceived behavioral control and entrepreneurial intention) and which are assessed using the Likert scale (1-7).

The fifth section requires information on human capital and other variables such as: age, gender, undergraduate course, and monthly income. The authors show that these variables do not directly influence intention but are useful to identify the effect of these factors on those who directly affect it.

## III. METHODOLOGICAL PROCEDURES

This research is configured as being of quantitative character, the results of the research can be understood based on the analysis of raw data collected with the aid of standardized and neutral instruments. The research also used mathematical language to describe the causes of a phenomenon and the relationships between variables.

As for the objective, this research is descriptive, as it describes the entrepreneurial intention of undergraduate students, both beginners and those in the process of completing, at a Municipal Public University of the State of São Paulo, during the first semester of 2020.

Based on the data provided by the secretary of the Department of Management and Business of the University studied, currently the undergraduate course in economics, accounting and management has a universe of 1050 students enrolled in the four years of the course.

The sample of this paper was probabilistic and finite, that is, considering a sampling error of 5% and a confidence level of 99%, we had a sample of 407 students. This number was obtained by the following equation, suggested by Santos (2015):

$$n = \frac{N.Z^2.p.(1-p)}{Z^2.p.(1-p) + e^2.(N-1)}$$

Where:

n - calculated sample.

N – population.

Z - standardized normal variable associated with the confidence level.

p - true probability of the event.

e - sampling error.

It is important to highlight that of the 407 research participants, 55.53% were female and 44.47% were male, with 64.86% undergraduate from the management course, 22.36% of the accounting sciences course and 12.78% of economics sciences. Another important fact is the age of the respondents. For the research sample, 82.80% are between 19 and 25 years old and 17.20% are over 26 years old.

The primary research data were obtained by applying a closed questionnaire with a Likert scale, developed by Liñan and Chen (2009) called the Entrepreneurial Intention Questionnaire, as explained in the previous section.

The data obtained from the questionnaire responses were tabulated on the Microsoft Excel spreadsheet and the data analysis was divided into 2 stages: the reliability analysis by Cronbach's α and the KMO using the SPSS software - version 22 and the exploratory factor analysis using the SmartPLS 3.3.2 software. This data analysis wants to test 5 basic hypotheses, as shown in Table 1.

*Table.1: Hypotheses*

| Hypotheses | Description | |
|---|---|---|
| H1 | Personal attitude positively influences entrepreneurial intention | PA→EI |
| H2 | Perceived behavioral control positively influences entrepreneurial intention | PBC→EI |

| H3 | Subjective norm positively influences entrepreneurial intention | SN→EI |
|---|---|---|
| H4 | Subjective norm positively influences personal attitude | SN→PA |
| H5 | Subjective norm positively influences perceived behavioral control | SN→PBC |

Source: Liñan and Chen (2009, p. 599)

## IV.    RESULTS

The entrepreneurial intention model, developed by Liñan and Chen (2009), is formed by independent variables. Given this characteristic, it was decided to use exploratory factor analysis. According to Hair et al. (2009), factor analysis in the main purpose of defining the inherent structure between the variables in the analysis.

However, before measuring the model variables by factor analysis, it is important to analyze the level of reliability of the sample to evaluate the consistency and stability of the measures attributed to the different variables. For this, this article used Cronbach's alpha to measure the level of reliability that is shown in Table 2.

*Table.2: Cronbach's Alpha*

| Variables | Cronbach's alpha |
|---|---|
| **Personal Attitude** | 0,893 |
| **Subjective Norm** | 0,708 |
| **Perceived Behavioral Control** | 0,902 |
| **Entrepreneurial Intention** | 0,948 |

When evaluating the reliability of the results obtained in the research, it was found that the indexes attributed to each variable in the model ranged between 0.708 and 0.948 (Table 2). Given this variation, it can be said that, theoretically, the scales can be considered reliable. According to Hair et al. (2009), the lower limit for a scale to be considered reliable is 0.7.

After analysis by Cronbach's alpha, it was analyzed the data obtained were suitable for the application of the factor analysis. Therefore, use the Kaiser-Meyer-Olkin (KMO) test which indicates the degree of susceptibility or the adjustment of the data for the factor analysis, that is, what is the level of confidence you can expect from the data when it is being treated by the multivariate method of factor analysis is successfully employed (Hair et al., 2009).

For interpretation of the obtained result, values close to 1.0 indicate that the factor analysis method is perfectly

adequate for the treatment of the data. On the other hand, values less than 0.5, indicate the inadequacy of the method (Hair et al., 2009). Table 3 presents the results obtained by the KMO test.

*Table.3: KMO Test*

| Variables | KMO |
|---|---|
| **Personal Attitude** | 0,872 |
| **Subjective Norm** | 0,611 |
| **Perceived Behavioral Control** | 0,882 |
| **Entrepreneurial Intention** | 0,912 |

When analyzing Table 3, it was found that the KMO varied between 0.611 and 0.912, showing that the values obtained in this test are adequate for the factor analysis, that is, the factor analysis is adequate for the proposed data treatment.

After the KMO analysis, the factor correlation matrix for the first hypothesis (Personal Attitude positively influences entrepreneurial intention) was analyzed, as shown in Table 4.

*Table.4: Factorial Correlation Matrix for the Personal Attitude and Entrepreneurial Intention Variables*

| | EI1 | EI2 | EI3 | EI4 | EI5 | EI6 |
|---|---|---|---|---|---|---|
| **PA1** | 0,406 | 0,403 | 0,426 | 0,387 | 0,369 | 0,400 |
| **PA2** | 0,604 | **0,709** | 0,681 | **0,701** | 0,690 | **0,728** |
| **PA3** | 0,502 | 0,563 | 0,624 | 0,677 | 0,654 | **0,707** |
| **PA4** | 0,591 | 0,654 | 0,668 | 0,672 | 0,636 | 0,681 |
| **PA5** | 0,635 | **0,735** | 0,695 | 0,697 | **0,702** | **0,717** |

When analyzing Table 4, it was noted that the personal attitude of undergraduate students in the Management, Accounting and Economic Sciences courses positively and moderately high influences entrepreneurial intention.

The correlations highlighted in green represent a high correlation with each other, that is, they present a clear association between the elements studied. Thus, it can be said that for respondents, the career as an entrepreneur is attractive to them and they, if they had the opportunity and resources, would create a company.

Table 5 presents the factor correlation matrix for the second hypothesis (perceived behavioral control positively influences entrepreneurial intention). The results obtained showed that the perceived behavioral control positively but moderately influences the entrepreneurial intention of the students participating in the research.

*Table.5: Factorial Correlation Matrix for the Perceived Behavioral Control and Entrepreneurial Intention Variables*

|  | EI1 | EI2 | EI3 | EI4 | EI5 | EI6 |
|---|---|---|---|---|---|---|
| **PBC1** | 0,335 | 0,589 | 0,405 | 0,377 | 0,412 | 0,499 |
| **PBC2** | 0,322 | 0,525 | 0,371 | 0,318 | 0,319 | 0,490 |
| **PBC3** | *0,244* | 0,515 | 0,345 | *0,292* | *0,293* | 0,418 |
| **PBC4** | *0,268* | 0,481 | 0,374 | *0,289* | *0,294* | 0,412 |
| **PBC5** | 0,306 | 0,515 | 0,368 | 0,310 | 0,313 | 0,428 |
| **PBC6** | *0,297* | 0,487 | 0,394 | *0,279* | *0,291* | 0,426 |

The correlations highlighted in orange represent a low correlation with each other, that is, they present a lack of association between the studied elements. In this way, it can be said that undergraduate students in the Management, Accounting and Economic Sciences courses do not consider themselves prepared to start a company, as they do not know the practical details necessary to create a company.

Table 6 presents the factor correlation matrix for the third hypothesis (subjective norm positively influences entrepreneurial intention). The results obtained showed that the subjective norm positively but weakly influences the entrepreneurial intention of the students studied.

*Table.6: Factorial Correlation Matrix for the Subjective Norm and Entrepreneurial Intention Variables*

|  | EI1 | EI2 | EI3 | EI4 | EI5 | EI6 |
|---|---|---|---|---|---|---|
| **SN1** | 0,132 | 0,169 | 0,086 | 0,125 | 0,106 | 0,131 |
| **SN2** | **0,800** | **0,700** | 0,103 | 0,500 | 0,006 | 0,052 |
| **SN3** | 0,050 | 0,034 | **-0,049** | **-0,060** | **-0,031** | **-0,057** |

The correlations highlighted in red represent a negative correlation with each other, that is, they present a lack of association between the studied elements. In this way, it can be said that colleagues do not influence the decision-making process of being an entrepreneur. The green correlations, which have a high correlation with each other, show that friends strongly influence the decision to create a company.

Tables 7 and 8 show the factorial correlation matrix for the fourth and fifth hypotheses (subjective norm positively influences personal attitude and subjective norm positively influences perceived behavior).

*Table.7: Factorial Correlation Matrix for the Subjective Norm and Personal Attitude Variables*

|  | PA1 | PA2 | PA3 | PA4 | PA5 |
|---|---|---|---|---|---|
| **SN1** | 0,193 | 0,161 | 0,220 | 0,218 | 0,212 |
| **SN2** | 0,209 | 0,154 | 0,188 | 0,176 | 0,133 |
| **SN3** | 0,086 | 0,041 | 0,011 | 0,018 | 0,074 |

*Table.8: Factorial Correlation Matrix for the Subjective Norm and Perceived Behavioral Control Variables*

|  | PBC1 | PBC2 | PBC3 | PBC4 | PBC5 | PBC6 |
|---|---|---|---|---|---|---|
| **SN1** | 0,195 | 0,114 | 0,150 | 0,120 | 0,075 | 0,136 |
| **SN2** | 0,084 | 0,062 | 0,023 | 0,038 | 0,098 | 0,035 |
| **SN3** | 0,108 | 0,038 | 0,033 | 0,081 | 0,142 | 0,043 |

When analyzing Tables 7 and 8, it was found that the subjective norm positively but weakly influences the personal attitude and perceived behavioral control of the students who participated in the research. Thus, it can be said that there is no social pressure exerted on individuals to become or not an entrepreneur, coming from the social circle in which they live.

## V. CONCLUSION

The current Brazilian economic scenario that promotes a climate of uncertainty in youth employment demonstrates the need to create alternatives for the future, being clear that self-employment and, specifically, the creation of companies, can work, no doubt, as one of the solutions to this problem.

Hecke (2011) corroborates this statement saying that endeavor can mean great job opportunities for students who complete an undergraduate course, especially in Administration, Accounting and Economic Sciences. Another important fact is that when creating a new company, it can mean leverage in the growth process of the region where these future entrepreneurs operate.

Based on this observation, this paper aimed to analyze the entrepreneurial intention of undergraduate students in the management, economics, and accounting sciences courses at a Municipal Public University of the State of São Paulo - Brazil.

Based on the entrepreneurial intention questionnaire (QIE) developed by Liñán and Chen (2009), it can be concluded that the entrepreneurial career is perceived as favorable by the students of management, economics and

accounting sciences from different periods, being seen as more attractive than formal work.

However, pursuing an entrepreneurial career is not necessarily a positive alternative in the opinion of those around the survey respondents to the point of being encouraged by families, friends, and colleagues. Finally, students consider that their knowledge about the mechanisms to support entrepreneurial practice is limited within the analyzed institution.

In order to improve knowledge about entrepreneurial practice, it is recommended that the municipal public university located in the state of São Paulo restructure the curriculum of the Management, Economic and Accounting Sciences courses, inserting subjects that contemplate the development of students' entrepreneurial intention.

Given the importance of university education in the development of entrepreneurial skills and competences, it is believed that the present study achieved its objective with consistent results. By observing the behavior of the municipal public university, students throughout the undergraduate course in Management, Economic and Accounting Sciences, it is expected to contribute to the progress of the courses in order to stimulate and promote entrepreneurship not only as a career option, but also as a field of study.

As suggestions for future studies, we point out the adoption of a longitudinal cut with monitoring of individuals for multiple measures corresponding to their evolution in the courses. It is also suggested to replicate this study with other degrees from the same university such as medicine, psychology, law, engineering, and others. Finally, it is suggested to expand this study in a comparative way with students from other universities located in the State of São Paulo.

## REFERENCES

[1] Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179-211.

[2] Bird, B. (1988). Implementing entrepreneurial ideas: The case for intention. *Academy of management Review*, 13(3), 442-453.

[3] Bird, B. J. (1992). The operation of intentions in time: The emergence of the new venture. *Entrepreneurship Theory and Practice*, 17, 11-11.

[4] Carvalho, D. (2004). *Variáveis associadas ao perfil empreendedor: relações com modelos familiares e formação empreendedora*. Rio de Janeiro: UFRRJ. Tese de Mestrado.

[5] Carvalho, P., & González, L. (2006). Modelo explicativo sobre a intenção empreendedora. *Comportamento Organizacional e Gestão*, 12(1), 43-65.

[6] Camozzato, E. S., Serafim, F. K., de Melo Cavalheiro, C. C., Lizote, S. A., & Verdinelli, M. A. (2018). Estilo cognitivo e intenção empreendedora dos estudantes de administração. *Revista Gestão Universitária na América Latina-GUAL*, 11(3), 105-121.

[7] Davidsson, P. (1995). *Determinants of entrepreneurial intentions.* Comunicação apresentada na conferência Rent IX, Piacenza, Itália, 23-24 de novembro.

[8] Dornelas, J. C. A. (2005). *Empreendedorismo*. Elsevier Brasil.

[9] Filion, L. J. (1991). O planejamento do seu sistema de aprendizagem empresarial: identifique uma visão e avalie o seu sistema de relações. *Revista de Administração de Empresas*, 31(3), 63-71.

[10] Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. &Tatham, R. L. (2009). *Análise Multivariada de Dados*. 6 ed. Porto Alegre, Bookman.

[11] Hecke, A. P. (2011). *A Intenção Empreendedora dos alunos concluintes dos cursos de graduação em administração e ciências contábeis das instituições de ensino superior de Curitiba – PR*. Curitiba: UFPR. Tese de Mestrado.

[12] Hueso, J. A., Jaén, I., Liñán, F., & Basuki, W. (2020). The influence of collectivistic personal values on the formation of entrepreneurial intentions. *International Small Business Journal*, 0266242620903007.

[13] Kristiansen, S. & Indarti, N. (2004). Entrepreneurial intention among Indonesian and Norwegian students. *Journal of Enterprising Culture*, 12(1), 55–78.

[14] Krueger, N. F. (1993). The impact of prior entrepreneurial exposure on perceptions of new venture feasibility and desirability. *Entrepreneurship Theory and Practice*, 18(1), 5–21.

[15] Lee, S. H. & Wong, P. K. (2004). An exploratory study of technopreneurial intentions: A career anchor perspective. *Journal of Business Venturing*, 19(1), 7–28.

[16] Lima, E., Lopes, R. M. A., Nassif, V. M. J., & Silva, D. (2011). Intenções e Atividades Empreendedoras dos Estudantes Universitários—Relatório do Estudo GUESSS Brasil 2011. Grupo APOE–Grupo de Estudo sobre Administração de Pequenas Organizações e Empreendedorismo, PMDA-UNINOVE. *Caderno de pesquisa*, (2011-01).

[17] Liñán, F. (2004). Intention-based models of entrepreneurship education. *Piccola Impresa/Small Business*, 2004(3), 11–35.

[18] Liñán, F., & Chen, Y. W. (2009). Development and Cross-Cultural application of a specific instrument to measure entrepreneurial intentions. *Entrepreneurship Theory and Practice*, 33(3), 593-617.

[19] Moraes, M. B., da Silva, A. A. C., Monteiro, R. D. C. R. V., & Mendrot, A. R. (2016). Intenção Empreendedora de Alunos de Graduação de uma Universidade Municipal do Estado de São Paulo. *Anais do IX EGEPE*. Passo Fundo.

[20] Nabi, G., Walmsley, A., Liñán, F., Akhtar, I., & Neame, C. (2018). Does entrepreneurship education in the first year of higher education develop entrepreneurial intentions? The role of learning and inspiration. *Studies in Higher Education*, 43(3), 452-467.

[21] Santos, G. E. O. (2015). *Cálculo amostral:* calculadora on-line. Disponível em: <http://www.calculoamostral.vai.la>. Acesso em: 01 fev. 2020.

[22] SCHUMPETER, J. (1997). *A teoria do desenvolvimento econômico (1912)*. São Paulo: Nova Cultural.

[23] Shapero, A. & Sokol, L. (1982). Social dimensions of entrepreneurship. In C.A. Kent, D.L. Sexton, & K.H. Vesper (Eds.), Encyclopedia of entrepreneurship (pp. 72–90). EnglewoodCliffs, NJ: Prentice Hall.

[24] Teixeira, A. A., & Davey, T. (2010). Attitudes of higher education students to new venture creation: the relevance of competencies and contextual factors. *Industry and Higher Education*, 24(5), 323-341.

# Augmented Reality Technology Associated with Gamification in the Educational Process: Practical Research in the Basic Computer Laboratory Discipline at CESMAC University Center

Tacyana Cinthya Matos Batista[1], Flaviana Nogueira de Lima[2]

[1]Master's degree in Education from the Universidad de la Empresa and Information System Specialist by Cesmac University Center, Brazil
[2]Undergraduate in Architecture and Urbanism from Cesmac University Center, Brazil

*Abstract*—*This research aimed to verify the applicability of Augmented Reality (AR) associated with gamification in the discipline of Basic Informatics Laboratory at the University Center - CESMAC, to facilitate the teaching and learning process in higher education. Checking the impression and reaction of participants to this teaching methodology.*

*Keywords*—*Teaching-learning. Augmented reality. Gamification. Motivation.*

## I. INTRODUCTION

The current generation is marked by the usual use of technologies in all areas, whether in the professional, educational, communication and daily fields. This digital age gives a new vision when it comes to using technology as a way to improve existing systems and the resources already used.

The idea of the research arose in view of the need, in addition to generating scientific and current content on the subject, to promote the introduction of these technologies in the teaching-learning process in order to maintain the motivation of students with the innovation of the process. The relevance of the study is based on the innovation of the use of technological devices in the educational area with a focus on the motivation of students, promoting theoretical and practical content in the educational area, which even in the face of technological advances produces little theoretical content on the subject.

Considering education as the basic foundation of human development, a curriculum capable of promoting professional training in line with the demands of the current market, which is increasingly demanding and complex, should be promoted. Currently, it is observed that the educational scenario maintains the reproductive practice of content, cast and without the right to promote an effective formation. In view of the fact, the question arises: Does the use of augmented reality associated with gamification influence the motivation of students being able to facilitate the teaching-learning process?

The main objective of this study was to apply the augmented reality associated with gamification, by involving students of the higher level of digital generation in the acquisition of learning, in the discipline of basic computer laboratory at Cesmac University Center, as well as comparing the students' performance in front of an exhibition class in the traditional methodology and an interactive class using technologies, presenting the applications of augmented reality and gamification aimed at motivating students from the digital generation to learning and verifying, in practice, the effectiveness of the use of Augmented Reality associated with gamification in the discipline of Basic Informatics Laboratory, and had as object the verification of the effectiveness of the application of augmented reality associated with gamification in the performance of students.

In order to confirm whether it is possible to positively influence the motivation of students with the use of technological resources such as augmented reality and

gamification and whether there is the possibility of comparatively measuring this motivation through practical tests.

## II. THEORETICAL FOUNDATION

Education has its legal bases in the Brazilian Federal Constitution, which determines the general rules to be adopted in the educational treatment. Focusing on it, as the responsibility of all social entities, making each one act in the sphere of his competence in a complementary way to the others.

Always aiming to combat inequalities and cushion their impacts, where everyone can have access to quality education, the Ministry of Education (MEC) comes with the responsibility of regulating and supervising educational institutions from early childhood education to higher education, including teaching to people with special needs, as well as in the distance modality, and in any age group.

Based on the current context, where globalization prevails and the whole becomes a cornerstone in what pertine to the educational process. Compliance with the reassessment of teaching in higher education is multifaceted and increasingly demanding and crowded. Therefore, the teacher must transmit the contents in order to attract students, making them more practical, always aiming to achieve them in their entirety. They should also have approaches that promote the training of professionals able to fully carry out their activities in the chosen areas of activity.

Almeida points out that current students are already born in constant contact with technological resources, and it is easier to manipulate them, including those from the less favored classes. It is up to teachers along with the educational environment to adapt to this reality and use the technological perspective. When selecting the technological resource to be applied, the educator must pay care for the entire context in which it will be used. Some of these mechanisms are Augmented Reality (AR), applications, and games, which can also be employed in a variety of ways depending on the purpose.

The games are gaining more and more space in the educational area by promoting a dynamic and interactive form of learning, establishing a satisfactory motivational scale. Knowing this, the use of gamification is presented as an appropriate tool and capable of motivating students, by using the game to facilitate and stimulate learning and develop the skills necessary for the training of the student, both as a professional and as a citizen.

Thus, these mechanisms, as long as applied in line with the objectives of the pedagogical project, enable a playful and effective learning, given that students are challenged to compete using their knowledge about the studied subject and, thus, are motivated to interact and learn the contents. Therefore, the use of technology in education is undoubtedly beneficial and effective in building creative and innovative knowledge. The study tried to ensure all the ethical standards required and, according to Prodanov and Freitas, sought to execute all phases of the study in a morally correct manner.

## III. METHODOLOGY

Regarding the objectives, the research was classified as exploratory, because it intends to generate conceptualization and more information about the theme. Its profile led to the selection of bibliographic research as the main technical procedure, associated with the application of tests and questionnaires to survey the results obtained.

The study was carried out in the Networking laboratory, located on Campus I of the CESMAC university center, where students of the Information Systems course were invited to participate in the research, duly enrolled, between the 1st period and the 8th period, in the period from November 22 to November 26, 2018, according to the following schedule: on November 22/23, the formal invitation was made to the students, day 24, the class was given under the traditional method and application of the questionnaires, on the 25th the technological class and application of the questionnaires was made and the 26th, the data were performed.

During the application of the study, the researcher was observed, empirically, empirically, a greater interest and motivation on the part of the students during the execution of the technological class. At the time it was observed that during the use of the kahoot tool, during the class with the use of technological resources, the students assumed a posture of interaction and participation, making it more dynamic and interactive.

## IV. RESULTS AND DISCUSSIONS

The resources employed and the methodology selected were aimed at confirming the following hypotheses: whether it is possible to confirm and positively influence the motivation of students with the use of technological resources such as augmented reality and gamification, and whether there is a possibility to measure this motivation comparatively through practical tests.

The relevance and justification of this study are based on the innovation of the use of technological devices in the educational area focused on the motivation of students, promoting theoretical and practical content in the educational area, which even in the face of technological advances produces little theoretical content on the subject.

The first analysis corresponds to the survey and compilation of quantitative data, which according to Peixoto and Córdoba, focuses on logical, palpable and measurable reasoning of the results obtained. It was observed through these, that the students presented similar results regarding the performance about subjective (traditional) or objective (technological) questions, pertinent to traditional and technological methods.

Qualitative analysis represents a more complex view of the study, where the complex and inductive side of the study is analyzed. Starting the phase, students were asked to answer an online questionnaire made available in Google Forms. Through the results obtained through it, it was concluded that the technological method promoted greater acceptance and motivation about the content selected to serve as the theme of the class, given, enabling an innovative and interesting resource in the transmission of the content.

## V. CONCLUSION

It is concluded that digital technology is a great ally of learning and, it is increasingly accessible and if well managed it is able to enhance learning. This practice inserts novelty in the educational environment and breaks with traditional standards, which promotes a relaxed and effective environment in the production of knowledge, because, as a result of the qualitative question number 8 (eight), of the students who attended the class with the use of technological resources 85.7%, stated that they felt safer and able to respond to qualitative exercise, while only 46.2% of the students who attended the traditional class. This points to the precariousness of the conventional teaching model, requiring the insertion of innovation and motivation in the process.

Considering that the present study was conducted as research and the application time was short, and the contact of students with technological resources was reduced, and even so it was effective and motivating, their definitive and usual insertion in the teaching-learning process in accordance with the pedagogical culture of the educational institution is an efficient means of improving the students' performance.

The results demonstrate the confirmation of the proposed objectives, as well as ratify the hypotheses raised, given

that it was possible to confirm that it is possible to positively influence the motivation of students with the use of technological resources such as augmented reality and gamification and whether there is possibility of measuring this motivation through practical tests.

The relevance of the study is the contribution of research to the academic environment, because it generated current scientific content on the subject, also contributes to an effective education focused on effective and modern professionalization. In view, the difficulties faced when researching current content and practical studies aimed at the production of scientific content aimed at innovative and quality education, as observed that there is still a lot of resistance, both from the educational institution and teachers in inserting technological resources in the educational area.

In a sense, considering the general analysis of the data, that is, qualitative and quantitative, there is a high rate of acceptance by students of the technological method, considered innovative and motivating, facilitating learning and providing a skilled pedagogical resource for the promotion of effective and practical knowledge. Evidencing the methodology as an instrument of great utility in the area of education, where its applicability combined with a good elaboration of pedagogical project is able to introduce a dynamic and effective educational environment.

## REFERENCES

[1] ALMEIDA, M. E. Informatics and teacher training. Brasilia: Ministry of Education, 2000.

[2] Brazil. Constitution (1988). Constitution of the Federative Republic of Brazil: promulgated on October 5, 1988. São Paulo: Rideel, 2019.

[3] Brazil. Law No. 8,069 of July 13, 1990. It provides for the Statute of the Child and Adolescent and provides other measures. Official Gazette [of] the Federative Republic of

[4] BRASIL, Brasília, DF, 16 Jul. 1990. Available in: http://www.planalto.gov.br/ccivil_03/LEIS/L8069.htm#art266. Access: 15 Mar. 2019.

[5] Brazil. Ministry of Education. Inep. The Education Development Plan: reasons, principles and programs. Brasilia, 2007

[6] Brazil. National Education Plan - PNE/Ministry of Education. Brasilia, DF: INEP, 2001

[7] DETERDING, S., KHALED, R., NACKE, L., DIXON, D. Gamification: Toward a Definition, CHI 2011. Gamification Workshop Proceedings, Vancouver, BC, Canada, 2011. Available from: http://gamification-research.org/wp-content/uploads/2011/ 04/02-Deterding-Khaled-Nacke-Dixon.pdf. Accessed 19 June 2018.

[8]  FLICK, Uwe. Introduction to research methodology: a beginner's guide. Translation: Magda Lopes. Porto Alegre: I think, 2013.

[9]  Kahoot. Available in: https://kahoot.com/. Accessed: Aug. 1. 2018.

[10] OBLINGER, D. G. The Next Generation of Educational Engagement. Journal of Interactive Media in Education, 8(1), 1–18, 2004.

[11] PRODANOV, C.C.; FREITAS, E. C. Methodology of Scientific Work: methods and techniques of research and academic work. 2 ed. New Hamburg: FEEVALE, 2013.

[12] SILVEIRA, Denise Tolfo; CORDOBA, Fernanda Peixoto. Scientific research. In:

**[13]** GERHARDT, Tatiana Engel; SILVEIRA, Denise Tolfo. Search methods. Porto Alegre: Ufrgs Publishing House, 2009.

# Air quality and microbiological control in a hospital in Paraíba, Brazil

Hermano Zenaide-Neto[1], José Soares do Nascimento[2]

[1]Departamento de Sistemática e Ecologia, Centro de Ciências Exatas e da Natureza, Universidade Federal da Paraíba, Brazil
[2]Departamento de Fisiologia e Patologia – Centro de Ciências da Saúde, Universidade Federal da Paraíba, Brazil

*Abstract*— *An elevated quantity of pathogenic microorganisms can be an indicator of poor air quality, putting patient's health in hospitals at risk. The sanitation of the refrigeration systems must be carried out efficiently and with the right products, capable of maintaining reduced levels of hospital infection. In this work, the aim was to analyze the fungal density in the air of a private hospital, located in João Pessoa-PB, Brazil. The effectiveness of the disinfectant used to clean air conditioning systems in these environments was also verified. In an in vitro experiment with Thilex® disinfectant against common microorganisms in the hospital environment, the antimicrobial activity, concentration and time of action were evaluated. For the analysis of the air in refrigerated places in the hospital, a bio-aerosol impactor was used to quantify the pathogens. The antimicrobial test indicated that Thilex® was effective against Klebsiella sp., Escherichia coli and Candida albicans, while Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus sp. and Aspergillus sp. presented resistance at the concentration of 2%, being controlled up to 20% of the product in distilled water and exposure time above 1 minute. The hospital's air samples indicated that 12 of the 23 rooms had a fungal density above the acceptable limit according to the current national regulatory standard, with a higher prevalence in obstetrics rooms. The most common genera were Aspergillus sp., Penicillium sp. and Monilia sp. These results indicate urgency in the development of more effective public policies in reducing the risk to patients exposed to low air quality in hospitals.*

*Keywords*— *Aeromicrobiology, Air conditioning, Anemophiles, Microbial control, Penicillium sp.*

## I. INTRODUCTION

Since the twentieth century, industries, homes, and hospitals have adopted the use of air conditioners to maintain indoor environments at a comfortable temperature (Afonso 2004). In urban centers, people spend about 90% of their time in environments acclimated by air cooling systems (Horve et al., 2019). It is expected that, with the increase in heatwaves around the world, the demand for the use of air conditioning systems in the long term may increase even more (Zuo et al. 2015).

These systems provide an ideal environment for the growth of potentially pathogenic microorganisms, such as fungi and bacteria, due to the high humidity rates and the accumulation of impurity in the devices (Hatayama et al. 2018). However, the diversity of bacteria and fungi residing in air conditioning filters and their possible health risks associated with hospitalized patients is not completely known (Acerbi et al. 2017).

The *split* system devices are the most used in healthcare centers in Brazil, due to their low cost,

durability, and easy maintenance (Marangoni et al. 2015). However, when the constant cleaning of the filters used in the equipment is hindering the growth of microbial bacteria. As these systems operate at high internal pressure, bacteria and fungi can be sprayed in the air and, therefore, they must consider the appropriate use of cleaning techniques and the replacement of these devices when necessary (Khare 2014).

Fungal infections occupy third place as the main cause of hospital infections and can have clinical manifestations that cause skin processes limited to generalized systemic infections (Blatzer 2017). Anemophilic fungi are microorganisms found dispersed in atmospheric air that can trigger allergic processes and cross-infections in immunocompromised patients, constituting the main contaminants in indoor air-conditioned environments (Calumby et al. 2019).

Immunocompromised patients belong to a group that may include people with hematological neoplasms, who have undergone transplants, with congenital immunodeficiencies and with the use of

immunosuppressive drug therapy (Martínez-Herrera et al., 2016).

It is a great interest in public health to minimize the risk of healthcare-associated infections (HAIs), especially in operating rooms. It is recommended that the microbial air reservoir be quantified through the analysis of samples, for which possible preventive measures, the quality of life of internalized patients is improved.

Anemophilic fungi and most pathogenic bioaerosols can disperse over great distances through the air and remain viable, increasing the possibility of infection even without contact with a source. Administrative Rules of the hospital protect vulnerable patients, maintaining strict airflow systems and isolating patients with infectious diseases transmitted by air in rooms that use HEPA filters in the piping. Despite these controls, the HAIs reaches an estimated 4.5 million deaths in Europe annually, leading to 37,000 deaths and adding 16 million additional days to hospitalized patients (Zingg et al. 2015). In Brazil, it is estimated that hospital infection rates reach 14% of hospitalized patients (ISC-UFBA, 2019).

The number of infections in surgical centers has increased in recent years, constituting a major health problem in Brazil, especially in Intensive Care Units (ICUs). These infections increase the length of hospital stay for patients and, consequently, increase the cost of hospital supplies, in addition to preventing bed rotation. Microbial resistance to antibiotics is one of the main causes of this and it can be intensified by poor air quality (Moura et al. 2018).

The control of internal microbial communities usually involves the removal of microbial biomass through physical and chemical agents. New infection prevention standards have been integrated into architectural designs and clinical procedures in healthcare facilities (Services 2004). Mechanical filtration, disinfection of cavities and walls of buildings, pressurization of rooms, and laminar flow have been implemented to control the spread of pathogens, but few studies confirm that they decrease HAIs taxes (Tang 2009). This can be caused by inefficiency in control methods. Common surface cleaning techniques do not remove all microbial biomass from surfaces where, after just a few days, microbial communities are found even in cleanrooms or sterile reagents (Kwan et al. 2018). In addition, the use of cleaning materials contaminated by bacteria can be a source of contamination unable to remove them (Dharan et al. 1999). The use of powerful antimicrobial cleaning solutions can often contribute to a decline in adherence to hospital staff cleaning protocols

over time, leading to the persistence of microorganisms in public environments (Boyce et al. 2014).

Two hypotheses were used in this essay. The first is that the disinfectant used to disinfect air conditioners in the hospital environment is not efficient for controlling common microorganisms. The second, that the quantity of these pathogenic microorganisms may present a health risk for immunocompromised patients in hospital environments.

The work was divided into two stages: 1) Analysis of the *in vitro* antimicrobial test using the sanitizing product against the most common microorganisms detected in the hospital environment to verify the antimicrobial effect, and 2) Sampling and quantification of potentially pathogenic microorganisms present inside the hospital for comparison with current legislation.

The general objective was to analyze the risks of microbial contamination of the hospital environment, verifying the antimicrobial effect of the sanitizing product used in air conditioning systems against different airborne pathogens, and to evaluate the population and the diversity of fungi in the private hospital in the city of João Pessoa-PB.

## II.   MATERIAL AND METHODS

### *In vitro* antimicrobial activity test

The manipulation of samples and microorganisms was carried out in the microbiology laboratory of the Department of Physiology and Pathology (DFP) located at the Health Sciences Center (CCS) of the Federal University of Paraíba.

Seven microbial clinical isolates with pathogenic potential were used, some representative of the human microbiome and others present on surfaces, and normally transient in indoor air in hospital environments. The cultures were provided by the Lauro Wanderley University Hospital - HULW-UFPB and kept in the DFP/CCS laboratory. The species were identified as *Aspergillus* sp. and *Candida albicans*, *Escherichia coli*, *Staphylococcus aureus*, *Bacillus* sp., *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. The growth and maintenance of the cultures were carried out in Agar Brain Heart Infusion (BHI) medium at 37 ° C for bacteria and Agar Sabouraud Dextrose at 25 ° C for fungi.

The Thilex® cleaning solution was aseptically diluted in sterile distilled water in the following concentrations: 2%, 20%, and 100% and the control with 0% (water only), making a final volume of 5mL in each

test tube. Then, a suspension of each previously cultured microorganism was standardized for turbidity based on the 0.5 McFarland scale tube and 1mL of this suspension was transferred to each tube containing the diluted solution. For each fungus, a suspension of around $10^8$ CFU/mL was standardized.

After homogenization in a vortex mixer, 1mL aliquots were transferred in series. The tubes included as the product products were left to stand at different times (1, 10 and 20 minutes) at room temperature and after that, a swab was embedded in each tube containing the dilutions and seeded in Petri dishes using the culture medium suitable for growth, in triplicate (BHI culture medium for bacteria and Agar Sabouraud for fungi). After incubation at $36 \pm 2$ ° C for 48 hours (bacteria) and 25 ° C for 96 hours (fungi), the viability of microbial cells as specified by the growth responses on the plate.

**Analysis of the microbiological quality of the hospital**

This stage of the study was carried out in a private hospital, located in the city of João Pessoa, state of Paraíba, Brazil. The samples were collected inside and outside the hospital and data were provided for this study with permission and consent signed by the hospital's directory board.

The site area is characterized by a high concentration of people during its operation. As the hospital has a large area divided into several environments, the following areas were selected for sample collection: cafeteria, general ICUs, pediatric ICU, coronary ICU, obstetrics rooms, pre-delivery room, operating room, and center of materials for sterilization (CME). With the rooms contained in each area, there were 23 rooms in total. In addition to these internal environments, an area outside the hospital was also selected, as determined by the methodology described (Fernandes, 2014), established near the side entrance of the parking lot.

Sampling was performed using the active method of air impaction. In view of a large number of samples, sampling was carried out in two days, with daily sampling from an external location. The equipment used in the sampling was a model of a 1-stage bioaerosol impactor, model CF-6 (Andersen type) that simulates the human respiratory tract, more specifically the terminal bronchi (1.1 to 2.1 μm in diameter) characterized by sampling pump, flow rate: 28.3L / min, supply: 110V, dimensions 241 x 139 x 114mm and 3,880g in weight.

In operation, the impactor causes the flow to be collected through a surface filled with holes of a predetermined diameter that prevents greater amounts of bacteria and fungi from 0.6 to 22 micrometers from

reaching and contaminating the medium, affecting the flow speed of air and causing molecules to deviate. Thus, inert microorganisms collide with the culture medium of disposable Petri dishes that were fixed to the impaction system with culture medium ready for use (Fernandes 2014). As plates were identified with location and sample number and the culture medium used was Agar Sabouraud Dextrose. The sampler was placed at a height of 1.5 meters and 70% alcohol was applied in the period between collections.

The indoor air renewal process was monitored with an analysis of the concentration of $CO^2$ in parts per million (PPM) in active environments using a direct chemical reading device in each room. An analysis was carried out by a third-party company that provided the data. The parameter used was recommended by RE/ANVISA nº 9, with the maximum recommended value of carbon dioxide in the environment, being $\leq 1000$ PPM, indicated for comfort and well-being.

The identification of the fungi used in the air samples was carried out by the slide microculture technique, which consisted of cultivation on microscopic slides in a humid chamber. For this, 0.5 cm² of Potato Dextrose Agar was used. With a flamed needle, each colony was transferred to fragments of the medium. A slide was added over the medium and incubated in a humid chamber, followed by the Petri dish lined with water-soaked paper. The incubation was performed in 3 to 5 days in an oven at 25 ° C. At the microscope, it was possible to visualize fruiting structures such as hyphae, conidia, and sporangiospores with the aid of the addition of lactophenol blue dye (Carvalho 2018).

For a macroscopic analysis of the colonies, characteristics such as color, texture, surface, and pigment dispersed in the culture medium were evaluated. At the end of these analyzes, they were sterilized and discarded.

With the results of the identification and the quantitative tests, the microbial containers were verified according to the provisions of the norms 9 of 2003, RDC no. 15, of March 15, 2012, and DRC no. 222, of March 28, 2018, from ANVISA.

Statistical analysis and graph production were used using the GraphPad Prism 8.0 and Microsoft Excel 2016 software.

## III.  RESULTS

*In vitro* **tests**

The microbial isolates originated from the University Hospital Lauro Wanderley - HULW-UFPB, in

the *in vitro* tests indicate that the microorganisms *Klebsiella* sp., *E. coli* and *C. albicans* were more susceptible to the disinfectant product, with no more growth in concentrations from 2 %, whereas *P. aeruginosa*, *S. aureus*, *Bacillus* sp. and *Aspergillus* sp. demonstrated susceptibility only from 20%.

*Table.1: Growth of the pathogens in different concentrations and exposition time of the sanitizing product Thilex®*

| MICROOR GANISM | PRODUCT CONCENTRATION AND EXPOSITION TIME | | | | |
|---|---|---|---|---|---|
| BACTERIA | Control | 2% | 20% (1 min) | 20% (10 min) | 20% (20 min) | 100% |
| *Escherichia coli* | + | - | - | - | - | - |
| *Staphylococcus aureus* | + | + | - | - | - | - |
| *Bacillus sp.* | + | + | - | - | - | - |
| *Klebsiella sp.* | + | - | - | - | - | - |
| *Pseudomonas aeruginosa* | + | + | - | - | - | - |
| FUNGI | Control | 2% | 20% (1 min) | 20% (10 min) | 20% (20 min) | 100% |
| *Candida albicans* | + | - | - | - | - | - |
| *Aspergillus sp.* | + | + | - | - | - | - |

**Fungal quantification in the hospital**

Analyzing the fungal community present in the hospital air in the 23 samples, it was found that in 12 samples concentrations were recorded above the ANVISA reference maximum limit, with the ratio of indoor air to outdoor air equal to or greater than 1.5. Fig. 1 indicates the indoor/outdoor ratio (or I/E ratio) between the sampling sites in an orderly manner. Environment classification parameter: internal sample / external sample: I/E ratio <1.5 = good; I/E ratio ≥ 1.5 = bad. The highest concentration of

fungi in the air (UFC / m³) was recorded (in descending order) in rooms 03, 05 and 01 of the obstetrics wards.
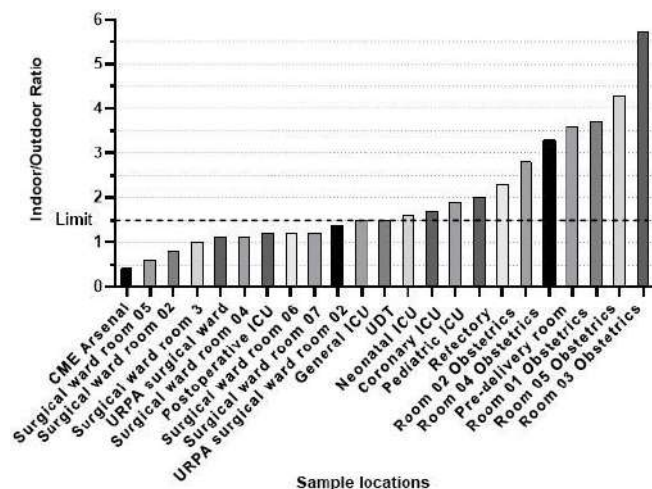


*Fig. 1: Indoor/outdoor ratio values between sample locations at the private hospital in Paraíba, Brazil.*

After incubation and counting of colony-forming units, the anemophilic fungal genera obtained from the samples were identified through microcultures for morphological analysis. Fig. 2 shows the genera most found in the hospital.
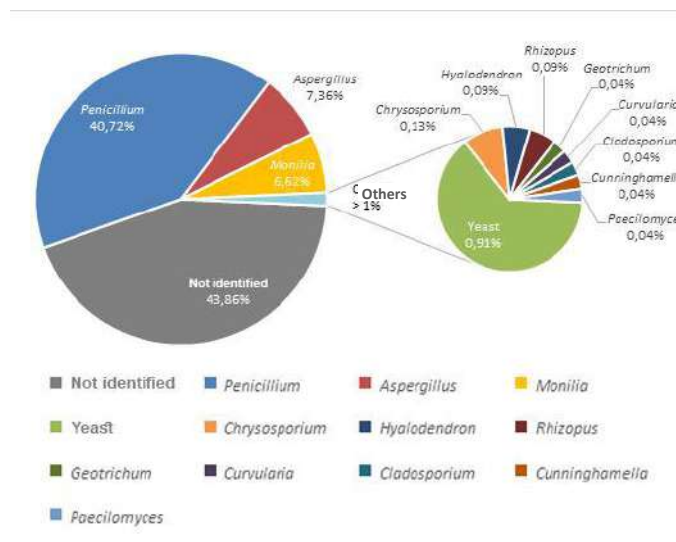


*Fig. 2: Average percentage of fungal diversity in the interior rooms of a private hospital in Paraíba, Brazil.*

The average percentage in all environments analyzed showed that among the identified genera, *Penicillium* with 40.72%, *Aspergillus* with 7.36%, *Monilia* with 6.62% and other less frequent genera predominated. However, most genera were not identified because they presented only the

formation of the mycelium, without reproductive structures.

There were two periods of collection to analyze the concentration of $CO_2$ in indoor environments. The concentration of $CO_2$ in indoor environments, according to the recommendations of RE/ANVISA nº 9, should not exceed the limit of 1000 PPM. Thus, when comparing the measured levels with the limits established by the legislation in force, as shown in the graph of figures 1, the operating room 05, Neonatal ICU and URPA reach values that exceed the maximum recommended value (MRV). The MRV is not exceeded in any of the other verified environments, providing a healthy environment for the occupants.

## IV. DISCUSSION

A possible explanation for the resistance of pathogens to the disinfectant may be the presence of anionic surfactant in the composition of the product. Previous tests indicate that cationic surfactants are more effective in terms of antimicrobial effect, even when there is a synergistic resistance between bacteria (Patrone et al. 2010). As for the time of action, the product demonstrated effectiveness after 1 minute against all microorganisms tested.

Microorganisms such as *A. niger* and *P. aeruginosa* are studied as an application for bioremediation in sewage treatment plants because of their ability to not only resist but also degrade anionic surfactants. In one study, the presence of detergent caused a partial inhibitory effect on the growth of *A. niger* biomass (about 51.4%), however, the fungus demonstrated to degrade 30% of the anionic surfactant present in the medium after 16 days (Jakovljevic 2016). A *P. aeruginosa* strain showed degradation of about 96% of an anionic surfactant in the culture medium in 48 hours of incubation (Ambily 2012). This degradation capacity may have contributed to the findings of the current study, with *Aspergillus* sp. and *P. aeruginosa* possibly showing resistance to the anionic surfactant present in the product Thilex®.

That said, the sanitizing product used in air conditioning units may not have a direct influence on the variation in the internal fungal density of the hospital since its effectiveness has been within the expected standards.

To reduce bias that could interfere with the experiment, distilled and sterile water was used, which in fact does not reflect the composition of the water collected directly from the taps, as occurs in the cleaning process inside the hospital. Thus, future studies may use tap water,

considering the microbiota present, as well as correlate the effects on other pathogens not tested in this work, using different products and contact times. It is emphasized that the aseptic handling of microorganisms for the contact test reflected significantly on the repeatability and reproducibility of the assay and should be taken into consideration for future tests.

The highest fungal density was associated with the obstetrics and pre-delivery rooms, with *Penicillium* being the most commonly identified genus. This phenomenon can be attributed to the increase in dust, in favor of the deposit of fungal spores and probably due to an infrequent or insufficient cleaning of the environment. Surfaces that show greater contamination are the upper parts of furniture and the upper surfaces of large equipment (refrigerators, sterilization devices, heaters, etc.), where it is easier to detect or cause moisture damage (Brunetti et al. 2006).

It is necessary to observe the room that registered the lowest concentration of fungi during the study, which was the arsenal of the CMS. CMS is an acronym for Central of Materials and Sterilization or Center of Sterile Materials, and the objective is to be a sector dedicated to the cleaning, conditioning, sterilization and distribution of all medical articles in the hospital. ANVISA has established guidelines for the functioning of a CME, which must consist of: reception and cleaning room; preparation and sterilization room; chemical disinfection room (when applicable); area for monitoring the sterilization process; and a storage and distribution room for sterile materials. As support environments, provision should be made for: a dressing room with a bathroom for employees; cleaning material deposit; a pantry for sector employees; administrative room, and space for employees to rest during the night shift. A high inspection regarding the sterilization of the CMS room can serve as a model for indicating possible guidelines for use in rooms that have a higher fungus count, adapting to the prohibitions of each sector and each hospital (Tavares et al. 1979).

These results highlight the importance of environmental requirements and the need for cleaning procedures that can prevent fungal contamination in hospital departments. Immediate preventive action and specific training for the cleaning team, through education programs and application of infection control procedures, as well as corrective cleaning measures in contaminated rooms, will certainly have a directly detectable positive effect on the environment. The ideal time interval for cleaning air conditioners varies in different regions, but most protocols recommend sanitary maintenance of the unit every 7 to 15 days or at least twice a month (Aparecida 2011; Brenier-Pinchart 2009).

The installation of HEPA filters aims to eliminate biological contaminants from the air. According to a technical note from ANVISA, an inspection must be carried out periodically and the filter must be replaced when the differential pressure of the airflow or the passage reaches 45mmca or after 18 months of use, even if the differential pressure is less than 45mmca (Anvisa 2013).

Due to access limitations to the hospital, it was not possible to collect the samples before and after disinfecting and cleaning the devices. The study by Dehghani et al. (2018), carried out in a hospital unit in Iran, indicates that there can be a significant difference in the count of microorganisms before and after cleaning the rooms.

In that same study, 41% of the rooms had counts higher than the recommended values and the most prevalent microorganisms among the genera *Aspergillus* and *Penicillium*. Factors that influence the results, according to the researchers: low ventilation, a little wet variation of floors in the rooms, inadequate filtration of the air-cooling systems, high ventilation, and lack of ideal management of infectious patients after surgery. A recommendation for this case is to use HEPA filters, implementing more rigorous disinfection procedures, and improving or controlling temperature and humidity (Dehghani et al. 2018). Another study, carried out in a Portuguese hospital showed that, according to a fungal sampling in indoor air, the predominant genera were *Penicillium* spp. (41%) and *Aspergillus* spp. (24%) Aspergillus species were: *A. fumigatus*, *A. versicolor*, *A. glaucos* and *A. niger* (Cabo Verde et al. 2015). These results corroborate to those found in the present research, where there was a predominance of these two genders in all environments analyzed.

The results indicated that rooms with a high fungus count are worrying when in a scenario in which patients that suffer allergies are present. Sensitization to fungal allergens may be associated with allergic respiratory disease and atopic dermatitis. One study investigated a relationship between sensitization to different allergic genes, specific IgE sensitization rates for *Candida*, and was 81.2%, followed by *Aspergillus* in 69.2% and *Penicillium* in 63.2%, with lower values in patients with atopic dermatitis (Chang et al. 2010).

The fungal diversity found in the present study can be explained by the excellent mechanism of dispersion of fungi suspended in the atmosphere, which can be transported as bioaerosols over long distances with the movement of air. Certain fungi develop adaptations favorable to their survival while they are dispersed in the atmosphere, present in pollution, skin, tissues, and water droplets (Martínez-Herrera et al. 2016).

In general, physical-chemical conditions are not favorable to the growth of microorganisms and most can only remain viable until suspended for a short period of time. However, fungal conidia can propagate units with longer viability rates due to properties such as thick cell walls, which protect against desiccation and the pigment (melanin), that protects against ultraviolet radiation. Other important adaptations are thermotolerance and nutritional versatility, which allows the use of diverse sources of carbon and nitrogen, as in the case of *Aspergillus* conidia when they germinate (Abad et al. 2010).

Fungal genera can turn superficial infections into invasive microorganisms. Although fungi have several routes of entry into the host, the most common is the inhalation of propagules; therefore, maintaining good air quality is essential in critical areas of hospitals to reduce invasive fungal infections (Martínez-Herrera et al. 2016).

One of the most important diseases, in this case, is asthma, the most prevalent condition in the age between 0 and 18 years. In addition, pregnant women, ICU patients, and newborns under one year of age are more susceptible to these pathogens. The presence of fungi in the hospital can also be a risk factor for the health of workers and hospital employees (Abbasi et al. 2019). As seen in the present study, of the five ICU rooms, three of them were committed to levels above the acceptable level, that is, in bad conditions.

An external layer of spores (conidia) in fungi is rich in hydrophobin, which allows them to remain suspended without depositing, a cysteine present in the hydrophobin is highly active in the fungi surfactant. As the hydrophobins are organized in an amphipathic monolayer that reduces the surface tension of the medium or the substrate on which the fungus grows, it allows the interface to be below the water and avoid hydrosaturation to maintain gas permeability. The degree of hydrophobicity among fungi varies from a highly hydrophobic level, affecting the efficiency of the spore dispersal capacity (Bayry et al. 2012). A high density of sporulated fungi found in hospitalizations confirms a high dispersion capacity in the air and a high risk of contamination for patients.

The presence of *A. fumigatus* in similar studies was higher in hospital corridors. In the present study, a greater diversity of fungi was observed in the coronary ICU. The way this room was designed, containing a reception in the center and cabins with beds around it, can cause the traffic of people in a circular motion to be intensified and this can contribute to a greater spread of spores. Results presented in other studies may vary depending on the type of hospital, location, number of patients and visitors, climatic

conditions, geographic location, and laboratory conditions, such as incubation temperature and culture medium. As the hospital is located in the middle of the city and close to an urban road, the entry of more pollutants from vehicles may be common; Hospitals located in the metropolitan area, surrounded by vegetation and pastures have the lowest amount of pollutants (Abbasi et al. 2019). Although it has been argued that a source of fungal spores inside the building, including structures and construction conditions, fungal contamination can also be caused by colonies that grow on trees, plants, and shrubs and entrances inside through the door and window (Dannemiller et al. 2016).

Species of *Aspergillus* have pathogenic potential, with special attention to *A. fumigatus*, due to its conidia that are more hydrophobic than other species, in addition to giving more air suspension time, it has the ability to hide the cell wall from inducing a response immune to the host. The hydrophobin RodA protein presents as a virulence factor that prevents the immune system recognition and the recruitment of neutrophils and the production of cytokines. Disinfection using products composed of hydrofluoric acid removes the RodA hydrophobin from the micro-organism and can decrease its pathogenic action. However, pathogenicity can be intensified in immunocompromised patients, making it impossible to generate an immune response and the risk of infection (Carrion et al. 2013).

The third most common fungal genus in this study was *Monilia*, with a higher prevalence in the postoperative ICU. These fungi are anamorphic, being a reproductive phase of *Monilinia* (Andrade 2016). They are not known as human pathogens, being more associated with diseases in angiosperm plants such as *Rosacea* and *Ericaceae*, in addition to causing fruit rot (Hu et al. 2011). Some species of the genus *Monilia* are identified as residents of the human intestinal microbiota and their clinical relevance is more useful for biological indicators of diseases, being observed in small numbers in the intestines of patients with chronic inflammatory diseases, such as Crohn's disease (El Mouzan et al. 2017).

Some yeast-like genera were found in the hospital's rooms. As stated earlier, *Candida albicans* is a predominant cause of invasive yeast infections; however, epidemiology of yeast infections is gradually evolving and other rare yeasts have emerged as life-threatening opportunistic pathogens. *Trichosporon* spp., the second or third most common cause of yeast infection, demonstrated less susceptibility to amphotericin B and 5-flucytosine and resistance to echinocandins (Guo et al. 2017). These findings reinforce the need to monitor the presence of invasive yeasts and antifungal resistance among the variations of regular yeasts today and in the future.

Regarding the concentration of $CO_2$ in the indoor environments analyzed in this study, the rooms with lower levels of air recovery (higher concentration of $CO_2$) do not correspond to a high concentration of fungi found. Like the neonatal ICU rooms, the operating room 5 and URPA showed values above the ANVISA VMR. Of these rooms, only the neonatal ICU has shown a high fungal count (I/E ratio> 1.5), and the room that shows the highest concentration of fungi, obstetrics room 3, has one of the lowest values of $CO_2$ concentration is compared to the other rooms.

There are studies in the literature that correlate the concentration of $CO_2$ with the increase of fungal concentration in indoor environments. This relationship may be more indirect, since it may indicate a high standard of human activity in the analyzed internal environment. As the rates of generation of $CO_2$ and bio-effluents depend on human activity, the concentration of $CO_2$, and the intensity of human bio-effluents in space exhibit a relationship related to the number of occupants. Therefore, the use of $CO_2$ concentration to monitor indoor air quality may be more appropriate to demonstrate the human population density of an indoor or outdoor environment (Chaivisit et al. 2018).

In short, fungal contamination is directly related to air quality, which is a major contributor to the transmission and diffusion of fungal spores. To reduce contamination, special equipment should be used for patients at risk, excessive human movement should be avoided in hospital corridors and windows should be closed. In addition, performing systematic disinfection of air conditioning systems, as well as periodic monitoring of the fungus population, which are indicators of environmental quality. One of the measures may be the use of HEPA filter in cooling systems, which easily and efficiently capture fungal spores and help to isolate environments used as operating rooms.

The results show that the environmental monitoring of biological indicators is an important tool and should be adopted by hospital infection control committees to investigate, control and reduce the occurrence of infections, contributing to reducing the economic impact on hospital admissions.

## V.    CONCLUSION

A high amount of pathogenic fungi is present at-risk sites in the private hospital located in João Pessoa-PB, Brazil. Of the 23 rooms analyzed, 12 had more fungi density than permitted by the norm, including obstetrics, pre-delivery, cafeteria and pediatric, coronary, and

neonatal ICUs. The most common genera found were *Penicillium* (40.72%), *Aspergillus* (7.36%), and *Monilia* (6.62%), however, most of the examples were not identified. The *in vitro* antimicrobial tests of the sanitizing product used in cleaning air conditioning devices (Thilex®) showed that *Klebsiella* sp., *E. coli* and *C. albicans* are susceptible and *P. aeruginosa*, *S. aureus*, *Bacillus* sp. and *Aspergillus* sp. are resistant to less than 2% of the product in distilled water, with the most suitable usage instructions being 20% of the product concentration and exposure time above 1 minute.

Adequate management of patient admission and visit time can be effective in contaminating indoor environments in hospitals, such as the use of protective filters for rooms with immunocompromised patients. In addition, the control of these parameters can prevent health and psychometric problems for health professionals in the long term.

## ACKNOWLEDGEMENTS

## REFERENCES

[1] Abad, A., Victoria Fernández-Molina, J., Bikandi, J., Ramírez, A., Margareto, J., Sendino, J., Luis Hernando, F., Pontón, J., Garaizar, J., & Rementeria, A. (2010). What makes Aspergillus fumigatus a successful pathogen? Genes and molecules involved in invasive aspergillosis. *Revista Iberoamericana de Micologia*, *27*(4), 155–182. https://doi.org/10.1016/j.riam.2010.10.003

[2] Abbasi, F., Jalili, M., Samaei, M. R., Mokhtari, A. M., & Azizi, E. (2019). The Monitoring of Fungal Contamination in Indoor Air of Two Hospitals in Shiraz. *Journal of Environmental Health and Sustainable Development*. https://doi.org/10.18502/jehsd.v4i4.2020

[3] Acerbi, E., Chïnard, C., Miller, D., Gaultier, N. E., Heinle, C. E., Chang, V. W. C., Uchida, A., Drautz-Moses, D. I., Schuster, S. C., & Lauro, F. M. (2017). Ecological succession of the microbial communities of an air-conditioning cooling coil in the tropics. *Indoor Air*, *27*(2), 345–353. https://doi.org/10.1111/ina.12306

[4] Afonso, S. martinez & Tipple, A. F. V. (2004). A qualidade do ar em ambientes hospitalares climatizados e sua influência na ocorrência de infecções. *Revista Eletrônica de Enfermagem*, *6*(2), 181–188. https://www.fen.ufg.br/fen_revista/revista6_2/pdf/Orig5_ar.pdf

[5] Andrade, K. M. (2016). *Caracterização de fungos Cercospóroides associados à vegetação de Mata Atlântica e*

cercanias, no Estado do Rio de Janeiro*. 136.

[6] ANVISA. (2013). Microbiologia Clínica para o Controle de Infecção Relacionada à Assistência à Saúde. Módulo 4: Proce- dimentos Laboratoriais: da requisição do exame à análise microbiológica e laudo final/Agência Nacional de Vigilância Sanitária. *Microbiologia Clínica Para o Controle de Infecção Relacionada à Assistência à Saúde*, *9*, 95.

[7] Aparecida, A., Silva, D. F., Rotinas, N. E., & Hospitalar, D. E. L. (2011). *Manual de Rotinas de Limpeza para área hospitalar*.

[8] Bayry, J., Aimanianda, V., Guijarro, J. I., Sunde, M., & Latgé, J. P. (2012). Hydrophobins-unique fungal proteins. *PLoS Pathogens*, *8*(5), 6–9. https://doi.org/10.1371/journal.ppat.1002700

[9] Blatzer, M., & Latgé, J. P. (2017). Metal-homeostasis in the pathobiology of the opportunistic human fungal pathogen Aspergillus fumigatus. *Current Opinion in Microbiology*, *40*, 152–159. https://doi.org/10.1016/j.mib.2017.11.015

[10] Boyce, J. M., Havill, N. L., Dumigan, D. G., Golebiewski, M., Balogun, O., Rizvani, R., Boyce, J. M., Havill, N. L., Dumigan, D. G., Golebiewski, M., & Balogun, O. (2014). *Monitoring the Effectiveness of Hospital Cleaning Practices by Use of an Adenosine Triphosphate Bioluminescence Assay*. *30*(7), 678–684. https://doi.org/10.1086/598243

[11] Brenier-Pinchart, M. P., Lebeau, B., Quesada, J. L., Mallaret, M. R., Borel, J. L., Mollard, A., Garban, F., Brion, J. P., Molina, L., Bosson, J. L., Cahn, J. Y., Grillot, R., & Pelloux, H. (2009). Influence of internal and outdoor factors on filamentous fungal flora in hematology wards. *American Journal of Infection Control*, *37*(8), 631–637. https://doi.org/10.1016/j.ajic.2009.03.013

[12] Brunetti, L., Santoro, E., Cavallo, P., Boccia, G., Motta, O., & Capunzo, M. (2006). Two-years surveillance of fungal contamination in three hospital departments in Campania Region. *Journal of Preventive Medicine and Hygiene*, *47*(1), 22–25. https://doi.org/10.15167/2421-4248/jpmh2006.47.1.12

[13] Cabo Verde, S., Almeida, S. M., Matos, J., Guerreiro, D., Meneses, M., Faria, T., Botelho, D., Santos, M., & Viegas, C. (2015). Microbiological assessment of indoor air quality at different hospital sites. *Research in Microbiology*, *166*(7), 557–563. https://doi.org/10.1016/j.resmic.2015.03.004

[14] Calumby, R. J. N., Silva, J. A., Silva, D. P., Moreira, R. T. de F., Araújo, M. A. dos S., Almeida, L. M., Grillo, L. A. M., & Alvino, V. (2019). Isolamento e identificação da microbiota fúngica anemófila em Unidade de Terapia Intensiva. *Brazilian Journal of Development*, *5*(10), 19708–19722. https://doi.org/10.34117/bjdv5n10-186

[15] Carrion, S. de J., Leal, S. M., Ghannoum, M. A., Aimanianda, V., Latgé, J.-P., & Pearlman, E. (2013). The RodA Hydrophobin on Aspergillus fumigatus Spores Masks Dectin-1– and Dectin-2–Dependent Responses and Enhances Fungal Survival In Vivo . *The Journal of Immunology*, *191*(5), 2581–2588. https://doi.org/10.4049/jimmunol.1300748

[16] Carvalho, H. K. De, Martins, D. L., & Júnior, D. P. L. (2018). *Isolamento e identificação de microrganismos*

*fúngicos em alimentos em grãos conservados e expostos em feiras livres e supermecados das cidades de Cuiabá e Várzea Grande / MT . Isolation and identification of fungal microorganisms in food grain preserved .*

[17] Chaivisit, P., Fontana, A., Galindo, S., Strub, C., Choosong, T., Kantachote, D., & Suksaroj, T. T. (2018). Airborne bacteria and fungi distribution characteristics in natural ventilation system of a university hospital in Thailand. *EnvironmentAsia*, *11*(2), 53–66. https://doi.org/10.14456/ea.2018.22

[18] Chang, F. Y., Lee, J. H., Yang, Y. H., Yu, H. H., Wang, L. C., Lin, Y. T., & Chiang, B. L. (2010). Analysis of the serum levels of fungi-specific immunoglobulin e in patients with allergic diseases. *International Archives of Allergy and Immunology*, *154*(1), 49–56. https://doi.org/10.1159/000319208

[19] Dannemiller, K. C., Gent, J. F., Leaderer, B. P., & Peccia, J. (2016). Indoor microbial communities: Influence on asthma severity in atopic and nonatopic children. *Journal of Allergy and Clinical Immunology*, *138*(1), 76-83.e1. https://doi.org/10.1016/j.jaci.2015.11.027

[20] Dehghani, M., Sorooshian, A., Nazmara, S., Norouzian, A., Delikhoon, M., Sciences, A., Sciences, M., & Sciences, M. (2018). *Concentration and type of bioaerosols before and after conventional disinfection and sterilization procedures inside hospital operating rooms*. 277–282. https://doi.org/10.1016/j.ecoenv.2018.08.034.Concentration

[21] Dharan, S., Mourouga, P., Copin, P., Bessmer, G., Tschanz, B., & Pittet, D. (1999). *Routine disinfection of patients ' environmental surfaces . Myth or reality ?* 113–117.

[22] El Mouzan, M., Wang, F., Al Mofarreh, M., Menon, R., Al Barrag, A., Korolev, K. S., Al Sarkhy, A., Al Asmi, M., Hamed, Y., Saeed, A., Dowd, S. E., Assiri, A., & Winter, H. (2017). Fungal Microbiota Profile in Newly Diagnosed Treatment-naïve Children with Crohn's Disease. *Journal of Crohn's & Colitis*, *11*(5), 586–592. https://doi.org/10.1093/ecco-jcc/jjw197

[23] Fernandes, H. P. (2014). *AVALIAÇÃO MICROBIOLÓGICA DA QUALIDADE DO AR NO INTERIOR DA BIBLIOTECA CENTRAL DO CAMPUS DA UNIVERSIDADE FEDERAL DE JUIZ DE FORA*.

[24] Guo, L. N., Xiao, M., Cao, B., Qu, F., Zhan, Y. L., Hu, Y. J., Wang, X. R., Liang, G. W., Gu, H. T., Qi, J., Yuan, H., Min, R., Wang, F. Y., Liu, L. J., Wang, H. Bin, Jiang, W., Duan, X. G., Xu, W. J., Yu, Y. H., … Xu, Y. C. (2017). Epidemiology and antifungal susceptibilies of yeast isolates causing invasive infections across urban Beijing, China. *Future Microbiology*, *12*(12), 1075–1086. https://doi.org/10.2217/fmb-2017-0036

[25] Hatayama, K., Oikawa, Y., & Ito, H. (2018). Bacterial community structures in air conditioners installed in Japanese residential buildings. *Antonie van Leeuwenhoek, International Journal of General and Molecular Microbiology*, *111*(1), 45–53. https://doi.org/10.1007/s10482-017-0925-4

[26] Horve, P. F., Lloyd, S., Mhuireach, G. A., Dietz, L., Fretz, M., Maccrone, G., Wymelenberg, K. Van Den, & Ishaq, S.

L. (2019). Building upon current knowledge and techniques of indoor microbiology to construct the next era of theory into microorganisms , health , and the built environment. *Journal of Exposure Science & Environmental Epidemiology*. https://doi.org/10.1038/s41370-019-0157-y

[27] Jakovljević, V. D., & Vrvić, M. M. (2016). Capacity of Aspergillus niger to Degrade Anionic Surfactants and Coproduce the Detergent Compatible Enzymes. *Applied Biochemistry and Microbiology*, *52*(2), 183–189. https://doi.org/10.1134/S0003683816020083

[28] Khare, P., & Marr, L. C. (2014). *Simulation of vertical concentration gradient of influenza viruses in dust resuspended by walking*. *2008*, 1–13. https://doi.org/10.1111/ina.12156

[29] Kwan, S. E., Shaughnessy, R. J., Hegarty, B., Haverinen-shaughnessy, U., Peccia, J., Box, P. O., Program, I. A., & Drive, S. T. (2018). *The Reestablishment of Microbial Communities after Surface Cleaning in Schools*. 0–2. https://doi.org/10.1111/jam.13898

[30] Marangoni, F., Tellini, T., Moreno, R. P. R., Ferreira, S. de O., & Konopatzki, E. A. (2015). *COMPARATIVO ECONÔMICO ENTRE CONDICIONADORES DE AR COM TECNOLOGIAS CONVENCIONAL E INVERTER*.

[31] Martínez-Herrera, E. O., Frías-De-León, M. G., Duarte-Escalante, E., Calderón-Ezquerro, M. del C., Jiménez-Martínez, M. del C., Acosta-Altamirano, G., Rivera-Becerril, F., Toriello, C., & Reyes-Montes, M. del R. (2016). Fungal diversity and Aspergillus species in hospital environments. *Annals of Agricultural and Environmental Medicine*, *23*(2), 264–269. https://doi.org/10.5604/12321966.1203888

[32] Moura, A. dos S., Souza, ; Gabriely Marques, Alves, ; Mateus Goulart, Mendonça, ; Marlon Vilela de Brito ; Luciana de Medeiros Castro Ladeira ; Vanessa F., Santos, ; Marcelo, & Carvalho, ; Marco Túlio Menezes. (2018). *Resistência bacteriana associada aos casos de infecção hospitalar na Santa Casa de Misericórdia de Passos ( MG ): estudo de caso*. 95–106.

[33] Patrone, V., Campana, R., Vittoria, E., & Baffone, W. (2010). In vitro synergistic activities of essential oils and surfactants in combination with cosmetic preservatives against pseudomonas aeruginosa and staphylococcus aureus. *Current Microbiology*, *60*(4), 237–241. https://doi.org/10.1007/s00284-009-9531-7

[34] Services, H. (2004). *Guidelines for Environmental Infection Control in Health-Care Facilities Recommendations of CDC and the Healthcare Centers for Disease Control and Prevention Healthcare Infection Control Practices Advisory Committee ( HICPAC ) Guidelines for Environmental*. *February*.

[35] Tang, J. W. (2009). *The effect of environmental parameters on the survival of airborne infectious agents*. *September*.

[36] Tavares, M. da C., Batista, F. A., Nagasawa, E., & Haffan, I. C. (1979). Central de material e esterilização em hospitais pontos a observar e erros a evitar. *Revista Brasileira de Enfermagem*, *32*(2), 230–238. https://doi.org/10.1590/0034-716719790002000010

[37] Zingg, W., Holmes, A., Dettenkofer, M., Goetting, T., Secci,

F., Clack, L., Allegranzi, B., Magiorakos, A. P., Pittet, D., Carmeli, Y., Dittrich, A., Ebner, W., Edwards, R., Ferlie, E., Gastmeier, P., Hryniewicz, W., Kalenic, S., Kilpatrick, C., Sorknes, N., … Vincent, C. (2015). Hospital organisation, management, and structure for prevention of health-care-associated infection: A systematic review and expert consensus. *The Lancet Infectious Diseases*, *15*(2), 212–224. https://doi.org/10.1016/S1473-3099(14)70854-0

[38] Zuo, J., Pullen, S., Palmer, J., Bennetts, H., Chileshe, N., & Ma, T. (2015). Impacts of heat waves and corresponding measures: A review. *Journal of Cleaner Production*, *92*, 1–12. https://doi.org/10.1016/j.jclepro.2014.12.078

# Situations of Obstetric Violence from the Perspective of Puerperal Women

Genir Isidorio da Silva Santana[1], Ana Catarina Torres de Lacerda[2], Liniker Scolfild Rodrigues da Silva[3], Maria José dos Santos Monteiro[4], Tatiane Barbosa Soares Silva[5], Gabriela Priscila Rodrigues da Silva[6], Jozivalda Venancio Caitano dos Santos[7], Érika Sophia Gouveia da Silva[8], Denise Cesário de Sousa[9], Anna Carollyne de Almeida Vasconcelos Silva[10], Fernanda Celiberti Soveral[11]

[1,5,6,9]Clinical Hospital (HC)/Federal University of Pernambuco (UFPE). Recife, Pernambuco, PE, Brazil.
[2]Nursing Department, Federal University of Pernambuco (UFPE). Recife, Pernambuco, PE, Brazil.
[3]Medical Sciences College (FCM)/University of Pernambuco (UPE). Recife, Pernambuco, PE, Brazil.
[4,10]Faculty of Human and Exact Sciences of the Sertão do São Francisco (FACESF). Recife, Pernambuco, PE, Brazil.
[7]Emergency Mobile Care Service (SAMU)/ Recife City Hall (PCR). Recife, Pernambuco, PE, Brazil.
[8]Faculty Redentor/Faculty IDE. Recife, Pernambuco, PE, Brazil. Recife, Pernambuco, PE, Brazil.
[11]Institute of Integral Medicine Prof. Fernando Figueiras (IMIP). Recife, Pernambuco, PE, Brazil.

*Abstract— To investigate situations of obstetric violence in the perception of puerperal women in a teaching hospital. Descriptive study, with a qualitative approach. Data collection used a semi-structured interview with 17 puerperal women. The puerperal women's statements were transcribed and analyzed through content analysis in the thematic modality proposed by Bardin. From the analysis of the statements, four thematic categories emerged: 1) Disrespect for the parturient, 2) Obstetric violence, 3) Violence revealed, 4) Unknown violence. The study revealed the need for changes in childbirth care to make is more welcoming, with pregnant women's protagonism, respecting their rights constituted by laws, and using good obstetric practices for a humanized childbirth free of violence.*

*Keywords— Gender-Based Violence, Midwifery, Nursing, Qualitative Research, Women's Health.*

## I. INTRODUCTION

The historical analysis of how women experienced their deliveries shows that there were changes in the whole process, with records showing that, in ancient civilizations, women performed their deliveries alone, at most, accompanied by a maternal figure who offered them protection, which would later come to fruition as midwives. This fact culturally sedimented the delivery in the home itself, happening as a natural, private and family process in which the woman was the protagonist of the parturition process [1].

Since the 1940s, the institutionalization of childbirth intensified, aiming to reduce maternal and neonatal mortality and, at the end of the last century, more than 90% of deliveries occurred in the hospital environment. The woman ceased to hold the lead role of her labor, being subjected to seemingly safe norms and interventions, without her consent or oppression, fear, shame and because of the idea that the hospital environment would provide the best care for her and her baby. Assisted by unknown people, away from their relatives and belongings, without the right of choices, contributing to maternal and neonatal risks [1].

To improve obstetric care, the World Health Organization (WHO) published a handbook in 1996, with practices based on scientific evidence called good practices for childbirth care. Ambulation, spray bath and immersion, lumbosacral massage, muscle relaxation, vertical positions, horse method or pelvic movement, aromatherapy, music therapy, Swiss ball, breathing exercises and the presence of a companion chosen by the parturient act in reducing the period of labor, effectively reduce pain and relieve anxiety,

bringing a physical and psychological comfort to the woman. Thus, they should be inserted in childbirth care [2,3].

On the other hand, procedures such as enema, trichotomy, prophylactic venous catheterization, supine and lithotomic position with or without stirrups, rectal examination, routine uterine washing, prolonged and directed pull effort, massage and distension of the perineum, parenteral ergomethrin and use of radiographic pelvimetry should not be used because they are harmful or ineffective. Early amniotomy, maneuvers related to perineum protection and cephalic pole management, active manipulation of the fetus, early clamping of the umbilical cord, fasting, routine episiotomy and active management of oxytocin labor should be carefully used, since there is no scientific evidence for their use [4].

However, even with scientific evidence supporting the implementation of good practices during labor and delivery, many women experience situations of violence. Exposed through negligence in care, social discrimination, verbal aggression and physical violence, including the non-use of analgesia when indicated, inadequate use of technology, with unnecessary interventions and procedures before the scientific evidence of the moment, causing interventions with potential risks and sequelae [5].

Although in Brazil there is no specific definition of obstetric violence, it is characterized by the appropriation of the body and reproductive processes of women by health professionals, through dehumanized treatment, abuse of medicalization and "pathologization" of natural processes, causing the loss of autonomy and ability to freely decide on their bodies and sexuality, negatively affecting the empowerment of their life and their choices [6].

Thus, the woman has the right to choose the type of delivery, intervention and procedure to be performed, to know their reasons, risks and benefits, to know the possibilities of analgesia and to choose the place of delivery and a companion. These measures should be taken consciously, taking into account maternal and fetal well-being and the autonomy of the parturient [4-6].

Due to the frequent discussions on the theme of social relevance, as it constantly occurs, implying violation of the rights of parturients, evidencing the need for improvement in the attention given to delivery and birth, highlighting the importance of the active participation of women in this context. Thus, this study sought to investigate situations of obstetric violence from the perspective of puerperal women at a teaching hospital.

## II. METHODS

This is a descriptive study with a qualitative approach, conducted in a university hospital in Recife/PE, Brazil. The participants were 17 puerperal women, aged over 18 years, in the immediate postpartum period. Submitted to normal delivery or cesarean section of the said hospital and hospitalized in the rooming-in accommodation at the time of research. Those with psychiatric disorders and who gave birth to stillborn fetuses were excluded. The number of interviewees was determined by theoretical saturation during data collection and analysis. The theoretical saturation was identified from the non-occurrence of new information, by the decreasing yield during the content analysis performed [7].

For information collection, a semi-structured interview guide was used, containing the guiding questions: Can you tell how your labor and delivery was? What did you find more difficult about your delivery? Have you ever felt disrespected or mistreated? This guide also had sociodemographic and obstetric issues collected from medical records. Data collection occurred between April and September 2015. An MP3 recorder was used to record the interviews, simultaneously with data collection.

The interviews were fully transcribed. Information was analyzed using the content analysis in the thematic modality, proposed by Bardin [8]. Constituting the following thematic categories: disrespect for the parturient, obstetric violence, violence revealed and unknown violence. The thematic categories were analyzed and interpreted according to the theoretical framework of childbirth care anchored in the World Health Organization [WHO] (1996) [2]. Data related to sample characterization were typed and analyzed in the Software SPSS (Statistical Package for the Social Sciences), version 21.0, using descriptive analysis techniques.

The research occurred after approval by the Research Ethics Committee (CEP) at the Health Sciences Center (CCS) of the Federal University of Pernambuco (UFPE), (CAAE: 40024514.5.0000.5208) and signing of the Informed Consent Form (ICF) by the interviewees. To maintain anonymity, the interviews were identified by alphanumeric codes, using the letter P and subsequent interview number, from 1 to 17. The study respected the formal requirements contained in national and international standards regulating researches involving human beings.

## III. RESULTS

The interviewees were between 18 and 44 years old, with an average age of 26.29 years, 70.6% were from the

Metropolitan Region of Recife and 29.4% from other cities in inland Recife. The majority lived in consensual union (52.9%), only 29.4% were unmarried and 17.6% were married. Regarding education, 17.6% had incomplete elementary school, 17.6% had complete elementary school, 23.5% had incomplete high school, 11.8% had complete high school, 5.9% had incomplete higher education and 23.5% had complete higher education. About the profession/occupation, 58.8% were housewives and 41.2% had paid activity. Regarding monthly family income, 5.9% lived with less than one minimum wage, 47.1% with a minimum wage, 35.3% with two minimum wages and 11.8% with three minimum wages.

Obstetric data, number of pregnancies ranged from one to five (mean=1.94), to one to four deliveries (mean= 1.71), abortions from zero to one (mean= 0.24). Gestational age ranged from 35 to 41 weeks (mean=39.12). The number of normal deliveries was 76.5%, with the remaining 23.5% submitted to cesarean section. The university hospital was the first choice for 41.2% of women. The presence of a companion was reported by 52.9% of the women, 52.9% walked during labor. All patients who gave birth by normal route stated that they were in lithotomy.

The use of oxytocin occurred in 76.5% of deliveries, amniotomy was performed in 52.9% of the women, 70.6% of the interviewees remained fasting throughout the labor, 17.6% used misoprostol and 52.9% received guidance on the procedures performed. The partogram was opened during labor and delivery care of only 17.6% of the women. Care was provided by obstetricians (94.1%) and by obstetric nurses (5.9%).

From the speech analysis, four thematic categories emerged: 1) Disrespect for the parturient, 2) Obstetric violence, 3) Violence revealed, 4) Unknown violence.

**Disrespect for the parturient**

Good obstetric practices guide professionals to what should and should not be done during labor. Some of these practices were not considered. Starting with the pilgrimage while seeking a place that leads pregnant women feel anxious and disrespected: *First I went there, I thought it was going to be there, the birth... Then they transferred me to another hospital, then there was no duty, no, it was full, then I came back again... And they sent me to (another maternity), so I was hospitalized there. Then the girl came and said that I was going to be transferred to another hospital because there was no anesthesiologist, then they sent me here* (P5). *I got there, they had no place for me there* (P6). *The hardest part was the uncertainty of migrating from one hospital to another, so I felt disrespected* (P9).

The parturients' statements showed that the non-respect of the woman's choice over her companion during labor and delivery contributed negatively to the delivery process. Only the female companion's was allowed in some cases, and her presence was limited only to labor, in a few cases, during vaginal delivery. In cesarean section, this right was denied to pregnant women, whose main argument was the lack of adequate clothing: *One, I don't know if she was a student too or a nurse, I don't know, I just know I asked if she (mother) could get in, so she said, "There's no cloth for me and I work here, imagine for a companion." Then my mother did not get in, I entered the delivery room alone* (P17). *At no point did he (husband) come in to see me because they did not let him* (P11). *My mother wanted to watch the birth... The boy's father also stayed outside because he could not watch, because they had no clothes for either of them* (P13).

The following statements reveal the disrespect to the woman's right to have her privacy preserved in the place of delivery, being subjected to several procedures with the presence of several people, without her prior consent, without the right of refusal, exposing her, making her the object of learning, violating her intimacy: *Two (students), the doctors were all near me, the boss and the doctors, they were all over me* (P2). *.. Many academic doctors, interns, everyone around me, and we are already nervous* (P15). *There were about ten people in the delivery room* (P13). *Many doctors came up to me, examined me and everything* (P8).

Although known as an effective method in relieving pain and anxiety during labor, simple and low-cost therapy, non-pharmacological practices were not used, or were inadequate, hindering labor, coping with pain, generating a sense of death: *They just told me to sit on the ball, there is no professional... what to do on the ball? Do I sit down? Do I jump? Do I walk? I was in so much pain that I do not even like to remember. (Crying) This was the whole night, the pain increasing and they only came to make the touch exam* (P11). *I do not ever want to have a child in my life again. Oh, my God! It was a terrible feeling! I thought I was going to die there. There was so much pain, so much pain. I did not know what that pain was like, first son. You do not know what it is like, you get lost. Because you think it is death, that pain, but I got it, I do not know how, but I did it* (P17).

Another practice reported was the restriction of food and liquids imposed by professionals, a procedure that was not questioned by pregnant women. Regardless of the

delivery route, the woman's desire and the labor stage, the restriction still extended to the first two hours after vaginal delivery: *Very hungry, it was very difficult for me ... only IV, it was very difficult. Here, I think that is where I had the most accurate guidance that I could even eat, but eating could make me suffer more... Then I followed what they told me* (P9). *Then I asked to drink water, she (professional) said I could not, then I put just a little bit of water on the lips and that was it* (P12). *I could not eat. I only ate two hours after delivery when I got to the infirmary* (P14).

**Obstetric violence**

Vaginal touch is part of the obstetric evaluation, but should not be performed repeatedly or frequently, especially by more than one professional, being important to guide the woman on the examination, request her authorization and perform in order to minimize the discomfort of the procedure: *They (professionals) always came to make the touch test* (P1). *There came another one to make the touch. Then I said: Are you making the touch test, I cannot take it anymore... It was hurting. It is horrible.* (P7). *Finger has no camera, so they were in doubt, one got in, got out, another got in, got out, one passed to another three, it seems it is two, four: You are playing with my uterus!* (P11).

The use of the oxytocin synthetic hormone to correct or accelerate the pattern of uterine contractility during labor was used deliberately, not respecting the physiology of childbirth, with absence of pain as the main justification for its indication: *They gave me an IV, a medicine* (P8). *I was given an IV to speed up the pain.* (P10). *I was not in pain, then the girl gave me an IV, so I started to feel pain, you know?* (P7). *They started putting medication on me to get to contractions* (P3). *They gave me an IV* (P16).

Routine amniotomy should not be performed in obstetric practice, since there is no scientific evidence that it improves outcomes, yet it is still a very common practice in obstetrics as evidenced in the following reports: *(The doctor) said I was five centimeters, then she broke my water* (P13). *The doctor said I was seven centimeters but the water had not broken, then she grabbed a thing (amniotomo), she broke herself* (P8). *They broke my water in the delivery room* (P3).

We can observe the use of perineum distension during the second stage of labor, a totally harmful practice that further increases the suffering and pain of the parturient and brings no benefit: *They opened the vagina as much as they could, because they were seeing the hair, "That's the hair.", had not crowned yet,... tried, tried, tried, nothing,*

*several times this, suffering was immense, the physical pain was inexplicable, unforgettable* (p15).

**Violence revealed**

In these discourses, the report of the excess of procedures configured as maltreatment and obstetric violence timidly begins to emerge. In this speech, we can perceive the team directed only to the care of the fetus, not taking into account the feelings and emotions of the parturient: *The team that met me was terrible, because they mistreated me, they were careless, because you're out there screaming, bleeding and they're just listening to your baby's heart and you don't count, don't you?- cry -... I was so angry. You have to learn more, go back to school, because in addition to making money, you have to love what you do, because first of all I think you have to have love and compassion for the patients... You are inhumane. It was perverse, it is like you are nobody, that was my anguish... I was already calling him (husband): Look, come get me, because, if I have to die, I would rather die at home* (P11).

Taking the pregnant woman to the delivery room and not waiting for the physiological time for birth entails a cascade of interventions, transforming the natural moment into something painful, the parturient has no autonomy over her body, feels violated, with psychological sequelae that need to be worked to reduce the damage in future pregnancies: *My problem was in the delivery room, which characterized obstetric violence... let' give her more IV... Open my vagina and I force to see if the baby crowned and nothing, then the obstetrician decided they would do the following: "I'm going to press your belly, it is going to open your vagina, you are going to push... Then the doctor was pressing here, here in the belly... Then he pressed a lot, and his physical condition so strong, a lot of force, right?... Suffering this violence, all over my body, he did that several times and nothing. Then the doctor grabbed the forceps and gave me more IV ... For me, it was abnormal, it was not a normal delivery, my baby was removed, like a caesarean... Feeling mistreated... I was scared. Now, I will never have a child through normal delivery again, by god's will, my next delivery will be a scheduled caesarean. So, it characterized an obstetric violence for me* (P15).

This report unveils the woman's dissatisfaction with the place of delivery, the procedures performed and the team's unawareness that provided the care, even though she accepted the interventions without questioning. Professionals must introduce themselves, ask for the consent of pregnant women and give them the opportunity to decide freely and consciously: *They made the touch test,*

*then they said I was going to be hospitalized, they put me in room two there, then I waited until the doctor came to give the pill, I stayed there a long, long time. For me, I would not have even come here, but was already here right? Do what? I did not like it at all. They took too long and some people had no idea about anything, they were interns I guess. They kept asking the doctor how to do or not to do, I did not like it at all. I kept my mouth shut because I was already feeling a lot of pain, so I let it go... They told me to lie on the bed there, then when she left, they also used the speculum, it hurt so much, they kept poking and poking ... A little disrespected, got it?* (P6).

**Unknown violence**

Although the puerperal women reported having experienced situations of disrespect to good practices of childbirth care, some of them characterizing obstetric violence, it is evident the unawareness of the subject and the lack of association of interventions suffered when questioned about disrespect and maltreatment during their labor and delivery: *Not at all* (P1). *No, not at all* (P2). *No, no* (P3). *No, never* (P4). *No* (P5). *No, I did not feel it, no* (P7). *I have nothing to say, no*. (P8). *No* (P10). *No, no, thank God, no* (P13). *No, never* (P14).

## IV. DISCUSSION

This study reveals that all women underwent some type of intervention during labor, and, although most classified as being at usual obstetric risk, they did not experience a natural delivery. The use of technology when well indicated improves obstetric indicators, but if used unnecessarily implies greater risks for women and the conceptus [9]. For this reason, its use must be supported by the updated scientific evidence.

A factor that can contribute to reducing unnecessary interventions is the work with greater autonomy of the obstetric nurse in the delivery room, because he/she plays a more appropriate role, presenting a better cost-effectiveness in the care of pregnancy and normal delivery, assessing risks and recognizing complications [3,9]. Having been supported by the Ministry of Health through Ordinance N. 2815 of 05/29/1998, which included in the Hospital Information System (SIH/SUS) table the procedures for normal delivery without dystocia performed by obstetric nurses and Ordinance GM N. 163 of 09/22/1998, which regulated the performance of normal delivery without dystocia by an obstetric nurse in the Public Health Organizations of the Unified Health System (SUS).

However, in this hospital, the difference in care was not perceived, given the excessive number of unnecessary procedures, even being a high-complexity institution, nurses could better assist labor. All professionals who assist women should have their behaviors supported by the updated scientific evidence. Encouraging pregnant women to have autonomy in the process of parturition, sharing care and respecting their choices. Starting with the right to give birth in the place they want. However, we recognize that the guarantee of these rights is not only linked to the professional who works in the delivery. The lack of structure and professionals in our maternity hospitals results in closed shifts and overcrowding, increasing the pilgrimage of pregnant women seeking a place to give birth, generating feelings of disrespect and anxiety. This violates what must be ensured, the right to know and have access to the maternity where she will receive care at the time of delivery. And when necessary, be referred, having her transport and place guaranteed [1,5,10].

Health services need to adapt to comply with what is exposed in Law n. 11,108 of April 7, 2005, which guarantees parturients the right to the presence of a companion during labor, delivery and immediate postpartum [4]. It is important to emphasize that the companion is chosen by the woman and should be accepted without distinction. His/her presence increases the chances of spontaneous vaginal delivery, decreases intrapartum analgesia and dissatisfaction, promotes shorter labor time, provides lower rate of cesarean section or instrumental vaginal delivery and decreases the chances that the baby has a low Apgar score in the fifth minute of life [10,11]. This right needs to be respected by the institutions in an integral way, denying because of the gender, restricting the companion to labor, allowing permanence only in one type of delivery, preventing access and permanence claiming failure in the physical structure, lack of clothing or under any pretext are violations of an acquired right, contributing to obstetric violence.

The parturient has the right to be assisted throughout her labor and delivery, observing her physical and psychological well-being, including respect for her privacy and the non-permission of unnecessary people in the delivery room. Performing procedures for teaching purposes without considering the integrity and intimacy of the patient causes obstetric violence [5]. According to the reports of our study, pregnant women were seen by several different people during their hospitalization, but they still spent most of their time alone, without adequate care. Making childbirth a painful event and an unpleasant experience.

Even though labor is generally painful, each woman responds to pain differently, suffering cultural, family, emotional influences, previous experiences and the social group surrounding her. Some describe this pain as terrible, death-like pain, preferring not to remember. The professional who assists the pregnant woman is responsible for providing conditions for her to support the discomforts of the parturition process [11]. This support can be offered through non-pharmacological pain relief techniques, such as immersion bath, shower, massage and aromatherapy, techniques that have demonstrated decreased perception of pain and anxiety. Freedom to take the most comfortable position and ambulation are practices that do not pose risks, so they can be recommended [11]. Activities not performed with most participants since study, even with a multidisciplinary team present in the delivery room.

The incentive and freedom of choice of women over positioning during labor and delivery and the adoption of vertical positions bring physical and psychological benefits and reveal greater satisfaction with the experience of childbirth [9]. Contrary to this recommendation, all the women interviewed reported not having chosen the position and gave birth in a lithotomy position. It reveals the preference of professionals for horizontalized delivery, with technology in favor of their comfort, failing to consider what is best for women.

Another factor that should be considered is the supply of liquids and soft diets during labor, as it contributes to the replacement of spent energy sources, besides preventing dehydration and ketosis, ensuring the well-being of the parturient and the conceptus [12]. However, fasting is still a common practice, as justification for the risk of aspiration of gastric contents, if pregnant women need the use of general anesthesia. To avoid this restriction, it is important to make an evaluation and, in case the pregnant woman is at usual risk, there is no need to prescribe fasting [12]. However, considering that the practice of offering food during labor is recent and many professionals guide fasting fearing complications, we understand why these pregnant women are afraid to eat, demonstrating that they are not being adequately oriented, which prevents them from choosing consciously, without fear or doubts according to their willingness to eat or not. It also reveals the failure in the care of women in the pregnancy cycle, because this information should be passed on during prenatal consultations, where there is continuous contact with the professional and reinforced during their hospitalization.

A finding that deserves attention was the low use of partogram in the deliveries investigated, which is a graphic instrument that allows monitoring the progress of childbirth, being a simple and effective tool that helps in taking appropriate behaviors. In developing countries, its proper use is related to less indication of cesarean sections and early identification of complications [11-12]. It should be adopted in the follow-up of hospital deliveries throughout the public network on the recommendation of the WHO and in the private network through Normative Resolution n. 368/2015. We observed that professionals used techniques such as oxytocin and rupture of amniotic membranes to accelerate labor in more than half of women, which should not be routinely used. The use of oxytocin, for example, in usual-risk women should be avoided, and may lead to complications and the greater need for surveillance of pregnant women [11]. The pain of labor is already intrinsic for many women who do not question these behaviors believing that their routine practice makes them absolutely essential.

In the care of the second period of labor, the directed pull was widely used in order to reduce the time of delivery. Nonetheless, its practice is not recommended, as it is more likely to lead to instrumental delivery, and may injure the pelvic floor. Although parturients regarded it as something inherent in childbirth, it clearly causes physical wear and discomfort. On the other hand, practices such as perineal distension, which should not be performed, episiotomy and forceps use, which should be observed regarding their need and cannot be routinely used, were reported by women within the context of violence. In addition to the reports within the context of violence on pressure at the bottom of the uterus (Kristeller maneuver), for which there is insufficient evidence to recommend or not its use [12], but which made it clear that the way it was applied should not be performed.

Obstetric violence revealed through the excess of unnecessary interventions, and practices not based on scientific evidence updated during labor, delivery and postpartum is a matter of public health. In Brazil, according to a national survey conducted in 2019, (12.6%) women reported having suffered obstetric violence [9]. In the present study, all women suffered some kind of disrespect, including procedures considered violence. However, most of them showed no knowledge of the subject. In order to typify and reduce obstetric violence in the country, law n. 7633/2014 is under process, which provides for the humanization of care to women and newborns during the pregnancy-puerperal cycle and provides other measures [13]. The urgency of dealing with this issue is widely notorious, because, despite the efforts of WHO and the Ministry of Health, with initiatives such as *Rede Cegonha*, there is still much to be done when it comes to humanization of childbirth [14].

The participants of this study had a good level of education, even though the majority did not recognize obstetric violence, situations of disrespect and the excess of procedures performed with them, all considered as common to labor, making it necessarily laborious and exhausting. The lack of information makes the woman vulnerable, without autonomy to decide freely on her body. The unequal relationship between the professionals who assisted them is noticeable, not being asked to actively participate in the parturition process. This professional attitude needs to be modified, however, it is necessary to change the way in which these professionals learn to approach women in the process of parturition. To eliminate violence, there must be a continuous educational process encompassing professionals who provide assistance directly and indirectly to women and family members. Institutions also must fulfill their role, adapting the infrastructure and making the place of birth a welcoming environment.

## V. CONCLUSION

This study showed that, although some women recognize that they were disrespected during their labor and delivery, they still do not associate this disrespect with obstetric violence, believing those practices as common during care, although they cause pain and anguish, supporting, not starring their deliveries.

Despite the several initiatives seeking humanized care, without unnecessary interventions, respecting the intimacy and autonomy of parturients, there is still need to move forward, with health education actions, policy creations, laws, debates in the media, in academic centers, emphasis on prenatal care, to broaden the understanding of the importance of birth humanization.

This work is expected to raise reflections about the need for broad discussions on obstetric care, directing care to women and their families in an integral way, making them autonomous to actively participate in the parturition process, and that good practices be carried out during labor, eliminating obstetric violence.

## REFERENCES

[1] Zanardo, G. L. P., Calderón, M., Nadal, A. H. R., & Habigzang, L. F. (2017). Violência obstétrica no Brasil: uma revisão narrativa. *Psicologia & Sociedade,* 29, e155043.

[2] World Health Organization. (1996). *Maternal and Newborn Health/Safe Motherhood Unit. Care in normal birth: a practical guide.* Recuperado em 8 agosto, 2020, de https://portaldeboaspraticas.iff.fiocruz.br/biblioteca/care-in-normal-birth-a-practical-guide/

[3] Pereira, S. B., Diaz, C. M. G., Backes, M. T. S., Ferreira, C. L. L., & Backes D.S. (2018). Good practices of labor and birth care from the perspective of health professionals. *Rev Bras Enferm,* 71(3), 1313-1319.

[4] Pauletti, J. M., Ribeiro, J. P., & Soares, M. C. (2020). Violência obstétrica: manifestações postadas em grupos virtuais no facebook. *Enfermería: Cuidados Humanizados*, 9(1), 1-18.

[5] Santos, R. C. S., & Souza, N. F. (2018). Violência institucional obstétrica no Brasil: revisão sistemática. *Estação Científica*, 5 (1), 57-68.

[6] Brasil, Ministério da Saúde. (2017). *Diretrizes nacionais de assistência ao parto normal: versão resumida.* Recuperado em 8 agosto, 2020, de http://bvsms.saude.gov.br/bvs/publicacoes/diretrizes_nacionais_assistencia_parto_normal.pdf

[7] Koerich, M. S., Backes, D. S., Sousa, F. G. M., Erdmann, A. L., & Alburquerque, G. L. (2016). Pesquisa-ação: ferramenta metodológica para a pesquisa qualitativa. *Rev Eletr Enf*, 11(3),717-23.

[8] Bardin, L. (2011). *Análise de Conteúdo.* Lisboa: Edições.

[9] Lansky, S., Souza, K. V. de, Peixoto, E. R. de M., Oliveira, B. J., Diniz, C. S. G., Vieira, N. F., Cunha, R. de O., & Friche, A. A. de L. Violência obstétrica: influência da exposição sentidos do nascer na vivência das gestantes. *Ciência & Saúde Coletiva*, 24(8), 2811-2824.

[10] Leal, M. C., Pereira, A. P. E., Domingues, R. M. S. M., Theme, M. M., Filha, Dias, M. A. B., Pereira, M. N., Bastos, M. H., & Gama, S. G. N. da. (2015). Intervenções obstétricas durante o trabalho de parto em brasileiras de risco habitual. *Caderno Saúde Pública*, 30(1), 17-47.

[11] Carvalho, I. S., & Brito, R. S. (2017). Formas de violência obstétrica vivenciadas por puérperas que tiveram parto normal. *Revista Electrónica trimestral de Enfermaría*, 47(16), 71-9.

[12] Oliveira, M. J. de. (2019). *Perspectivas Jurídicas Acerca da Violência Obstétrica no Brasil.* Trabalho de Conclusão de Curso, Universidade Federal da Paraíba, Santa Rita, Paraíba, Brasil.

[13] Brasil, Câmara dos Deputados. *Projeto de Lei nº 7.633/2014. Dispõe sobre a humanização da assistência à mulher e ao neonato durante o ciclo gravídico-puerperal e dá outras providências.* Recuperado em 8 agosto, 2020, de http://www.camara.gov.br/proposicoesWeb/fichadetramitacao?idProposicao=617546<.

[14] Lima, S. S. de, Braga, M. C., Vanderlei, L. C. de M., Luna, C. F., & Frias, P. G. (2020). Avaliação do impacto de programas de assistência pré-natal, parto e ao recém-nascido nas mortes neonatais evitáveis em Pernambuco, Brasil: estudo de adequação. *Cadernos de Saúde Pública*, 36(2), e00039719.

# The Importance of Traceability of Implantable Medical Devices for Safety of Patients and Hospital Institutions: A Narrative Review

Roberta Rosas Trigueiro Gomes[1], Liniker Scolfild Rodrigues da Silva[2], Ana Cecília Fragoso Veloso[3], Aléxia Laís Silva Soares[4], Ivana Dutra Barbosa[5], Janaina Vieira da Cunha[6], Wanessa Starléia Batista da Silva[7], Alexandra Silva Cavalcanti Pedro[8], Sannie Maria Pinheiro Muniz Ribeiro[9], Thainá de Carvalho Sobral Chaves[10], Joel Azevedo de Menezes Neto[11], Wilma Nelly Barbosa Cavalcanti Silva[12]

[1,3,10]Redentor College/Education Development Institute (IDE College). Recife, Pernambuco, PE, Brazil.
[2]Medical Sciences College (FCM). University of Pernambuco (UPE). Recife, Pernambuco, PE, Brazil.
[4]Management and Environment Integrated College (FACIGMA). Recife, Pernambuco, PE, Brazil.
[5]International College of Curitiba (FACINTER). Curitiba, Paraná, PR, Brazil.
[6]São Miguel University Center (UNISÃOMIGUEL). Recife, Pernambuco, PE, Brazil.
[7,8]Estácio de Sá College of Recife. Recife, Pernambuco, PE, Brazil.
[9]CEAT College (FACEAT). São Paulo, São Paulo, SP, Brazil.
[11]Nursing Department. College of Belo Jardim (FBJ). Belo Jardim, Pernambuco, PE, Brazil.
[12]Nossa Senhora das Graças Nursing School (FENSG). University of Pernambuco (UPE). Recife, Pernambuco, PE, Brazil.

*Abstract— Implantable medical devices are materials that assist or replace partially or totally for the purpose of preventing, treating, or compensating for a disease, injury, or disability. It is important to follow patient safety protocols such as effective communication, safe surgery and regulations to ensure the procedure free of risk and damage. To verify the predictors that guarantee safe use and comply with the safety of the patient and hospital institutions. This is a narrative study, which sought articles published in the past 10 years (2009 to 2019), in Portuguese, fully available. The following data platforms were consulted: BDENF, LILACS and SciELO. Research was conducted through original articles, theses, dissertations, booklets, collegiate board regulations, regulation of ANVISA and handbook of good practices, all in the Portuguese language. The data were organized and presented in figures and tables. Of the 87 articles found, after reading the abstracts, 04 studies met the inclusion criteria and were thematically specified, classifying the knowledge elaborated on the subject. The research reflects on the importance of presenting labels and controlling the use of devices to ensure the safe use of the material. However, there were no Brazilian publications specifically on the theme and, in this sense, quantitative and qualitative researches on the subject should be developed.*

*Keywords— Implantable Devices; Patient's Records; Patient Safety; Traceability; Orthoses and Prostheses.*

## I. INTRODUCTION

Hospital institutions aim to meet patients according to their needs and with hospital procedures and services at various levels of complexities. In many of these visits, patients are submitted to specific procedures in surgical and hemodynamic centers, undergoing tests and procedures in which the use of orthoses, prostheses and special materials (OPSM) is essential, and this care aims to meet the patient with quality and safety. Thus, the quality of patient care and safety is fundamental to avoid errors,

adverse events and failures, thus increasing the credibility and reliability of care and the institution [1].

According to the World Health Organization (WHO), patient safety is the reduction of risk of unnecessary harm associated with health care to an acceptable minimum, considering constant components closely related to patient care. Currently, 4% to 17% of patients admitted to a hospital unit suffer events, which are not related to the underlying pathology [2].

Several aspects can be critical for adequate care, especially regarding the use of implantable equipment and devices that can adversely affect the patient's health conditions. Orthoses can be conceptualized as any permanent or transient material that assists the functions of a limb or organ, which does not require surgery. Prostheses are any permanent or transient material that replaces the entire or part of a limb, organ or tissue involved in a surgical act [3].

Brazil (2016) reports that special materials are understood as any material or device used in the implementation of OPSM that assist in the diagnostic or therapeutic procedure, not covering the criteria of orthoses or prostheses [3].

The Resolution of the Collegiate Board of the National Health Surveillance Agency n.185/2001 also defines that implantable medical devices are any medical product designed to be fully introduced into the human body or to replace an epithelial or ocular surface, through surgical intervention, with intended long-term permanence. Also considered an implantable medical product is any medical product intended to be partially introduced into the human body through surgical intervention with intended long-term permanence [4].

Orthoses, Prostheses and Special Materials are medical devices used for a range of health needs, such as pain relief, restoration of mobility, recovery or improvement of the function of an organ, diagnosis and aesthetic functions and the fields of application of these products are diverse and in almost all health areas. Due to its complexity, for the application of these products, a multiprofessional and multidisciplinary team is necessary, so that the risks of handling and using them are eliminated or minimized to the maximum, as the intended use purpose is reached safely. For the manufacture of these products, highly sophisticated technologies are used and strict quality controls are required [4].

Each or all of these have their own characteristics with a risk associated with use exposure. The risk corresponds to a probability of occurrence of an event, which may or may not cause damage to the collectivity and in the event

of the occurrence of any problem or complication related to the device. Thus, there is need to monitor this material, allowing the identification of particularities of the product and all its traceability [3].

Several resolutions seek greater control of the use and monitoring of the quality of these products, ensuring greater patient safety before a procedure that will use these materials, the correct supervision of materials, reception of the product, verification of registration, validity of legislation, enabling the safe conditions of use, integrity of the product packaging, the characteristics of the materials, whether they are reprocessed or single use, the control of occurrences of adverse effects and the control of the market are some objectives of traceability according to the Federal Council of Medicine (CFM) n°1804/2006 [5].

From this, there are two steps to this control. The primordial phase that is related to the registration of the product and the knowledge of manufacturing conditions, which is understood as a step before commercialization. The second phase is related to the use that affects the problems to the use of the product, also known as "Technosurveillance", after marketing [6].

The Handbook of Good Management Practices of the OPSM of the Ministry of Health [MS] (2016) defines that traceability is the ability to trace a history, application or location of an item through previously recorded information, as well as related information and its identification and coding, generating knowledge about its origin and its final destination. The information should be inserted in the patient's medical records, delivered to the patient and in the tax documentation, which generates collection to the material, aiming at a supporting effect [3].

For Prestes and Rangel (2007), the definition of medical records provided for in CFM resolution n. 1,638/02, being conceptualized as an individualized document consisting of a grouping of recorded information generated from facts, events and situations about the patient's health, of a legal, confidential and scientific nature, which enables effective communication between members of the multidisciplinary team and the continuity of care provided to the individual [7].

Despite its importance and usefulness for the other functions, the elaboration and general care with such document are often omitted by the health professionals who write on it and, when they point, they invariably do so with negligence, with illegible letter and without the chronological sequence. A well-prepared medical record indicates not only the seriousness of the professionals, but also a true instrument of judicial defense [7].

The correct management of Implantable Medical Devices (IMDs) and the reports made in the medical records are important points for ensuring safety and exempt non-conformities, thus being important to give visibility to this theme, since the traceability of implanted medical devices is a factor that directly interferes with patient safety and, when not well performed and regulated, can produce complications to the patient, family, hospital institution and to whom provided the product.

From this perspective and the reflective exercise of investigating health issues from the field of management and control of implanted devices, as well as the recognition of the importance of traceability labels, the present study of narrative literature review was motivated. Therefore, this study aims to verify the predictors that guarantee safe use and complies with the safety of the patient and hospital institutions.

## II. METHODS

This is a narrative literature review with a qualitative approach, which has a comprehensive character and proposes to portray the development of a given theme, from a theoretical or contextual point of view, through analysis and interpretation of the existing scientific production. This synthesis of knowledge from the description of comprehensive themes favors the identification of knowledge gaps to support the execution of new researches. Furthermore, its operationalization can systematically occur with methodological rigor [8].

To guide this review, the following question was formulated: "What is the importance of traceability of hospital medical devices for safety of the patient and hospital institutions?". The Virtual Health Library (VHL) was accessed in the databases: Latin American and Caribbean Literature (LILACS), Nursing Database (BDENF), as well as in the Virtual Library: Scientific Electronic Library Online (SciELO).

Through advanced search, using the delimiting terms of the search, "traceability"; "implantable devices", "patient safety", "patient records" as descriptors by the integrated search with the Boolean operator AND and to achieve the purest and most reliable refinement and data collection in a period indexed from the years 2009 to 2019, generating a content based on scientific evidence. This process involved activities of investigation, identification, study, mapping and analysis.

After this stage, the articles were directly read by the abstract, observing that no articles published in Brazil were found with these descriptors, in addition to documents that directly address this subject.

The inclusion criteria defined for the selection of articles were: original articles, published in Portuguese, whose object of study is of interest to this narrative review and fully available free of charge in electronic format in the database, portraying the theme on the importance of traceability of implantable medical devices, in an indexed period between 2009 and 2019, as well as theses, dissertations, booklets, collegiate board regulations, regulation of ANVISA and good practice handbook [3].

The exclusion criteria defined were: articles published with complete content not available virtually or in journals not edited Brazil, experience reports and other integrative reviews or that did not have all the inclusion criteria.

The selection of studies was based on the Preferred Reporting Items for Systematic Review and Meta-Analyses - PRISMA, a four-step flowchart, with the objective of assisting in the development of articles [9]. The search strategies used on the databases were presented in the flowchart (Figure 1).
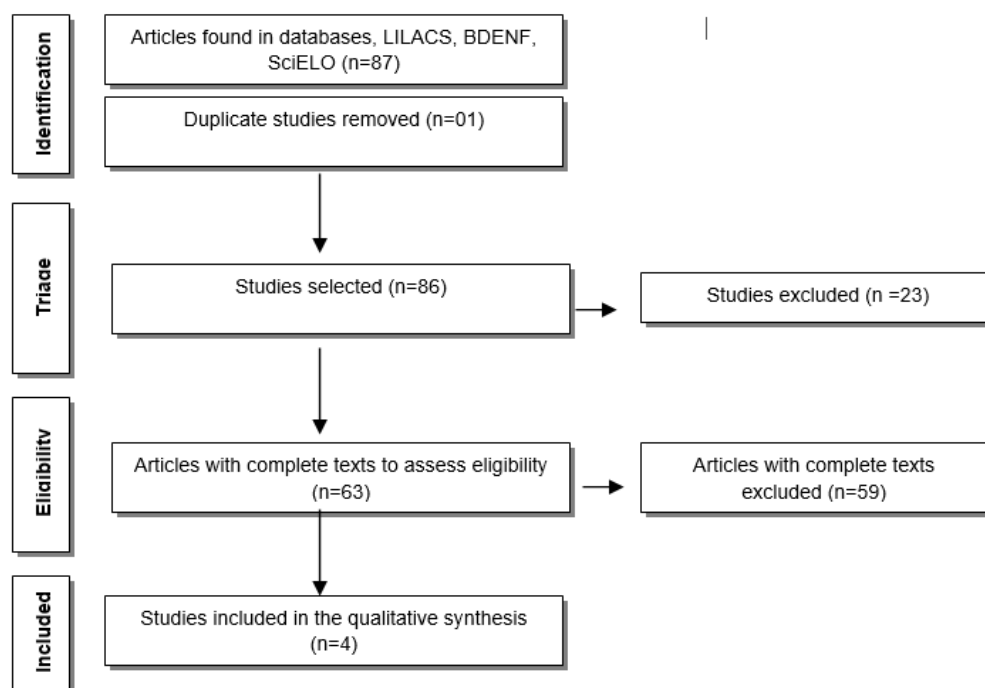
*Fig 1: Flowchart of the selection of studies. Recife, Pernambuco (PE), Brazil, 2020.*

*Adapted by PRISMA [9].*

**Source:** *Created by the authors.*

## III. RESULTS AND DISCUSSION

The presentation of the results and discussion of the obtained data was performed descriptively, with categories listed for discussion, enabling the reader to evaluate the applicability of the elaborated review, in order to achieve the objective of this method, that is, positively affect the understanding of the objectives of this study.

Two phases were performed to obtain the results. The first phase was the search for articles, which returned 87 scientific productions using the aforementioned descriptors. Of these, 66 presented complete text and met the inclusion criterion related to the language, which was Portuguese.

Of these 66 selected productions, 64 met the inclusion criteria when classified as article. Of these, 01 was available in more than one database, justifying its exclusion, remaining 63. After reading the titles and abstracts of these productions, 59 were excluded for not answering the guiding question of this study. Therefore, 04 remained, which became part of the analysis of this narrative review study.

After the selection of articles, a second phase began, in which there was a direct reading of the works of master's dissertations, institutional booklets, regulations of the National Health Surveillance Agency (ANVISA), sources of regulations of medical and nursing councils, books, technical standards and handbooks of good practices in OPSM [2,3,5].

Data analysis was through Minayo's theme technique (2007), which is the discovery of the meaning cores, which consist of the communication about periodicity or the presence of some meaning for the object that will be explored. This method of analysis consists of three stages: pre-analysis, which is the organization of the obtained data; the exploration of the material, which classifies the elements in order to reach the core of the understanding of the text through the formulation of categories and the treatment of the obtained results and interpretation, which articulates the data assimilated to the theoretical framework, aiming to answer the research questions [10].

The results of these studies show that the subject is scarcely discussed and has been complemented with norms and handbooks. The table describes the titles, authors and objectives of the article that composes the sample of this work.

*Table 1: Results found in studies according to title, authors, year of publication, and objectives that make up the sample. Recife, Pernambuco (PE), Brazil, 2020.*

| TITLE | AUTHOR/YEAR OF PUBLICATION | OBJECTIVES |
|---|---|---|
| **A1** - Incidence of in-hospital adverse events in the state of Rio de Janeiro, Brazil: evaluation of patient medical record [11]. | Pavão et al., (2011) | To evaluate the quality of information in the medical records of three teaching hospitals in the state of Rio de Janeiro, which participated in the baseline study to estimate the incidence of adverse events (AE) and the importance of developing measures aimed at improving the quality of the medical record, as these will reflect on the quality of patient care. |
| **A2** - Nursing care and the focus on patient safety in the Brazilian scenario [12]. | Silva, et al., (2016) | To analyze the contribution of nursing to patient safety in Brazil. The study highlights the existence of positive actions and the reduction of incidents concerning patient care and safety. |
| **A3** - Assessment of the care process with orthotics, prosthetics and special materials [1]. | Moraes C.S; Rabin E.G; Viegas K., (2017) | To highlight the evaluation of potential flaws in the OPSM care work process in a high-complexity hospital. It stresses points in the process that can be critical and important for adequate care and that any failure in one of these steps can result in the absence of OPSM availability and affect directly and negatively on the patient's health condition. |
| **A4** - Patient safety approached from the rights of users [13]. | Benrens, R., (2019) | The article highlights the lack of protection and respect for the user's rights, the evidence that the participation and the possibility of the patients' participation in the treatment and the rights justifying it. |

**Source:** *Created by the authors.*

As for the objectives of the authors, even with different themes, somehow, all of them focus on patient safety, thus linking the other themes as importance of the report in medical records and that, through these records, adverse events can be observed and methods can be traced for the quality of care and reduction of risks and the patient's right. However, there are still few publications, agreeing with Moraes, Rabin and Viégas, (2018), the importance and need for researches contributing to this process [1].

For a more detailed view, Table 2 shows the titles, authors and objectives of dissertations clearly addressing the flawed points and gaps of nonconformities.

*Table 2: Results found from dissertations according to title, authors, year of publication, and objectives that make up the sample. Recife, Pernambuco (PE), Brazil, 2020.*

| TITLE | AUTHOR/YEAR OF PUBLICATION | OBJECTIVES |
|---|---|---|
| **D 1** - Assessment of the care process with orthotics, prosthetics and special materials [14]. | Moraes, C.S., (2014) | The work analyzes the failures in the OPSM process of a hospital and the impact of these failures regarding the lack of registration, standardization of materials and pre and post audit analysis. |
| **D2** - The traceability of implantable medical devices and the unique identification system: A bibliometric study [6]. | Cabral, J.A., (2019) | The work shows the importance of systematizing and analyzing nationally and internationally the importance of DMI's traceability and the Unique Device Identification, showing the increase on this theme. |

**Source:** *Created by the authors.*

The two authors are complementary by mentioning failures at the beginning of the device management process until the final process, bringing inconsistency and risk to patients and hospital institutions.

From the analysis of the themes of the articles, dissertations, ANVISA regulations, CBRs, publications of public consultations, good practice handbook, books and booklets, three thematic categories emerged.

**Ensuring surgical health products that meet the safety of patients and hospital institutions:**

IMDs have had an important rise in health and this is punctuated by the increased number of elderly people, incidents of violence and occurrences and accidents in general. In the past, the ease of use of these devices was unmeasured, because these materials were not subject to an evaluation and certification of their consumer, the prices charged in the market changed and ended up affecting and reaching public or supplementary health costs [15].

According to Brazil (2015), this ease gave scope for the occurrence of crimes of component tampering and falsification of materials in the manufacture of products, causing adverse effects and serious health complications, ranging from simple damage to irreversible losses, fraud of indications to unnecessary surgeries and materials with incorrect indication, changes of records in medical records in the quantity used, use of expired materials, fraud in budget and bids and overbilling, thus violating the principles of safe surgery and compromising patient safety [15].

These practices violate the ethical and professional code and are characterized as a heinous crime by the Brazilian Penal Code, Law n. 9677 of JULY 2, 1998, Art. 273, item 1B.

The fundamental principles of the code of medical ethics, cites medicine, which cannot, under any circumstance or form, be exercised as a trade, and medical work cannot be exploited by third parties for profit, political or religious purpose. The doctor is forbidden to practice or indicate unnecessary acts or prohibited by the legislation in force in the country and exaggerate the severity of the diagnosis or prognosis, complicate the therapy or exceed the number of visits, consultations or any other medical procedure, thus providing a mercantilist exercise [15].

According to the fact, in recent years, the use of these materials was hesitated by economic and financial unrest and, for safe processes of the devices, there was need to have a responsibility behavior of all those involved in the process of these products, from their manufacture, storage, use to their disposal [15].

In view of the above case, measures were taken to contain the health risk and guarantee the safety of users of these materials, the collection of devices with questionable quality, impositions for the implementation of good practices through regulations, clarification and guidance for the activation of technosurveillance [3].

Thus, it is possible to promote an increase in technical notifications of products and adverse events in the NOTIVISA (Health Surveillance Notification System) system, the creation of the sentinel network and the grouping of registers divided by groups and subgroups, since the existence of the huge variety of categories and subcategories of identification of these products is a complicating factor, either in the regulatory sphere or in health services, actions were promoted in order to avoid surgeries with products of non-conforming characteristics for their use and damage to the patient [3].

The table below synthetize regulatory resolutions regarding the promotion, protection of patient safety and traceability of IMD materials. These CBRs are published by ANVISA in the Official Gazette and are available at the electronic website of the National Agency [4].

*Table 3: Anvisa's Collegiate Board Resolution (CBR). Recife, Pernambuco (PE), Brazil, 2020.*

| ANVISA COLLEGIATE BOARD RESOLUTION | THEMATIC |
|---|---|
| CBR N. 56 OF APRIL 06, 2001 | Establishes essential safety and efficacy requirements to be met by health products. |
| CBR N. 185 OF OCTOBER 22, 2001 | Approves the Technical Regulation contained in the annex of this Resolution, which regulates the registration, alteration, revalidation and cancellation of the registration of medical products at the National Health Surveillance Agency - Anvisa. |
| CBR N. 156 OF AUGUST 11, 2006 | Defines and regulates medical products with forbidden and allowed reprocessing. |
| CBR N. 2605 OF AUGUST 11, 2006 | Establishes the list of single-use medical products with forbidden reprocessing. |
| CBR N. 185 OF OCTOBER 13, 2006 | Deals with the regulation of economic information and health products, checking the market price, the intended number of patients, the price of the domestic and worldwide market. |
| CBR N. 59 OF AUGUST 25, 2008 | Institutes the technical regulation with the general requirements for grouping in families and orthopedic implant systems for registration purposes. |
| CBR N. 2 OF JANUARY 25, 2010 | Provides for the management of health technologies in health facilities. |
| CBR N. 14 OF APRIL 5, 2011 | Institutes the technical regulation with the requirements for grouping materials used in health for registration with ANVISA and adopts traceability labels for implantable products. |
| CBR N. 63 OF NOVEMBER 25, 2011 | Provides for Good Operating Practice Requirements for Health Services. |
| CBR N. 23 OF APRIL 4, 2012 | Provides for the mandatory execution and notification of field actions by health product registration holders in Brazil. |
| CBR N. 36 OF JULY 25, 2013 | Institutes actions for patient safety in health services |

**Source:** *Created by the authors.*

These regulations, technical standards and the handbook of good practices ensure the use of these materials, preventing the patient from undergoing a new procedure, and, after his/her hospital discharge, a better quality of life with a warranty of the implanted product. The adequate control and efficiency of OPSM are significant for ensuring adequate care and a legal obligation of health operators. The adherence of measures that ensure that traceability labels with the necessary information follow ANVISA standards belongs to them, and patients are allowed to know about the technical specifications of OPSM, the tracking from its manufacture to its final use, enabling information whenever necessary if there is need to investigate an adverse event or product life [2].

**The importance for increasing safety in medical hospitals and health professionals:**

Patient safety is the responsibility of hospital units and all health professionals that provide direct care. Even before a patient's admission to perform a surgical procedure, a process is already in progress and, when there is admission for the performance of this procedure, there is a complement of this care until the hospital discharge [1].

For Moraes (2014), the sectors involved are the preoperative authorization center, scheduling, OPSM center, responsible for receiving and returning the devices, sterilization center, operating room, hemodynamics, postoperative authorization and hospital technology and there are a variety of critical processes for this care and any failure in one of these steps can directly affect the patient's care and procedure and hospital expenses, thus causing a high cost to the institution [14].

In view of the above, initial failures of technical knowledge of the responsible for the surgical scheduling and the incorrect indication of the product by the doctor in the scheduling, the material inaccurately registered in the system, information unavailable for the areas involved, failure to identify the product received, wrong or incomplete material are extremely important points for breaching patient safety, thus, for institutions that work with implanted devices, there is need to maintain an effective cycle, a controlled management with all the requirements of current legislation [14].

The registration of the products present in any of these stages of management will be denied in case of non-complied conditions, requirements or procedures for such purposes provided for by Law, regulation or instruction of the competent body, according to Law n. 6360 of SEPTEMBER 23, 1976, in Art. 15.

In order to have greater control over these aforementioned processes, addressing crucial points and educating the relationship of these processes provides a greater guarantee of the safety of the procedure performed and patient safety through traceability of materials. These controls are obtained in the pre-audit, device management and post-audit phases, according to the table [2].

*Table 4: Regulatory instructions and good management practices for IMDs. Recife, Pernambuco (PE), Brazil, 2020 [2,3].*

| HEALTH AUDIT AND REGULATION STEPS | HEALTH AUDIT AND REGULATION PROCESSES |
|---|---|
| PRE-AUDIT | Verify if the requested procedures are included in the ANS list; Check if the material is compatible with the procedure to be performed; Analyze if the procedure is compatible with the clinical case; Check if the listed materials are technically equivalent; Research on products by ANVISA (product models, process, product origin, risk class and validity), ANS and evidence-based studies. |
| OPSM MANAGEMENT | Verification of the material ordered with the material delivered, documented and registered. Electronic receipt presentation and supply authorization. Check and record the information of receipt number, code, quantity, validity, lot, value, CNPJ, legal names of the manufacturer and suppliers. |
| POST-AUDIT | Registration of doctors in a surgical report and in the patient's record, mandatory use of traceability labels and packaging in each document and receipt. Carry out in-place audit for verification and control. |

**Source:** *Created by the authors.*

The access to these IMDs, aid equipment and accessories in establishments must be checked and documented. They must be delivered with Auxiliary Electronic Receipt (Danfe) and Supply Authorization (SA), belonging to the person responsible for this function to make the provisional or definitive reception according to Articles 15 and 73 of Law n. 8,666/1993. After the reception, the information recommended in the organizations containing receipt, code, quantitative, validity, lot, value, CNPJ and legal names of the manufacturer and supplier must be recorded [3].

This activity ceases the risk of incomplete information, avoiding using divergent material, ensuring the possibility of a safe procedure, unifies and facilitates communication between all involved, avoiding possible failures in this stage [1,14].

Health professionals, such as the doctor, are responsible for the procedures performed, the use of implanted devices and the prohibitions according to the CFM (2000); Brazil, (2006) and Brazil, (2010). Nursing professionals are responsible for most of the actions and care provided to the patient, obtaining an excellent condition for reducing incidents and complications and better contributing through control and checking, reducing possible failures [5,12,16,17].

According to the Brazilian Society of Nurses of Surgical and Sterilization Center, to check the implantable

materials necessary for the procedures and verify the availability and functionality of materials, instruments and equipment for performing the surgical act are the nurse's function. The MSC nurse must define and regulate deadlines for receiving sterilized and reprocessing products, and the nursing technician is responsible for checking these materials, availability, the guarantee of records and the traceability of the implanted IMDs [1].

The IMD used should be recorded by all healthcare professionals related to the procedure, in the room expense report, in the surgical description and in the patient's medical records, and this information should contain quantity, size, traceability labels contained in the product packaging and in Danfe. The surgical description is the responsibility of the professional who performs the surgical act and should contain the steps performed and the relationship of the IMDs [3].

Inadequate documentation or lack of information in the medical records may be related to an adverse event, because it is responsible for providing the necessary information for the specific and appropriate care of each patient [11].

Identification labels are fundamental as a supporting document for the implantation of the devices. The supplier must give possession of 05 traceability labels with the essential information for tracking and should be fixed in the patient's medical records, delivered to the patient, attached in the receipt documentation, made available to the supplier and surgeon. The information must contain the name or business model, identification of the manufacturer or importer, product code or voucher in the system, making number and Anvisa registration number (2017) according to CBR n. 14, of April 5, 2011. When there is incompatibility or excessive amount used between the uses of OPSM, the professional should report a mandatory technical and plausible justification [18].

The IMDs with non-complied packaging, such as deteriorated, open or contaminated not used in the surgical procedure, should have their loss justified [3]. According to Art. 4, the attending physician, directly responsible for the procedure, is obliged to communicate to the technical director any defects or failures in the quality of the product or in his/her implanting instruments.

The post-procedure conference is carried out through an audit, being essential to ensure the veracity of the information, observing legible surgical description, imaging examinations, the conference of the attached label, which must be identical to the authorized material [3].

## The importance of product control for health after registration, market control and patient rights:

Ramos (2017), mentions that the control of health products and their traceability are extremely fundamental and important for patient safety. The lack of this control provides a huge gap for the reverse objectives. Performing unnecessary implants, employing more expensive technologies, even without recommendation for use or bringing necessary benefits, using unnecessary quantity of products and defrauding reports to collect unused products are events that evidence the lack of quality of the procedure and risks to the patient [15,19].

For the Institute of Supplementary Health Studies (2018), it is clear that management efficiency reflects in the control of waste and allows greater investments for the benefit of the assistance itself, diagramming the use of a certain input, or preventing mistaken or hasty indication, while still providing assistance when necessary [20].

The patient has the right to have access to the necessary information and health care services, consent or refuse voluntarily and with adequate prior information regarding the diagnostic and therapeutic procedures to be performed, have a second opinion or opinion of another professional at any stage of treatment and may change doctors or institutions, if not feeling safe, and have access to clear and accurate notes in the medical records of all relevant information about his/her health. Patient rights are basic rights known by users of health services, offering safe and quality care [4].

According to the WHO recommendation in resolution adopted at the 55th and continued at the 57th World Health Assembly, Brazil instituted the National Patient Safety Program (PNSP). The program was created by Ordinance 529/2013 of the Ministry of Health, and, among its objectives, presented in article 3, item II, is involving patients and family members in safety actions [21]. One of the main guidelines of this program is the establishment of protocols by the health service, including patient identification, surgical safety and incidence notification.

Implants can be permanent or removable and the risks associated with their insertion can be during surgery with the placement or removal of IMDs, infection, reaction to the materials of the devices or implant failure, thus the absolute control of these IMDs allows issuing a Technosurveillance alert [2].

Brazil (2017), aiming at quality control and care safety, the implanted OPSM must be permanently monitored. The professional must record the occurrence in an appropriate form when the IMD present some quality change, so that the supplier allows exchanging or returning and the

institutions must communicate the occurrence and these failure events to ANVISA through the notification system of this body [4].

"NOTIVISA is a computerized system to receive notifications of adverse events and technical complaints of products and services under sanitary surveillance" [4].

NOTIVISA received only information associated with the use of products under health surveillance, but with the publication of CBR 36/2013, which establishes patient safety actions, the system began to receive notifications of incidents and adverse events not only associated with the use of products, but also related to the provision of health care. Complaints of adverse events such as failures during the surgical procedure and technical complaints associated with deviation of product quality, counterfeit product, unregistered product, irregular advertising, companies without COA, are notified in order to reduce fraud, avoiding the compromise of quality and patient safety, as well as promoting actions to protect public and private health [4].

The absolute control of these products through mandatory registration in ANVISA and traceability provides the investigation if the occurrence is isolated or of a whole making, resulting in a request for the return of a making or an entire line of products made by the manufacturer [21].

For Bergamine (2019), it is not uncommon for the patient to undergo a new surgery and not know what type of device has been used, and, to avoid this type of exposure, traceability labels are necessary because it allows the localization of information about the product, minimizes losses and costs for the institution, reduces the risk if there is need for new devices and serves as a support in case of an eventual indemnification. The traceability label is also important until after hospital discharge, because it serves as a means of proving that the patient has a device once one may need to present this information [21].

## IV. CONCLUSION

This study showed that a safe procedure is fundamental for the patient's quality of life and the responsibility of hospital institutions.

Nursing care is indispensable to promote this type of care, because it is the link of information among other health professionals, bringing possibilities that can lead to changes in the process and outcomes. It is essential to follow patient safety protocols according to their steps and we can observe in this study that effective communication

and safe surgery are important points when an institution actively works with IMDs.

Seeking the best result before the use of these devices, there is need to maintain a clear, truthful and accurate information that meets all the requirements of the current legislation, and, through the traceability of these implants, control policies and improvements can be outlined for the patient.

Therefore, controlling, evaluating, investigating, certifying and documenting are actions that avoid incidents related to adverse events and problems of composition, raw material and product quality, and, once notified, ensure legal support of health professionals and hospital institutions. They also enable parameters for the control of material in the market, avoiding possible complications, and serves to outline goals and public health policies to cease these incidents.

The doctor is responsible for informing the patient of the need to implant the devices and the procedures that will be performed, in addition to explaining the particularities and their routines after the procedure, as well as guiding with essential information and without any doubts, ensuring that the patient and his/her family have a safe return to home, since the patient has the right to receive the traceability label as a document supporting the use of the material or as information whether a new procedure is necessary.

The research reflects on the importance of presenting labels and controlling the use of devices for patient safety, health professionals and hospital institutions, suggesting quantitative and qualitative researches on the subject.

## REFERENCES

[1] Moraes, C. S., Rabin, E. G., & Viégas, K. (2018). Assessment of the care process with orthotics, prosthetics and special materials. Revista Brasileira de Enfermagem, 71(3), 1099-1105.

[2] Unimed do Brasil. (2017). Cartilha de Utilização da Etiqueta de Rastreabilidade: São Paulo: Área de Comunicação da Unimed do Brasil, Recuperado em 16 maio, 2020, de https://www.centralnacionalunimed.com.br/documents/2520 476/8442146/Cartilha+de+Utiliza%C3%A7%C3%A3o+da+ Etiqueta+de+Rastreabilidade.pdf/66871278-547e-4c67-ba9b-4abfa21ec6f0

[3] Brasil, Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Especializada e Temática (2016). Manual de boas práticas de gestão das Órteses, Próteses e Materiais Especiais (OPME). Recuperado em. 16 maio 2020, de http://bvsms.saude.gov.br/bvs/publicacoes/manual_praticas_ gestao_proteses_materiais_especiais.pdf

[4] Brasil, Agência Nacional de Vigilância Sanitária. (2017). Casos marcantes da trajetória da Regulação Sanitária. Recuperado em 16 maio 2020, de http://portal.anvisa.gov.br/documents/3487091/0/Trajetoria.pdf/66a8cdf0-46d2-4c96-94b8-5a1a4728df85

[5] Brasil, Conselho Federal de Medicina. (2006) Resolução CFM n. 1804/2006. Estabelece normas para utilização de materiais de implantes. Recuperado em. 16 maio 2020, de http://www.portalmedico.org.br/resolucoes/cfm/2006/1804_2006.htm

[6] Cabral, J. A. (2019). A Rastreabilidade dos Dispositivos Médicos Implantáveis - Dmi e o Sistema de Identificação Única de Dispositivo (Udi): Um Estudo Bibliométrico. Rio de Janeiro.

[7] Prestes, L. C. L., Jr., & Rangel, M. (2007). Prontuário médico e suas implicações médico-legais na rotina do coloproctologista. Revista Brasileira de Coloproctologia, 27(2), 154-157.

[8] Brum, C. N., et al. (2015). Revisão narrativa de literatura: aspectos conceituais e metodológicos na construção do conhecimento de enfermagem. In: LACERDA, M. R.; COSTENARO, R.G.S. (Orgs). Metodologias da pesquisa para a enfermagem em saúde: da teoria à prática. Porto Alegre: Moriá. Recuperado em 10 e março de 2020, de http://www.scielo.br/pdf/tce/v17n4/18.pdf [9] Galvão, T. F., Pansani, T. de S. A., & Harrad, D. (2015). Principais Itens para Relatar Revisões Sistematicas e Meta-Analise: A Recomendação Prisma. Epidemiologia e Serviços de Saúde, 24(2), 335-342.

[9] Minayo, M. C. S. (2006). O desafio do conhecimento: pesquisa qualitativa em saúde. São Paulo: Hucitec.

[10] Pavão, A. L. B., Andrade, D., Mendes, W., Martins, M., & Travasssos, C. Estudo de incidência de eventos adversos hospitalares, Rio de Janeiro, Brasil: avaliação da qualidade do prontuário do paciente. Revista Brasileira de Epidemiologia, 14(4), 651-661.

[11] Silva, A. T., Alves, M. G., Sanches, R. S., Terra, F. de S., & Resck, Z. M. R. (2016) Assistência de enfermagem e o enfoque da segurança do paciente no cenário brasileiro. Saúde em Debate, 40(111), 292-301.

[12] Behrens, Ronaldo. (2019). Segurança do paciente e os direitos do usuário. Revista Bioética, 27(2), 253-260.

[13] Moraes, C. (2014). Avaliação do Processo de Órtese, Prótese e Materiais Especiais a Partir do Método de Ánalise dos Modos de Falhas e Efeitos. Rio dos Sinos.

[14] Brasil. (2015). Órteses, Próteses e Materiais Especiais. Recuperado em. 16 maio 2020, de https://www2.camara.leg.br/atividade-legislativa/comissoes/comissoes-temporarias/parlamentar-de-inquerito/55a-legislatura/cpi-mafia-das-orteses-e-proteses-no-brasil/documentos/notas-tecnicas/nota-tecnica-orteses-proteses-e-materiais-especiais

[15] Brasil, Conselho Federal de Medicina. Resolução. (2000). CFM n. 1595/2000. Disciplinar a propaganda de equipamentos e produtos farmacêuticos junto à categoria médica, além de salientar a importância de que possíveis conflitos de interesse no relacionamento entre médicos e a indústria farmacêutica sejam explicitados, sempre que necessário. 2000. Recuperado em. 16 maio 2020, de http://www.portalmedico.org.br/resolucoes/cfm/2000/1595_2000.htm

[16] Brasil, Conselho Federal de Medicina. (2010). Resolução CFM n. 1956/2010. Disciplina a prescrição de materiais implantáveis, órteses e próteses e determina arbitragem de especialista quando houver conflito. Recuperado em. 16 maio 2020, de http://www.portalmedico.org.br/resolucoes/CFM/2010/1956_2010.htm

[17] Brasil, Agência Nacional de Vigilância Sanitária. (2017). Pacientes pela segurança do paciente em serviços de saúde: Como posso contribuir para aumentar a segurança do paciente? Orientações aos pacientes, familiares e acompanhantes. Recuperado em. 16 maio 2020, de file:///C:/Users/brenn/Downloads/GUIA_SEGURANA_PACIENTE_ATUALIZADA.pdf

[18] Ramos, P. (2017). A máfia das próteses: uma ameaça à saúde. São Paulo: Évora.

[19] Instituto de Estudos de Saúde Suplementar. (2018). Estudos Especiais Arcabouço Normativo para Prevenção e Combate à Fraude na Saúde Suplementar no Brasil. Recuperado em. 16 maio 2020, de https://www.iess.org.br/cms/rep/Arcabouco_Normativo_FINAL.pdf

[20] Bergamini, A. (2019). Rastreabilidade e a garantia de segurança ao paciente. Medicina S/A.

# A comparative study of some well-reservoir coupling models in the numerical simulation of oil reservoirs

Rebeca Costa Dias do Rosário[1], Grazione de Souza[1] and Helio Pedro Amaral Souto[1]

[1]Departamento de Modelagem Computacional, Universidade do Estado do Rio de Janeiro, Rua Bonfim, 25, Vila Amélia, 28625-570 - Nova Friburgo, RJ, Brazil
Emails: rebecacostadias@gmail.com, gsouza@iprj.uerj.br, helio@iprj.uerj.br

*Abstract* — *In reservoir simulation, the most known well-reservoir coupling technique is based on the Peaceman's equivalent radius, which is applied on the productivity index computation, that is used to relate flow rate, wellbore pressure, and the mesh block pressure. Original Peaceman's model considers the assumption of steady-state flow, leading to an artifact on the calculation of the wellbore pressure, called numerical wellbore storage. This artifact is more significant for coarser meshes and initial time instants, and it is also a function of fluid and rock properties. In this context, we have implemented and compared different Peaceman's technique extensions for productivity index calculation incorporating transient effects to prevent numerical wellbore storage. We have also considered some production scenarios for a vertical well and single-phase oil flow.*

*Keywords* — *Numerical storage, Peaceman's equivalent radius, Transient well index, Well-reservoir coupling.*

## I. INTRODUCTION

During the 1960s, the term Numerical Simulation of Reservoirs became common in the oil industry [14], referring to the use of physical-mathematical models and computational tools to predict the performance of hydrocarbon reservoirs under different production scenarios. According to Dumkwu et al. [16], Numerical Reservoir Simulation has become an ally in Reservoir Engineering, and we use it in decision making that involves many financial resources, in estimating underground reserves, and to forecast and improve performance production of reservoirs in the oil and gas industry. This work focuses on the calculation of pressure estimates in wells, using well-reservoir coupling techniques.

### 1.1. Determination of pressure in oil wells

Petroleum is the name given to natural hydrocarbon mixtures that can be found in the solid, liquid, and gas phases, depending on the pressure and temperature conditions. In nature, oil can appear in only one phase, or it can appear as a multiphase mixture in equilibrium [30]. In many cases, the fluid phase in the reservoir depends on the thermodynamics properties

of the fluid produced at the surface. Knowledge of the behavior, under pressure and temperature variations, of oil, natural gas, and water, alone or in combination, is of fundamental interest to Petroleum Engineering [14], whether under static or moving conditions, in the rocks of the reservoir or ducts.

Over the years, Petroleum Engineering has recognized the need for accurate information related to physical conditions in the well and inside the reservoir. With the initial progress in oil recovery methods, it became clear that calculations made with information from the surface or the top of the well could often lead to misunderstandings. Sclater et al. [33] described the first pressure value record at the bottom of the well and fluid collection in the well, under pressure, for sampling. These same authors define rock bottom data by referring to pressure, temperature, gas-oil ratio, and the chemical and physical nature of the fluid. Millikan et al. [21] highlighted the need of accurate wellbore pressure measurements when they described the first accurate pressure gauge, and they pointed to the fundamental importance of wellbore pressure knowledge for Petroleum Engineering,

in search of more efficient recovery and lifting procedures. Based on this contribution, we were able to measure pressure, which is essential information for reservoir performance calculations [14].

The Well Testing Analysis is the engineering branch which obtains estimates of properties of the well-reservoir system from wellbore data under production/injection conditions, as well as through the application of inverse problems. We are interested in the pressure variation in the well as a function of time. We accomplish this by measuring the pressures at the bottom of the well and the flow at the surface, for example. From the measured pressure response, it is possible to determine reservoir properties useful for planning the completion of the well or the reservoir depletion plan [35]. During a well test, we can create a transient pressure response by a temporary change in the production rate. The well response is usually monitored for a relatively short period, compared to the reservoir life, depending on the test objectives. For estimates involving regions around the wells, we often carried out tests in less than two days. In the case of tests to analyze the reservoir boundaries, it may take several months to register pressure data [20].

It is usual to use analytical solutions to interpret the results of pressure tests in wells. Theis [37] proposed one of the first theoretical solutions for determining the well pressure, depending on the flow rate and the duration of production. Considering the one-dimensional flow in the radial direction in a reservoir described in Cylindrical coordinates, producing at a constant flow $q_{sc}$ (defined in standard conditions, negative for production and positive for injection), from the initial time $t=0$, the analytical solution for the pressure in the reservoir in a radius $r$ is given by [30]:

$$p(r,t) = p_i + \frac{q_{sc}B\mu}{4\pi kh}\left[-E_i\left(-\frac{\phi\mu c_t r^2}{4kt}\right)\right], \qquad (1)$$

where $p_i$ is the initial pressure of the porous medium, $\mu$ is the viscosity of the fluid, $k$ is the permeability of the medium, $h$ is the reservoir thickness, $E_i$ is the Integral Exponential Function, $\phi$ is the porosity of the medium and $c_t$ is the total compressibility that includes the contribution of the fluid ($c_o$) and rock ($c_\phi$) compressibilities ($c_t = c_o + c_\phi$).

For small values of the argument ($X < 0.025$), the integral exponential function can be approximated,

with an error of less than 1%, by [26],

$$E_i(-X) \cong \ln(\lambda X), \qquad (2)$$

where $\lambda = \exp(0.57722)$, and 0.57722 is the Euler constant. Thus, the pressure in the well ($p_{wf}$) is approximated by

$$p_{wf}(t) \cong p_i + \frac{q_{sc}B\mu}{4\pi kh}\left[-\ln\left(\frac{\lambda\phi\mu c_t r_w^2}{4kt}\right)\right], \qquad (3)$$

where $r_w$ is the radius of the well.

Throughout the years, researchers have developed models for more complex reservoirs. However, there are many situations for which analytical solutions do not exist or are difficult to obtain. Heterogeneous reservoirs with irregular borders and with complex well geometry are examples where numerical simulation is the alternative to determine transient pressure responses.

### 1.2. Numerical reservoir simulation

As already said, we often use reservoir simulation models in the oil and gas industry. The reasons for such acceptance are due to some advances [17]:

1. in computing (particularly concerning the speed of processing and the increase in the storage capacity of computers);

2. numerical techniques for solving partial differential equations (PDEs);

3. reservoir simulators suitable for use in modeling field cases;

4. reservoir characterization techniques, among other factors.

The ultimate goal of a numerical simulation study is to accurately predict flow and pressure in the well and estimate pressure distributions in the reservoir (and saturation, in the multiphase case). When we intend to incorporate well modeling in reservoir simulation, some difficulties appear, which we can separate into three main categories [17]:

1. The cell of the computational mesh that contains the well is usually large compared to the wellbore radius, due to the discrepancy between the spatial scales involved. The average diameter of the production/injection well is about 10 cm, while the dimensions of a reservoir can be kilometers. Therefore, the cell pressure calculated is a poor estimate of the pressure in the well;

2. Coupling is a complex interaction between the reservoir (porous medium) and the well (a duct), particularly in the case of wells that pass through several layers of the porous medium;

3. There are difficulties in describing the well-reservoir coupling in the multiphase flow when the total production flow of the well is specified.

It is also worth noting that there is a variation in the time scale, with phenomena involving strong pressure gradients that may occur in short periods, such as fractions of an hour, and border effects (such as, for example, pressure drop at the reservoir boundaries concerning the initial pressure) that may take months to appear. These times are a function of the characteristics of the well-reservoir system. Other problems can also arise when considering the location of the producer/injector well displaced from the center of the cell, or even when there are several wells in a cell in the computational mesh.

The well-reservoir coupling model appears as a central component in reservoir simulation. Peaceman [26] introduced a well-known and commonly used model, which considers that the flow between the reservoir and the producing well is steady-state. Extensions were also created, for example, for the case of anisotropy [27], the incorporation of transient effects [9], and techniques for horizontal wells [2]. Although this coupling model provides suitable results for reservoirs in a wide range of applications, including their extensions, it introduces a phenomenon called numerical storage (due to the similarity of the results when considering wellbore storage, although it does not correspond to the physical behavior in the well) for the initial instants, and the application of methodologies to circumvent this numerical issue is the main objective of this work.

Therefore, this work aims to implement a model for a transient coupling of the well-reservoir system to minimize the phenomenon of numerical storage originating from the steady-state well-reservoir coupling, using the technique of Peaceman [26]. We consider here a single-phase flow, of a slightly compressible oil, in a reservoir containing a vertical producer well that penetrates the entire oil reservoir. We also use a polynomial function, with low error and wide application range, when calculating the integral exponential $E_i$.

## II. FLOW MODELING IN POROUS MEDIA

In this work, we consider the following hypotheses for the flow in the porous medium:

1. the porous medium is homogeneous and anisotropic in terms of its permeability;

2. porosity is a linear function of pressure;

3. the compressibility of the rock is small and constant;

4. the fluid is Newtonian and slightly compressible;

5. the fluid has a constant chemical composition;

6. there are no electrokinetic effects;

7. there are no inertial or turbulent effects;

8. the flow is single-phase and isothermal;

9. there are no chemical reactions.

### 2.1. Governing equations

The continuity equation is a mass balance equation so that the difference in mass entering and leaving a control volume must be equal to the accumulation of mass within the control volume in a given time interval. In oil reservoirs, the control volume is a portion of the porous medium that can contain one, two, or three phases of fluid [17]. It is worth mentioning that we consider the porous medium as a continuum. So, we define the physical properties, at any point, using the concept of Representative Elementary Volume (REV) [41]. For single-phase mass flows in a porous medium, we can write the continuity equation in the form:

$$\frac{\partial}{\partial t}(\phi\rho) + \nabla \cdot (\rho\mathbf{v}) - \frac{q_m}{V_b} = 0 \qquad (4)$$

where $\rho$ is the density of the fluid, $\mathbf{v}$ is the apparent fluid velocity (flow rate divided by the cross-sectional area), $q_m$ is a source term representing the production or injection of fluid, and $V_b$ is the volume of the rock (solid material plus pores).

We can also write the continuity equation in terms of the formation volume factor [17], $B = \rho_{sc}/\rho$, as

$$\frac{\partial}{\partial t}\left(\frac{\phi}{B}\right) + \nabla \cdot \left(\frac{\mathbf{v}}{B}\right) - \frac{q_m}{V_b \rho_{sc}} = 0, \qquad (5)$$

where the $sc$ subscript indicates the standard conditions.

The civil engineer Henry Darcy, in 1856, through experiments of vertical water filtration in columns of

homogeneous sand, obtained the first equation used to describe the movement of fluids in porous media. This equation was later called Darcy's law. It is an empirical relationship between the mass flow rate of fluid through a porous medium and the potential gradient, defined in the form [15]

$$-\nabla \Phi = \frac{\mathbf{v}}{K}, \tag{6}$$

where $K$ symbolizes the hydraulic conductivity of the porous medium, which combines fluid and medium properties, and $\nabla \Phi$ is the potential gradient, defined as [17, 30],

$$\nabla \Phi = \nabla p - \gamma_G \nabla D \tag{7}$$

where $\gamma_G = \rho g$, $g$ is the magnitude of the acceleration due to gravity, and $D$ is the depth (positive in the vertically downward direction). Later, Darcy's law could be deduced mathematically from the balance equations that govern the single-phase flow of a Newtonian fluid [40].

Rewriting Darcy's law in terms of the properties of the fluid, we can express the surface flow velocity as

$$\mathbf{v} = -\frac{\mathbf{k}}{\mu} \left( \nabla p - \rho g \nabla D \right), \tag{8}$$

where $\mathbf{k}$ is the absolute permeability tensor.

From the definition of the compressibility coefficients of the rock and the fluid, it is possible to rewrite the transient term of Eq. (5) in the form

$$
\begin{aligned}
\frac{\partial}{\partial t} \left( \frac{\phi}{B} \right) &= \phi \frac{d}{dp} \left( \frac{1}{B} \right) \frac{\partial p}{\partial t} + \frac{1}{B} \frac{d\phi}{dp} \frac{\partial p}{\partial t} \\
&= \left[ \phi \frac{d}{dp} \left( \frac{1}{B} \right) + \frac{1}{B} \frac{d\phi}{dp} \right] \frac{\partial p}{\partial t} \\
&= \left( \frac{\phi c_o}{B^0} + \frac{c_\phi \phi^0}{B} \right) \frac{\partial p}{\partial t},
\end{aligned}
\tag{9}
$$

where we considered that $\phi = \phi(p)$ and $B = B(p)$ and that [17]

$$\phi = \phi^o \left[ 1 + c_\phi(p - p^o) \right], \tag{10}$$

$$\rho = \rho^0 \left[ 1 + c_o(p - p^0) \right], \tag{11}$$

$$B = \frac{B^0}{[1 + c_o(p - p^0)]}, \tag{12}$$

$$\mu = \frac{\mu^0}{[1 - c_\mu(p - p^0)]}, \tag{13}$$

where the superscript $0$ indicates the reference conditions, and $c_\mu$ is the coefficient of variation of viscosity, and we assume that $c_o$ and $c_\phi$ are small and constants.

We obtain the Hydraulic Diffusivity Equation (HDE) by combining Darcy's law with the mass conservation equation. Now, writing Eq. (8) in terms of its components,

$$v_x = \frac{k_x}{\mu} \left( -\frac{\partial p}{\partial x} + \rho g \frac{\partial D}{\partial x} \right), \tag{14}$$

$$v_y = \frac{k_y}{\mu} \left( -\frac{\partial p}{\partial y} + \rho g \frac{\partial D}{\partial y} \right), \tag{15}$$

$$v_z = \frac{k_z}{\mu} \left( -\frac{\partial p}{\partial z} + \rho g \frac{\partial D}{\partial z} \right). \tag{16}$$

In turn, we can write the conservation equation as

$$\frac{\partial}{\partial t} \left( \frac{\phi}{B} \right) = -\frac{\partial}{\partial x} \left( \frac{v_x}{B} \right) - \frac{\partial}{\partial y} \left( \frac{v_y}{B} \right) - \frac{\partial}{\partial z} \left( \frac{v_z}{B} \right) + \frac{q_m}{V_b \rho_{sc}}. \tag{17}$$

Next, we multiply Eq. (17) by $V_b = dxdydz$,

$$
\begin{aligned}
V_b \frac{\partial}{\partial t} \left( \frac{\phi}{B} \right) &= -\frac{\partial}{\partial x} \left( \frac{v_x A_x}{B} \right) dx - \frac{\partial}{\partial y} \left( \frac{v_y A_y}{B} \right) dy \\
&\quad - \frac{\partial}{\partial z} \left( \frac{v_z A_z}{B} \right) dz + \frac{q_m}{\rho_{sc}},
\end{aligned}
\tag{18}
$$

where $A_x$, $A_y$, and $A_z$ are, respectively, the areas of surfaces normal to the $x$-, $y$- and $z$- directions.

Then, replacing $v_x$, $v_y$, and $v_z$ and using the definition $q_{sc} = q_m/\rho_{sc}$ we finally obtain

$$
\begin{aligned}
V_b \frac{\partial}{\partial t} \left( \frac{\phi}{B} \right) &= \frac{\partial}{\partial x} \left[ \frac{A_x k_x}{\mu B} \left( \frac{\partial p}{\partial x} - \rho g \frac{\partial D}{\partial x} \right) \right] dx \\
&\quad + \frac{\partial}{\partial y} \left[ \frac{A_y k_y}{\mu B} \left( \frac{\partial p}{\partial y} - \rho g \frac{\partial D}{\partial y} \right) \right] dy \\
&\quad + \frac{\partial}{\partial z} \left[ \frac{A_z k_z}{\mu B} \left( \frac{\partial p}{\partial z} - \rho g \frac{\partial D}{\partial z} \right) \right] dz \\
&\quad + q_{sc}.
\end{aligned}
\tag{19}
$$

Now, using the result obtained in Eq. (9),

$$
\begin{aligned}
\Gamma_p \frac{\partial p}{\partial t} &= \frac{\partial}{\partial x} \left[ \frac{A_x k_x}{\mu B} \left( \frac{\partial p}{\partial x} - \rho g \frac{\partial D}{\partial x} \right) \right] dx \\
&\quad + \frac{\partial}{\partial y} \left[ \frac{A_y k_y}{\mu B} \left( \frac{\partial p}{\partial y} - \rho g \frac{\partial D}{\partial y} \right) \right] dy \\
&\quad + \frac{\partial}{\partial z} \left[ \frac{A_z k_z}{\mu B} \left( \frac{\partial p}{\partial z} - \rho g \frac{\partial D}{\partial z} \right) \right] dz + q_{sc}
\end{aligned}
\tag{20}
$$

where the $\Gamma_p$ coefficient represents the compressibility effects of rock and fluid, given by

$$\Gamma_p = V_b \left( \frac{\phi c_o}{B^0} + \frac{c_\phi \phi^0}{B} \right). \qquad (21)$$

Incorporating the gravitational effects in the term $\Gamma_G$, we can rewrite the HDE as follows:

$$
\begin{aligned}
\Gamma_p \frac{\partial p}{\partial t} &= \frac{\partial}{\partial x}\left( \frac{A_x k_x}{\mu B} \frac{\partial p}{\partial x} \right) dx + \frac{\partial}{\partial y}\left( \frac{A_y k_y}{\mu B} \frac{\partial p}{\partial y} \right) dy \\
&+ \frac{\partial}{\partial z}\left( \frac{A_z k_z}{\mu B} \frac{\partial p}{\partial z} \right) dz + q_{sc} + \Gamma_G,
\end{aligned}
\qquad (22)
$$

where

$$
\begin{aligned}
\Gamma_G &= \frac{\partial}{\partial x}\left( -\rho g \frac{\partial D}{\partial x} \right) dx + \frac{\partial}{\partial y}\left( -\rho g \frac{\partial D}{\partial y} \right) dy \\
&+ \frac{\partial}{\partial z}\left( -\rho g \frac{\partial D}{\partial z} \right) dz.
\end{aligned}
\qquad (23)
$$

## 2.2. Initial and boundary conditions

To solve Eq. (22), we need to provide the appropriate initial and boundary conditions. As an initial condition, we take

$$p(x, y, z, t = 0) = p_{ini}(x, y, z), \qquad (24)$$

where $p_{ini}$ is the initial pressure distribution before the reservoir is disturbed by fluid production/injection.

As external boundary conditions (external borders of the reservoir), we can use prescribed pressure or flow rate. For a sealed rectangular parallelepiped reservoir of edges $L_x$, $L_y$ and $L_z$, we have

$$\left( \frac{\partial p}{\partial x} \right)_{x=0,L_x} = \left( \frac{\partial p}{\partial y} \right)_{y=0,L_y} = \left( \frac{\partial p}{\partial z} \right)_{z=0,L_z} = 0. \qquad (25)$$

## 2.3. Source term

In the numerical simulation of reservoirs, wells are considered internal boundaries, and, in the case of the use of Cartesian coordinates, the term source, used to represent wells, is directly related to the use of well-reservoir coupling techniques. We can impose these boundary conditions specifying the pressure in the well (Dirichlet condition) or the flow rate in the well (Neumann condition) [17].

For the representation of wells, it is necessary to obtain an expression that relates the pressure in the porous medium, $p$, with the pressure in the well, $p_{wf}$, and the flow rate in the well, $q_{sc}$. As an example of

how we can use expressions of this type, we assume steady-state flow in the region close to the well. Further, we consider the radial flow of an incompressible fluid towards the vertical well of radius $r_w$, in a rock formation with uniform permeability and thickness. So, assuming these conditions, it is possible to write [17]:

$$q_{sc} = \frac{-2\pi k_H h r}{\mu B} \frac{\partial p}{\partial r}, \qquad (26)$$

where $k_H$ represents the permeability value in the radial direction.

Integrating Eq. (26) between the radius of the well, $r_w$, and an arbitrary radius, $r$, where $r_w \leq r \leq r_e$ ($r_e$ is the external radius), it is possible to obtain an equation for the pressure distribution for the steady-state well-coupling,

$$p = p_{wf} - \frac{q_{sc}\mu B}{2\pi k_H h} \ln \left( \frac{r}{r_w} \right). \qquad (27)$$

For $r = r_e$, where we define the pressure as $p_e$, we can rewrite Eq. (27) as

$$q_{sc} = \frac{-2\pi k_H h}{\mu B \ln \left( \dfrac{r_e}{r_w} \right)} (p_e - p_{wf}), \qquad (28)$$

so that Eq. (28) provides the well production in terms of external and well pressures.

In general, we express the production rate, under standard conditions, using the pressure of the well and the average pressure of the reservoir [17]. From the development of Van et al. [39], for a reservoir described in Cylindrical coordinates, considering the average volumetric pressure in the oil reservoir, $\overline{p}$, between $r_w$ and $r_e$, and even though $r_e \gg r_w$, we have

$$q_{sc} = \frac{-2\pi k_H h}{\mu B \left[ \ln \left( \dfrac{r_e}{r_w} \right) + s - \dfrac{1}{2} \right]} (\overline{p} - p_{wf}), \qquad (29)$$

which differs from Eq. (28) only by the skin factor $s$, the 1/2 in the denominator, and by replacing $p_e$ with $\overline{p}$. The introduction of the skin factor makes Eq. (29) more general, valid for the case where there is an additional pressure drop around the well, for example, due to the formation damage. For the specific case in which the permeability may change, we determine the $s$ factor by [18, 30]

$$s = \left( \frac{k}{k_s} - 1 \right) \ln \left( \frac{r_s}{r_w} \right), \qquad (30)$$

where $k_s$ is the modified permeability, and $r_s$ is the radius of the region where the permeability can vary. When $k_s < k$, the value of $s$ is positive, and we have damage to the formation. Otherwise, $s$ is negative, and we have stimulation. On the other hand, when $s = 0$, there is no influence on the productivity of the well by local permeability changes near the well [30].

Commonly, we rewrite Eq. (29) in a more compact form, introduced by Van et al. [39],

$$q_{sc} = -J_w(\bar{p} - p_{wf}) \tag{31}$$

where $J_w$ is the Productivity Index (PI):

$$J_w = \frac{2\pi k_H h}{\mu B \left[\ln\left(\dfrac{r_e}{r_w}\right) + s - F\right]} \tag{32}$$

or yet,

$$J_w = \frac{G_w}{\mu B} \tag{33}$$

where $G_w$ is the geometric factor of the well, defined as

$$G_w = \frac{2\pi k h}{\ln\left(\dfrac{r_e}{r_w}\right) + s - F}. \tag{34}$$

The factor $F$, in Eqs. (32) and (34), assumes the values of $1/2$ for steady-state conditions and $3/4$ for the pseudo-steady state [17]. The representation of Eq. (32) for the Productivity Index comes from analytical solutions. However, we also apply the concept of the Productivity Index in the context of numerical reservoir simulation, and its calculation is associated, in this case, with the use of well-reservoir coupling techniques.

## III. NUMERICAL METHODOLOGY

We describe fluid flow in porous media using a set of partial differential equations, and we can not always obtain analytical solutions due to the non-linear nature of the equations. Therefore, we must use numerical techniques to solve the balance equations that govern the flow. Among the numerical methods that we can apply in its resolution, we choose to use the Finite Difference Method (FDM), which is the most used in the oil industry [17, 26].

### 3.1. Discretization

Discretization is the process of converting the PDE, valid in the continuous medium that defines the resolution domain, by a set of algebraic equations defined in a discrete domain, to obtain a numerical solution. The first step in the discretization stage is the choice and construction of the numerical mesh, that is, the partitioning of the resolution domain. In the Finite Difference Method, this implies a computational mesh with a finite number of nodes where we determine the values of the dependent variables. Then, we must approximate the existing derivatives in the governing partial differential equations.

Generally, we use two mesh systems in numerical simulation of reservoirs: the centered block system and the distributed point system [17]. In this work, we use the former.

The mesh system contains, in the $x$-direction, $n_x$ cells that we superimpose on the reservoir. We center each $i$ cell on $x_i$, and we designate its borders by $x_{i-1/2}$ and $x_{i+1/2}$. The cells have dimensions equal to $\Delta x_i$, constants or not, satisfying the following relation

$$\sum_{i=1}^{n_x} \Delta x_i = L_x. \tag{35}$$

so that the cells must cover the entire $L_x$ length of the reservoir [17]. Similarly, it is also possible to discretize the reservoir in the $y$- and $z$- directions.

The cells should be small enough to describe the heterogeneous nature of the reservoir and, thus, allowing to represent the flow characteristics adequately. However, it is necessary to carefully determine the total number of cells in the mesh, because the higher the number of them, the higher the number of unknowns in the algebraic system that must be solved, implying an increase in computational effort.

In Fig. 1, a three-dimensional reservoir is discretized into $n_x$ blocks (or cells) in the $x$-direction, $n_y$ blocks in the $y$-direction, and $n_z$ blocks in the $z$-direction, considering that $n_x = n_y = n_z = 3$, for this particular case. In more general situations, the dimensions of the blocks need not be the same, and:

$$\sum_{j=1}^{n_y} \Delta y_j = L_y, \tag{36}$$

$$\sum_{k=1}^{n_z} \Delta z_k = L_z, \tag{37}$$

where the $j$ and $k$ indexes indicate the blocks in the $y$- and $z$- directions, respectively. In this system, we number the border blocks by adding the fraction $\pm 1/2$ to one of the $i$, $j$, and $k$ indexes, depending on the border that we want to represent. For example, we indicate the boundary between cells $i,j,k$ and $i+1,j,k$ by $i+1/2,j,k$.
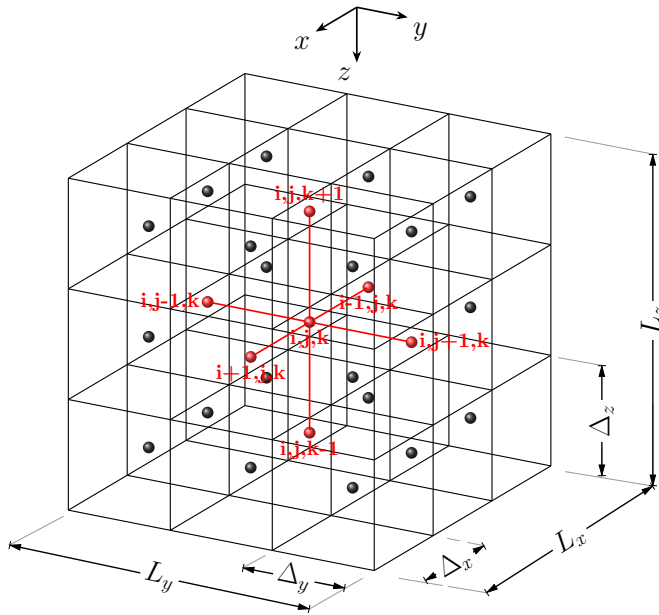


Fig. 1: *Discretized domain.*

### 3.2. Numerical approximation of derivatives

Considering the partitioning illustrated in Fig. 1 and a totally implicit numerical scheme, the first term containing the spatial derivatives of Eq. (22) can be discretized by a central difference approximation of second-order,

$$\left[\frac{\partial}{\partial x}\left(T_x\frac{\partial p}{\partial x}\right)dx\right]^{n+1}_{i,j,k} \approx \left(T_x\frac{\partial p}{\partial x}\right)^{n+1}_{i+1/2,j,k}$$
$$- \left(T_x\frac{\partial p}{\partial x}\right)^{n+1}_{i-1/2,j,k}, \quad (38)$$

where

$$T_x = \frac{A_x k_x}{\mu B}, \quad (39)$$

with similar equations for $y$- and $z$- directions. Still, in Eq. (38), we do not know the pressures at time $n+1$, $\Delta x_{i,j,k}$ is the spacing of the cell $i$ in the $x$-direction, and the subscript $i \pm 1/2$ indicates that the variables must be evaluated at the cell boundary in the

$x$-direction. We can also obtain similar forms for the $y$- and $z$- directions, considering that $\Delta y_{i,j,k}$ and $\Delta z_{i,j,k}$ are the spacing in these respective directions and that we represent these boundaries by the indexes $j \pm 1/2$ and $k \pm 1/2$.

Before proceeding, we introduce transmissibilities as being represented by $\mathbb{T}_x$, $\mathbb{T}_y$ and $\mathbb{T}_z$:

$$\mathbb{T}^{n+1}_{x_{i\pm\frac{1}{2},j,k}} \equiv \left(\frac{A_x k_x}{\mu B \Delta x}\right)^{n+1}_{i\pm\frac{1}{2},j,k} = \left(\frac{T_x}{\Delta x}\right)^{n+1}_{i\pm\frac{1}{2},j,k}, \quad (40)$$

$$\mathbb{T}^{n+1}_{y_{i,j\pm\frac{1}{2},k}} \equiv \left(\frac{A_y k_y}{\mu B \Delta y}\right)^{n+1}_{i,j\pm\frac{1}{2},k} = \left(\frac{T_y}{\Delta y}\right)^{n+1}_{i,j\pm\frac{1}{2},k}, \quad (41)$$

$$\mathbb{T}^{n+1}_{z_{i,j,k\pm\frac{1}{2}}} \equiv \left(\frac{A_z k_z}{\mu B \Delta z}\right)^{n+1}_{i,j,k\pm\frac{1}{2}} = \left(\frac{T_z}{\Delta z}\right)^{n+1}_{i,j,k\pm\frac{1}{2}}, \quad (42)$$

and we calculate the properties at the cell interface using harmonic averages for rock and geometric properties, and arithmetic means for fluid properties.

Again, employing central difference approximations,

$$\left(\frac{\partial p}{\partial x}\right)^{n+1}_{i+\frac{1}{2},j,k} \approx \frac{p^{n+1}_{i+1,j,k} - p^{n+1}_{i,j,k}}{x_{i+1,j,k} - x_{i,j,k}} = \frac{p^{n+1}_{i+1,j,k} - p^{n+1}_{i,j,k}}{\triangle x_{i+\frac{1}{2},j,k}}$$

$$(43)$$

$$\left(\frac{\partial p}{\partial x}\right)^{n+1}_{i-\frac{1}{2},j,k} \approx \frac{p^{n+1}_{i,j,k} - p^{n+1}_{i-1,j,k}}{x_{i,j,k} - x_{i-1,j,k}} = \frac{p^{n+1}_{i,j,k} - p^{n+1}_{i-1,j,k}}{\triangle x_{i-\frac{1}{2},j,k}}$$

$$(44)$$

and we can proceed similarly to the $y$- and $z$- directions.

Now, we apply conservative expansions to the terms of accumulation to preserve the mass balance. It is worth mentioning that the use of non-conservative schemes in the finite difference equations does not necessarily produce results that are not correct [17]. Therefore, the final discretized form is given by:

$$(\Gamma_p)^{n+1}_{i,j,k} = V_{b,i,j,k}\left[\frac{\phi^o c_\phi}{B^{n+1}} + \frac{\phi^n c_o}{B^0}\right]_{i,j,k}, \quad (45)$$

where $V_{b,i,j,k} = \Delta x_i \Delta y_j \Delta z_k$.

We approximate the time derivative by a backward Euler scheme

$$\left(\frac{\partial p}{\partial t}\right)^{n+1}_{i,j,k} \approx \frac{p^{n+1}_{i,j,k} - p^n_{i,j,k}}{\Delta t}. \quad (46)$$

Finally, considering the use of an iterative resolution aiming to linearize the system of equations we obtain

$$\mathbb{T}^{n+1,v}_{x_{i+\frac{1}{2},j,k}} \left( p^{n+1,v+1}_{i+1,j,k} - p^{n+1,v+1}_{i,j,k} \right)$$

$$+ \quad \mathbb{T}^{n+1,v}_{x_{i-\frac{1}{2},j,k}} \left( p^{n+1,v+1}_{i-1,j,k} - p^{n+1,v+1}_{i,j,k} \right)$$

$$+ \quad \mathbb{T}^{n+1,v}_{y_{i,j+\frac{1}{2},k}} \left( p^{n+1,v+1}_{i,j+1,k} - p^{n+1,v+1}_{i,j,k} \right)$$

$$+ \quad \mathbb{T}^{n+1,v}_{y_{i,j-\frac{1}{2},k}} \left( p^{n+1,v+1}_{i,j-1,k} - p^{n+1,v+1}_{i,j,k} \right)$$

$$+ \quad \mathbb{T}^{n+1,v}_{z_{i,j,k+\frac{1}{2}}} \left( p^{n+1,v+1}_{i,j,k+1} - p^{n+1,v+1}_{i,j,k} \right)$$

$$+ \quad \mathbb{T}^{n+1,v}_{z_{i,j,k-\frac{1}{2}}} \left( p^{n+1,v+1}_{i,j,k-1} - p^{n+1,v+1}_{i,j,k} \right)$$

$$= \quad -(q_{sc})^{n+1,v+1}_{i,j,k} - (\Gamma_G)^{n+1,v}_{i,j,k}$$

$$+ \quad (\Gamma_p)^{n+1,v}_{i,j,k} \left( \frac{p^{n+1,v+1}_{i,j,k} - p^n_{i,j,k}}{\Delta t} \right) \quad (47)$$

where the level $v$ indicates the known values while the level $v+1$ the values to be determined.

Next, we move on to the discretization stage of the well-reservoir coupling,

$$(q_{sc})^{n+1,v+1}_{i,j,k} = -(J_w)^{n+1,v}_{i,j,k} \left[ p^{n+1,v+1}_{i,j,k} - (p_{wf})^{n+1,v+1}_{i,j,k} \right]. \quad (48)$$

Through the term $(J_w)^{n+1,v}_{i,j,k}$ the well-reservoir coupling occurs, following the methodologies based on the work of Peaceman [26], which is still the most used to date in numerical reservoir simulation studies.

We note that we use the term $q_{sc}$ to represent a source term for the computational mesh cell. In general, the well passes through a set of cells in the computational mesh. Therefore, the expression to the total flow of the producing well is given by:

$$Q_{sc} = -\sum_{k=W_i}^{W_f} (J_w)^{n+1,v}_{i,j,k} \left[ p^{n+1,v+1}_{i,j,k} - (p_{wf})^{n+1,v+1}_{i,j,k} \right] \quad (49)$$

if we assume a vertical well that contains the cells $W_i$ up to $W_f$ (Fig. 2) and we do not consider the frictional and convective effects inside the well.
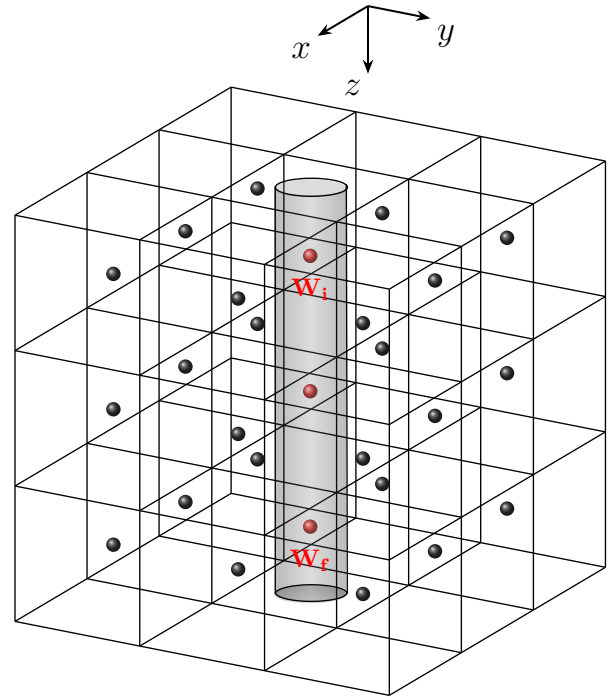


Fig. 2: *Vertical well in the computational domain.*

We adopted as a reference level $k = W$ for calculating the pressure in the well. Considering only the gravitational effects inside the well, we can write:

$$(p_{wf})^{n+1,v+1}_{i,j,W} = \frac{\sum_k (J_w)^{n+1,v}_{i,j,k} \, p^{n+1,v+1}_{i,j,k}}{\sum_k (J_w)^{n+1,v}_{i,j,k}}$$

$$+ \quad \frac{\sum_k (J_w)^{n+1,v}_{i,j,k} \Lambda_{i,j,k} + Q_{sc}}{\sum_k (J_w)^{n+1,v}_{i,j,k}} \quad (50)$$

where

$$\Lambda_{i,j,k} = -(\rho g)^{n+1,v}_{i,j,k+1/2} (D_{i,j,k} - D_{i,j,W}) \quad (51)$$

and we find the pressure in the well, in each layer, in the computational cell in terms of wellbore pressure in the reference level layer:

$$(p_{wf})^{n+1,v+1}_{i,j,k} = (p_{wf})^{n+1,v+1}_{i,j,W}$$

$$+ \quad (\rho g)^{n+1,v}_{i,j,k+1/2} (D_{i,j,k} - D_{i,j,W}), \quad (52)$$

and $\rho^{n+1,v}_{i,j,k+1/2}$ is the arithmetic mean between $\rho^{n+1,v}_{i,j,k}$ and $\rho^{n+1,v}_{i,j,W}$.

### 3.3.  Numerical solution of the algebraic equation system

The set composed of Eqs. (47) and (50) forms a linear system of equations whose dependent variables are the pressures in the reservoir and the production well.

We choose the Conjugate Gradient Method [19] to solve the resulting algebraic equation system. Initially, it was a direct method [19]. However, it became known for its properties as an iterative method, especially after the development of sophisticated preconditioning techniques [32].

We can increase the rate of convergence in the iterative process by using preconditioning techniques to reduce the conditioning number of the matrix by changing the original system of equations and, thus, their eigenvalues. Thus, the method used here is the Preconditioned Conjugate Gradient (PCG), using a diagonal preconditioning technique [7, 17, 32]. If we consider an iterative procedure, we attain the numerical convergence when

$$max \left| \chi^{n+1,v+1} - \chi^{n+1,v} \right| < tol \qquad (53)$$

where $\chi$ represents the pressure in the reservoir, and well and $tol$ is a numerical tolerance. We use a two-step iteration procedure [17]:

1. in a set of internal iterations, we apply the PCG method to obtain the pressures, and

2. in a set of external iterations, we update the coefficients, such as the transmissibilities.

## IV.  WELL-RESERVOIR COUPLING

The modeling of wells in the numerical simulation of reservoirs presents some difficulties as, for example, the discrepancies in spatial scales when comparing the wellbore radius with the dimensions of the oil reservoir, the geometry of complex wells, the flow transition from the porous medium to a duct, among other factors. In this section, we investigate the treatment of the term source, review some well-reservoir coupling models, focusing on the Peaceman [26] model and its extensions, and discuss the methodology that incorporates the transient effects, both in the productivity index and in the equivalent radius.

### 4.1.  Some well-reservoir coupling models

One of the difficulties in modeling wells in field-scale simulations is the fact that the region where the highest pressure gradients typically occur is close to the well, which is much smaller than the usual dimensions of a cell in a computational mesh [13]. Except for simulations that somehow make use of Cylindrical coordinates, source/sink terms are, in general, used for the implementation of internal boundary conditions involving wells [3, 17]. Well-reservoir coupling techniques aim to relate the pressure in the reservoir cells to the pressure in the well, by using, for example, equations that contain source/sink terms and the productivity index [35].

Among the first works to related the pressures in the cell and the well, we found that of Van et al. [39]. They stated that the pressure of the cell containing the well (for a wellbore centered in it) must be equal to the average volumetric pressure of the cell. Thus, for the hypotheses of steady-state flow, the average pressure $\overline{p}$ (or the pressure in the cell), located in the reservoir between the radii $r_w$ and $r_b$ ($r_b \gg r_w$) is given by:

$$\overline{p} = p_{wf} + \frac{2\pi q_{sc} B \mu}{kh} \left[ \ln\left(\frac{r_b}{r_w}\right) - \frac{1}{2} \right], \qquad (54)$$

where $r_b$ is called the block radius and determined, for a vertical well, as

$$r_b = \sqrt{\frac{\Delta x \Delta y}{\pi}}. \qquad (55)$$

We observe, then, that a methodology to deal with the problem of the representation of wells in Cartesian coordinates consists of initially considering the one-dimensional and radial mass flow around the well [3]. The idea is to reconcile the analytical solutions, which we can obtain for the one-dimensional flow in Cylindrical coordinates, with the discretized equations, written in Cartesian coordinates.

### 4.2.  Peaceman's equivalent radius

We can obtain the first models for well-reservoir coupling by considering a two-dimensional flow governed by the Darcy equation written in Cartesian coordinates and a one-dimensional flow in a cylindrical reservoir. Peaceman [26], to obtain its well-reservoir coupling model, used the discrete equation for the pressure $p(x, y)$ in the two-dimensional flow together with the analytical solution for the pressure $p(r)$ in the

one-dimensional flow, both for a porous medium of the same length $\Delta z$.

From the hypotheses of steady-state flow, homogeneous and isotropic porous medium ($k_x = k_y = k_H$), assuming that $\Delta x = \Delta y$, and symmetry, we obtain from the discrete form of HDE [17]

$$p_{i+1,j} = p_{i,j} - \frac{B\mu q_{sc}}{4k_H \Delta z}. \tag{56}$$

On the other hand, we know that the analytical solution of the one-dimensional flow in the radial direction, in a reservoir described in Cylindrical coordinates, for a steady-state flow, is given by [12]

$$p(r) = p_{wf} - \frac{q_{sc}B\mu}{2\pi k_H \Delta z} \ln\left(\frac{r}{r_w}\right). \tag{57}$$

Peaceman [26] considered the pressure $p(r)$ coinciding with the pressure $p_{i+1,j}$. So, for $r = \Delta x$, we obtain

$$p(\Delta x) = p_{i+1,j} = p_{wf} - \frac{q_{sc}B\mu}{2\pi k \Delta z} \ln\left(\frac{\Delta x}{r_w}\right). \tag{58}$$

Combining Eqs. (56) and (58), that is, considering the discrete form in Cartesian coordinates and the analytical expression for the Cylindrical geometry around the well, we can arrive in an equation for the flow in the well, written using the productivity index,

$$
\begin{aligned}
q_{sc} &= -\frac{2\pi k_H \Delta z (p_{i,j} - p_{wf})}{B\mu \ln\left(\frac{r_{eq}}{r_w}\right)} \\
&= -\frac{G_w}{B\mu}(p_{i,j} - p_{wf}) \\
&= -J_w (p_{i,j} - p_{wf}),
\end{aligned}
\tag{59}
$$

where $r_{eq}$ is Peaceman's equivalent radius, $r_{eq} \approx 0.198\Delta x$ [17].

Since then, researchers have created several extensions assuming a steady-state flow, from the Peaceman model for the equivalent radius [26], to improve the numerical approximation considering other hypotheses. For example, the concept of the equivalent radius was investigated for the case of $k_x \neq k_y$ and $\Delta x \neq \Delta y$, thus allowing us to address more comprehensive situations in numerical simulations [27]. Using coordinate transformations, Peaceman [27] obtained the following expression for the equivalent radius

$$r_{eq} = 0.28 \left[ \frac{\sqrt{\sqrt{\frac{k_y}{k_x}} (\Delta x)^2 + \sqrt{\frac{k_x}{k_y}} (\Delta y)^2}}{\sqrt[4]{\frac{k_y}{k_x}} + \sqrt[4]{\frac{k_x}{k_y}}} \right] \tag{60}$$

which we must use in conjunction with the equation

$$q_{sc} = -\frac{2\pi\sqrt{k_x k_y}\Delta z}{B\mu \ln\left(\frac{r_{eq}}{r_w}\right)} (p_{i,j} - p_{wf}). \tag{61}$$

It is worth mentioning that this derivation for the equivalent radius, for an anisotropic medium, considers that $\Delta x \neq \Delta y$ but that the mesh is uniform and that the well is far from the reservoir borders.

Other extensions have been developed, such as the one used by Al-Mohannadi et al. [2]

$$J_w = \frac{2\pi\sqrt{k_y k_z}\Delta x}{B\mu} \frac{\Delta x}{\left[1 - \left(\frac{r_w^2}{r_{eq}^2}\right)\right]\ln\left(\frac{r_{eq}}{r_w}\right)} \tag{62}$$

where

$$r_{eq} = \sqrt{\frac{\Delta z \Delta y}{\pi}} e^{-0.5} \tag{63}$$

for a horizontal well parallel to the $x$-axis.

Another well-coupling model, also for a horizontal well, is given by [4, 5]

$$J_w = -\frac{2\pi\sqrt{k_y k_z}\Delta x}{B\mu \ln\left(\frac{r_{eq}}{r_w}\right)} \tag{64}$$

where

$$
\begin{aligned}
r_{eq} &= 0.14 (k_y k_x)^{1/4} \left(\frac{\Delta y^2}{k_y} + \frac{\Delta z^2}{k_y}\right)^{1/2} \\
&\quad \cdot \left\{ \frac{1 + \exp\left[2.215 - 3.88\left(\frac{n_y n_y}{\alpha_H}\right)\right]}{1 + 0.533\left(\frac{\alpha_H}{n_z}\right)} \right\}
\end{aligned}
\tag{65}
$$

for a well parallel to the $x$-axis, where $\alpha_H = (\Delta y/\Delta x)\sqrt{k_z/k_y}$. As examples of other methodologies we can quote Peaceman [28], Peaceman [29], and Babu et al. [6]. Researchers have even studied inclined wells [22].

So that we can apply these well-reservoir coupling models, some restrictions must be considered, such as, for example, the existence of a minimum distance between the wells and the reservoir borders, and between the wells themselves. Despite its limitations [23], we extensively use the technique introduced by Peaceman [26] in the numerical simulation of reservoirs.

4.3. Extensions for the transient productivity index

As already said, the results obtained with the technique suggested by Peaceman [26] are subject to a numerical artifact, which is not related to the phenomenon of physical wellbore storage. Fundamentally, this happens due to the use of the hypothesis of steady-state flow near the well. In reality, we should have considered the fluid flow as being transient. Therefore, other models have been developed, including the well-reservoir coupling for the transient regime. For flow in the transient and pseudo-steady state regime, in the vicinity of the well, Peaceman [26] suggested that we can obtain the equivalent radius from the following equation:

$$r_{eq} = [4t_D \exp(-\lambda - 4\pi p_D)]\Delta L \qquad (66)$$

where

$$t_D = \left(\frac{k}{\phi \mu c_t \Delta L^2}\right) t \qquad (67)$$

is the dimensionless time and $\Delta L$ ($\Delta L = \Delta x = \Delta y$) is the spatial increment of the computational mesh, and

$$p_D = -\left(\frac{kh}{q_{sc}B\mu}\right)(p_{ini} - p_{i,j,k}) \qquad (68)$$

is the dimensionless pressure, and $p_{i,j,k}$ is the pressure in the cell that contains the well. Blanc et al. [9] also concluded that when $t_D > 1$, the equivalent radius calculated using Eq. (66) is close enough to its value determined by Peaceman's model for steady-state flow.

Over time, we have been using analytical solutions capturing the transient regime, in the porous medium, to interpret the results of pressure tests in wells. Theis [37], for example, offered one of the first solutions to the problem of pressure drop in a well.

Blanc et al. [9] presented a correction to the original Peaceman model and introduced the Transient Well Index:

$$J_{TWI} = \frac{4\pi kh}{\mu B \left[E_1\left(-\frac{\phi c_t \mu r_w^2}{4kt}\right) - E_1\left(\frac{\phi \mu c_t r_{eq}^2}{4kt}\right)\right]} \qquad (69)$$

where $E_1(u) = -E_i(-u)$ and $r_{eq} = 0.198\,\Delta L$ (steady-state flow hypothesis). This model offers better solutions than those obtained with the conventional

Peaceman technique for the initial times, but it can present deviations when the transient regime appears in the porous medium [9].

Therefore, instead of using the equivalent radius as $r_{eq} = 0.198\,\Delta x$, it is possible to calculate its transient version. The pressure variation, for radial flow in the transient regime and a vertical well, is given by [2]:

$$\Delta p = -\frac{q_{sc}B\mu}{L_H \sqrt{k_x k_y}} E_1\left(\frac{\phi c_t \mu r_{eq}^2}{t\sqrt{k_x k_y}}\right). \qquad (70)$$

From Eq. (70), we can use the Newton-Raphson method to determine the $r_{eq}$ as a function of time,

$$r_{eq_{n+1}} = r_{eq_n} - \frac{f(r_{eq_n})}{f'(r_{eq_n})}, \qquad (71)$$

where the subscripts $n$ and $n+1$ represent the iterations in the Newton-Raphson method and

$$f(r_{eq_n}) = -\frac{q_{sc}B\mu}{4\pi\Delta z\sqrt{k_x k_y}} E_1\left[\frac{r_{eq_n}^2}{4\left(\frac{\sqrt{k_x k_y}}{\phi \mu c_t}\right)t}\right] - \Delta p, \qquad (72)$$

while its derivative is given by

$$f'(r_{eq_n}) = \frac{q_{sc}B\mu}{2\pi r_{eq_n}\Delta z\sqrt{k_x k_y}} \exp\left[-\frac{r_{eq_n}^2}{4\left(\frac{\sqrt{k_x k_y}}{\phi \mu c_t}\right)t}\right]. \qquad (73)$$

In Eq. (72), $\Delta p = p_{ini} - p_{i,j,k}$, where $p_{ini}$ is the initial pressure of the reservoir, and $p_{i,j,k}$ is the pressure in the cell containing the well.

From these equations, we can obtain the expression for the determination of the equivalent transient radius

$$r_{eq_{n+1}} = r_{eq_n}\left\{1 - \left[\frac{q_{sc}B\mu E_1(\sigma) + 4\Delta p\pi\Delta z\sqrt{k_x k_y}}{2qB\mu \exp(-\sigma)}\right]\right\} \qquad (74)$$

where

$$\sigma = \frac{r_{eq_i}^2}{4\left(\frac{\sqrt{k_x k_y}}{\phi c_t \mu}\right)t} \qquad (75)$$

and

$$\Delta p = p_{ini} - p_{i,j,k}. \tag{76}$$

In this work, $p_{i,j,k}$ is evaluated at time $t^{n+1}$.

When the boundary effects start to affect the wellbore pressure behavior, $r_{eq}(t)$ becomes too large to represent the flow dynamics. In this case, we calculate $r_{eq}(t)$ from Eqs. (70), (71) and (72) while $t \leq t^*$, where $t^*$ is the characteristic time associated with the boundary effects [2]. For $t > t^*$, we must use $r_{eq} = r_{eq}(t^*)$, and we keep the transient equivalent radius, calculated at $t^*$, frozen until the end of the simulations.

Here, a criterion to shift the equivalent transient radius calculation is considered, based on the time required to reach the pseudo-steady regime. Therefore, we use the concept of dimensionless time considering $A$ (the area normal to the $z$-axis) as a reference [30] so that

$$t_{DA} = \frac{kt}{\phi \mu c_t A}, \tag{77}$$

and we assume that the producing well is in the center of the reservoir and that it has a square drainage area. For $t_{DA} < 0.09$, the reservoir still behaves as being infinite (transient regime). On the other hand, for $t_{DA} = 0.1$, we reach the pseudo-steady flow regime [30].

## V. NUMERICAL RESULTS

In the study carried out in this work, the well-reservoir coupling models, including transient effects, were incorporated into our simulator, developed in C programming language.

We calculate the well pressure values considering a constant production flow rate under standard conditions. We use two types of graphs in the analysis of the results:

1. specialized plot: well pressure curve as a function of time;

2. diagnostic plot: pressure drop curves in the well, $\Delta p_{wf}$, and the Bourdet derivative [11]

$$\Delta p'_{wf} = \frac{d\Delta p_{wf}}{d \ln \Delta t} = \Delta t \frac{d}{dt}(\Delta p_{wf}). \tag{78}$$

as a function of time.

Our approach is in the context of reservoir simulation and the transient analysis of pressure tests. We know that from the pressure values, it is possible to determine some reservoir properties, useful for planning the completion of the well or the reservoir depletion plan. In addition to the well-reservoir coupling model of Peaceman [26], considering a steady-state flow, three extensions were implemented, assuming a transient flow regime. In all simulations, we stipulate that $\Delta x = \Delta y$ and $k_x = k_y = k_z = k$.

### 5.1. Model 1

It is the conventional model of Peaceman [26], where we assume a steady-state flow and whose productivity index and the equivalent radius considered are, respectively, given by

$$J_w = \frac{2\pi k \Delta z}{B\mu \ln\left(\frac{r_{eq}}{r_w}\right)} \tag{79}$$

and

$$r_{eq} = 0.198 \Delta x. \tag{80}$$

### 5.2. Model 2

Peaceman [26] also proposed this model. However, it considers that the flow is transient in the cells containing the well. The productivity index is the same as for Model 1, although the equivalent radius incorporates the transient effects:

$$J_w = \frac{2\pi k \Delta z}{B\mu \ln\left(\frac{r_{eq}}{r_w}\right)} \tag{81}$$

where

$$r_{eq} = [4t_D \exp(-\lambda - 4\pi p_D)]^{1/2}\Delta x, \tag{82}$$

$\lambda = \exp(0.57722)$, $0.57722$ is Euler's constant,

$$t_D = \left(\frac{k}{\phi \mu c_t \Delta x^2}\right)t, \tag{83}$$

$$p_D = -\left(\frac{k\Delta z}{q_{sc}B\mu}\right)(p_{ini} - p_{i,j,k}), \tag{84}$$

and we use here the criterion provided, based on $t_{DA}$, to shift the calculation of the equivalent radius (we do not update $r_{eq}$ when border effects occur).

### 5.3. Model 3

Blanc et al. [9] originally proposed this model, and it employs a transient productivity index. Nevertheless, the equivalent radius proposed by Peaceman [26], for the steady-state flow (Model 1), is applied

$$J_{TWI} = \frac{4\pi k \Delta z}{\mu B \left[ E_1 \left( \frac{\phi \mu c_t r_w^2}{4kt} \right) - E_1 \left( \frac{\phi c_t \mu r_{eq}^2}{4kt} \right) \right]} \quad (85)$$

where

$$r_{eq} = 0.198 \Delta x. \quad (86)$$

### 5.4. Model 4

In this well-reservoir coupling model, we consider the incorporation of transient effects in the productivity index and the equivalent radius [2, 9]. The productivity index is the same as that defined in Model 3, and we calculate the equivalent transient radius using the Newton-Raphson method. Thus, we have:

$$J_{TWI} = \frac{4\pi k \Delta z}{\mu B \left[ E_1 \left( \frac{\phi \mu c_t r_w^2}{4kt} \right) - E_1 \left( \frac{\phi c_t \mu r_{eq}^2}{4kt} \right) \right]} \quad (87)$$

knowing that

$$r_{eq_{n+1}} = r_{eq_n} - \frac{f(r_{eq_n})}{f'(r_{eq_n})}, \quad (88)$$

and

$$f(r_{eq_n}) = -\frac{q_{sc} B \mu}{4\pi \Delta z k} E_1 \left[ \frac{r_{eq_n}^2}{4 \left( \frac{k}{\phi \mu c_t} \right) t} \right] - \Delta p. \quad (89)$$

The criterion based on Eq. (77) is also applied to interrupt the update of the transient equivalent radius.

Many analytical approaches to evaluate $E_1(u)$ have appeared in the literature. Tseng and Lee [38] provide an excellent survey on the subject. Note that there is no single analytical approximation that is valid for the entire range for $u > 0$. Tseng and Lee [38] claim that different methods are suitable for approximating $E_1(u)$ for a wide range of $u$ values. Nevertheless, in practical applications, we often do not have only a single calculation method that covers the entire range of interest [8].

In this work, as we are interested in the shortest times and flows that may have low permeabilities

and high viscosities, using power series to approximate the exponential integrals $E_i$ is not suitable for us. Therefore, we chose the approximation of the exponential integral $E_1(x)$ suggested by Segletes [34], based on a polynomial fit [31]. It is not our knowledge that others have done this previously.

### 5.5. Analytical solution and mesh refinement

Now, we compare the results obtained with the different models of well-reservoir coupling. Table 1 contains the parameters used in the construction of the standard simulation case. Unless when explicitly mentioned, the data in this table are those used in all simulations performed.

Table 1: *Parameters for standard simulation.*

| Parameter | Value | Unit |
|---|---|---|
| $B^0$ | 1.3 | RB/STB |
| $c_o$ | $4 \times 10^{-6}$ | psi$^{-1}$ |
| $c_\mu$ | $2 \times 10^{-6}$ | psi$^{-1}$ |
| $c_\phi$ | $3 \times 10^{-6}$ | psi$^{-1}$ |
| $k_x$, $k_y$ and $k_z$ | $1 \times 10^{-2}$ | Darcy |
| $L_x$ | 10,000 | ft |
| $L_y$ | 10,000 | ft |
| $L_z$ | 80 | ft |
| $L_{wf}$ | 80 | ft |
| $n_x$ | 81 | – |
| $n_y$ | 81 | – |
| $n_z$ | 5 | – |
| $p_{ini}$ | 8,000 | psi |
| $p^0$ | 8,000 | psi |
| $Q_{sc}$ | -400 | STB/day |
| $r_w$ | 0.2 | ft |
| $tol$ | $1 \times 10^{-6}$ | psi |
| $t_{max}$ | 730 | day |
| $\delta_{\Delta t}$ | 1.2 | – |
| $\Delta t_{ini}$ | $1 \times 10^{-5}$ | day |
| $\Delta t_{max}$ | 10 | day |
| $\mu$ | 1.1 | cp |
| $\rho$ | 52.4 | lb/ft$^3$ |
| $\phi$ | 0.2 | – |
| $\phi^0$ | 0.2 | – |

In this table, $L_{wf}$ is the length of the producing well, $t_{max}$ represents the maximum production time, $\delta_{\Delta t}$ is the factor used to vary the time increment ($\Delta t^{n+1} = \delta_{\Delta t} \Delta t^n$), and $\Delta t_{ini}$ and $\Delta t_{max}$ are the initial

and maximum values of the time increment, respectively.

Here, the results show the pressure curves in the well, the pressure drop, and the Bourdet derivative [11, 10] as a function of the elapsed production time.

The first test performed was done to compare results from well-reservoir coupling models with an analytical solution for the particular case of constant viscosity and formation volume factor. Figures 3 and 4 show comparisons of the results obtained with Models 1 and 4, using the standard set of parameters for the simulations, with the results obtained with the analytical solution given by Ozkan [25].

It should be made clear that the analytical solution, as already said, makes use of simplifying assumptions, such as $B$ and $\mu$ constants. Besides, we must apply a numerical procedure to obtain the analytical solution, which depends on the evaluation of functions of Bessel [24] and numerical inversion of Laplace transform [25], performed using the Stehfest algorithm [36]. Therefore, the results for the analytical solution are not available in the entire range of numerical results. Even so, it is possible to observe that the results are in good agreement with the numerical results obtained using Model 4. On the other hand, we note a deviation when there is a comparison with Model 1 (Fig. 3). When the border effects are present, the three solutions have very similar behaviors (about 250 days of production). Figure 4 corroborates the discussions about Fig. 3, and we see that the Bourdet derivative highlights the difference in the behavior of the numerical solution and the effect of the numerical artifact due to the use of a constant equivalent radius ($r_{eq}$).

Also noteworthy is the qualitative similarity of the result obtained with the original technique of Peaceman [26] (Model 1) with the behavior of the pressure when there is physical storage in the well. Also, there is a discontinuity in the derivative curves corresponding to the transient and the pseudo-permanent regimes. It is due to the strategy employed to change the calculation of the equivalent radius. From these results, it is possible to conclude that the results of Model 4 present a behavior compatible with that expected for the real problem.

Aiming to compare the four well-reservoir coupling models that we implemented in this work, in Fig. 5,

we show the set of results for the pressure in the well. We can note the existence of a plateau in the curve obtained with Model 1 for the initial production times. For the standard case, this plateau (numerical storage) lasts approximately one day of production, interfering in the pressure response, reaching a difference of about 33 psi for the same time when compared to the Model 4 (in principle, the most correct). Regarding the models that incorporate the transient effects in the equivalent radius, Models 2 [26] and 4, we observe that we obtained better results with these models (superimposed in Fig. 5) in comparison with those based on the steady-state flow assumption. Besides that, in the initial instants of production, the numerical artifact no longer appears, and we correctly capture the expected flow regimes. However, according to Blanc et al. [9], the results of Model 2 are not always as favorable as those obtained here. For example, it can happen if we vary the reservoir and fluid properties.

Given the results obtained with Model 3 (Fig. 5), it is possible to observe the numerical artifact occurring. However, with less intensity than that of Model 1, and we do not perceive it when the production begins. It appears approximately 15 minutes after the beginning of the production. Nevertheless, after about one day, the results show behavior consistent with those of Models 2 and 4. We should remark that the results of Model 3 are in line with that reported by Blanc et al. [9]. On the other hand, in Model 4, when we incorporate transient effects in both productivity index and equivalent radius, the numerical artifact does not exist anymore, and the results are physically correct for the entire production duration. For the four models, we capture the border effect when we reach a time of approximately 250 days of production. Among the four models, we can say that Models 2 and 4 were the ones that presented the best results considering the transient flow regime. Finally, we should stress that the behavior of Model 4 results is also in line with those reported by Blanc et al. [9].

Furthermore, we also carried out a mesh refinement study using Models 1 and 4 that take into account the transient effects of flow. Table 2 shows the number of cells that we used in the generation of the different meshes that we employed in the mesh refinement study. Here, $n_x$, $n_y$, and $n_z$ are the number of cells used to discretize the oil reservoir in the $x$-, $y$- and $z$- directions, respectively.
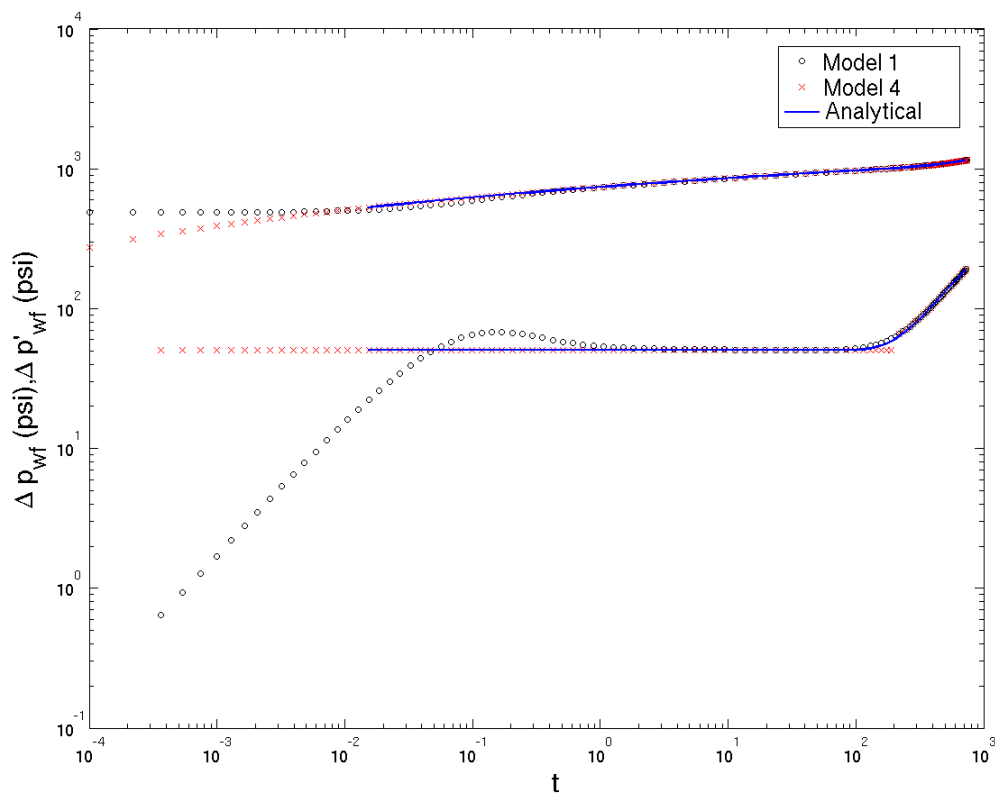
Fig. 3: *Comparison of the results of Models 1 and 4 with the analytical solution. Specialized plot.*
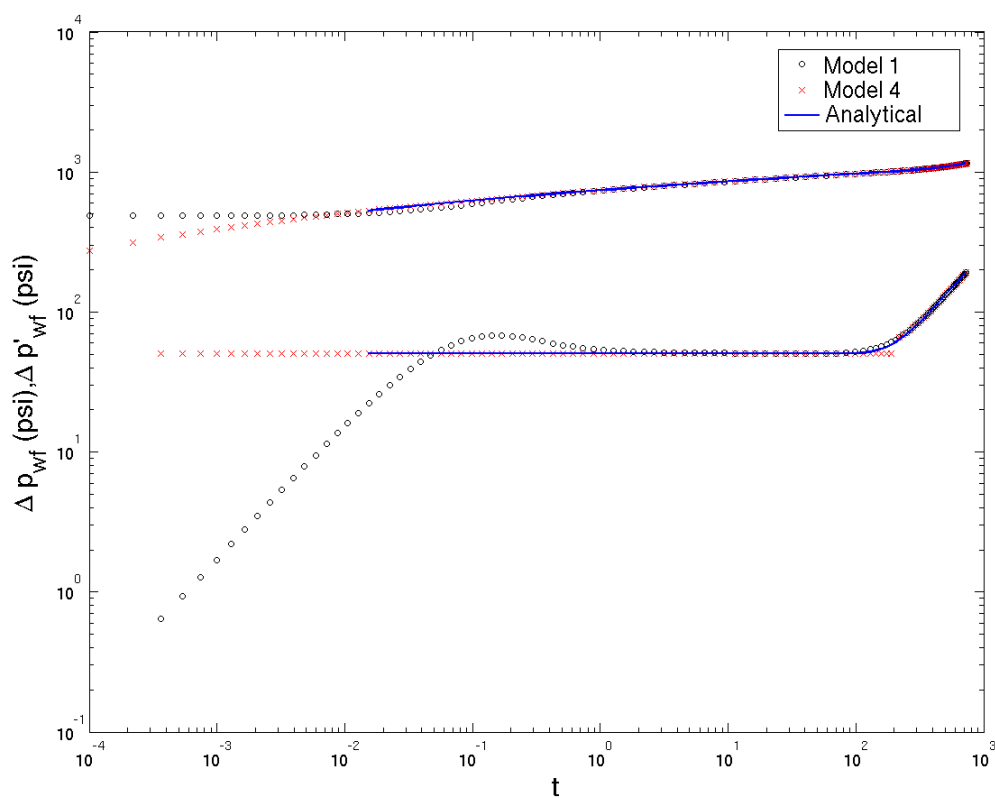


Fig. 4: *Comparison of the results of Models 1 and 4 with the analytical solution. Diagnostic plot.*
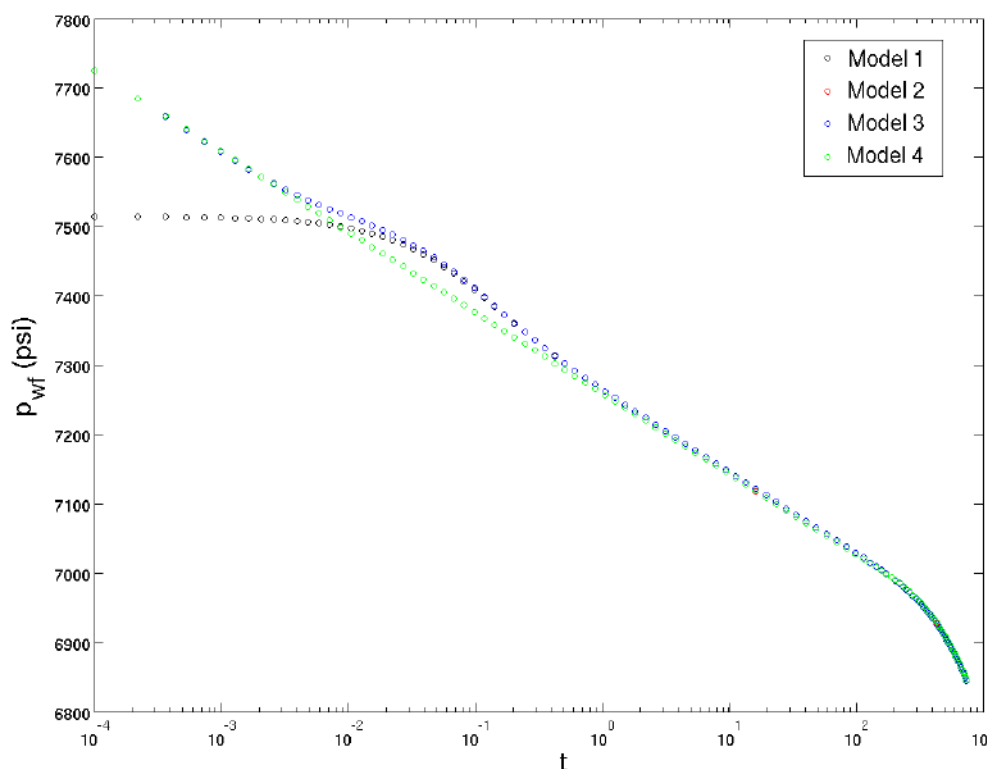
Fig. 5: *Comparison of the results of the four well-reservoir coupling models.*

We can see the results, well pressure as a function of time, in Figs. 6 and 7.

Table 2: *Meshes.*

| Mesh | $n_x$ | $n_y$ | $n_z$ |
|------|-------|-------|-------|
| 1 | 11 | 11 | 5 |
| 2 | 21 | 21 | 5 |
| 3 | 41 | 41 | 5 |
| 4 | 81 | 81 | 5 |
| 5 | 161 | 161 | 5 |

For Model 1, it was possible to observe a numerical convergence as we refine the mesh. Except for the initial moments, where the solutions are quite different. We can also realize that the mesh refinement influences the magnitude of the numerical artifact, since the more refined the mesh, the smaller the storage phenomenon. For example, for Mesh 1 ($n_x=n_y=11$), we noted that the numerical artifact lasted approximately 30 days, while for Mesh 5 ($n_x=n_y=161$) the duration was about 0.1 days.

On the other hand, we did not observe the same behavior when we used Model 4 (Fig. 7), which incor-

porates the transient effects. In this case, the pressure variation presents a behavior compatible with that of real fluid flow in an oil reservoir. Although the results are practically overlapping, for all meshes and time, including the border effects, numerical convergence did not occur in a similar way to that of Model 1. However, the difference between the values is small, and we cannot see it in the graph. It is worth pointing out that the same issue was reported in the literature [1, 2], indicating a possible loss of accuracy when we utilize very refined meshes. However, this is still an open problem. Another important conclusion that we can draw is the fact that we can use less refined meshes, because the difference between the pressure values, obtained with more refined meshes, is almost imperceptible. Therefore, this fact implies less computational effort.

We also analyzed the influence, on well pressure variation, of the growth rate of the time step in the well-reservoir coupling for Model 4. We obtained the results considering three different values of the growth rate of the time step, $\delta_{\Delta t}=1.15$, 1.20, and 1.25. We show the results in Figs. 8 and 9, for the pressure in the well, the pressure drop, and the derivative of the
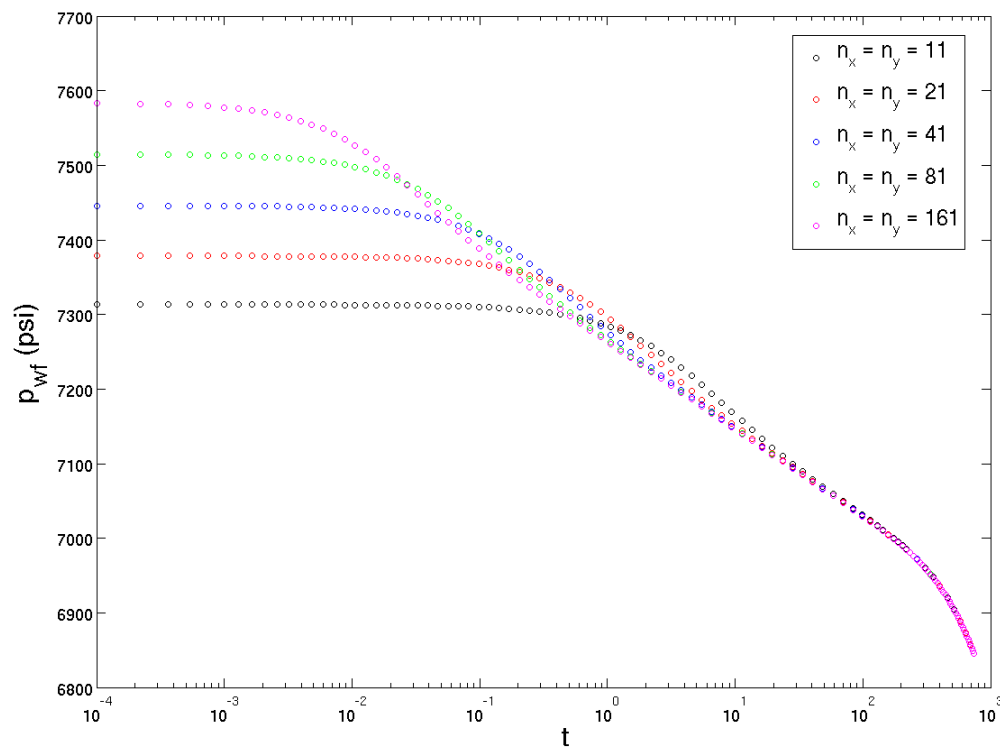
Fig. 6: *Result of mesh refinement for Model 1.*
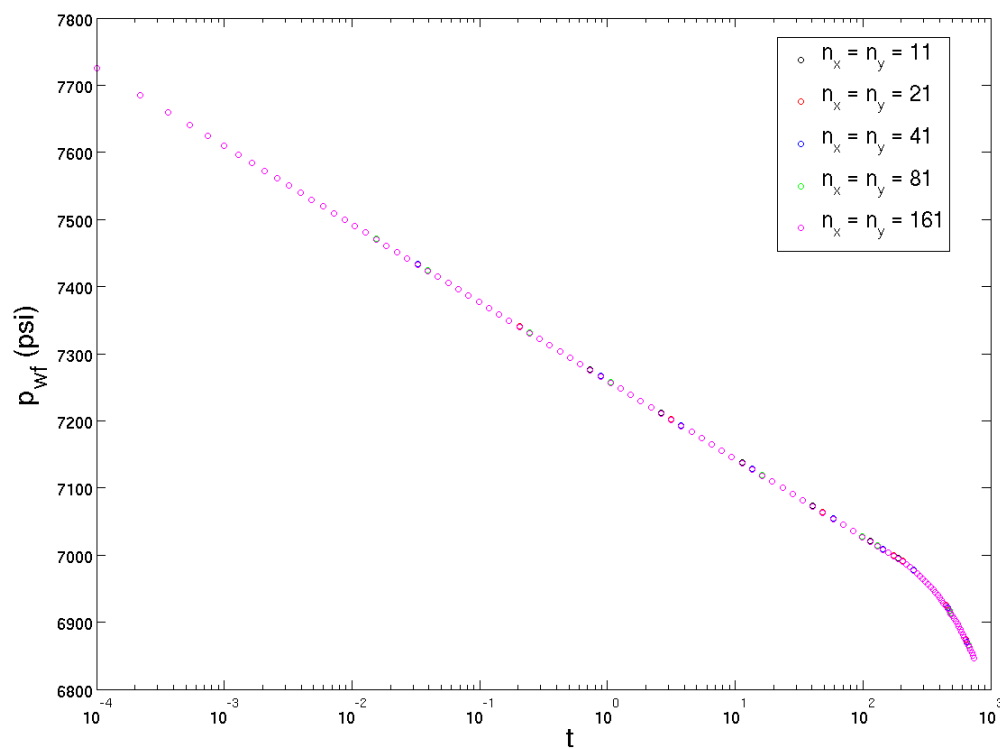


Fig. 7: *Result of mesh refinement for Model 4.*

pressure drop. For all the values, we noticed that the results are practically the same. Furthermore, they coincide throughout all simulation time and present the behavior expected for this type of flow. That is, for the single-phase flow of oil in a reservoir containing a vertical producer well.

### 5.6.   Low permeability and high viscosity

We also performed other simulations varying the permeability and viscosity. However, we employed lower values for permeability and higher for viscosity. In this study, we only considered Models 1 and 4 and specialized plots. We did a more detailed analysis to compare the two well-reservoir coupling models, for these permeability and viscosity values, to understand how the choice of the model may impact the results when the numerical artifact is more significant. We considered a total production time of 80 days and a prescribed flow ($q_{sc}$) of -100 STB/day. This approach aims to deal with situations closer to those of unconventional reservoirs. This type of study has become a trend more recently, and, in general, the effect of numerical storage tends to be more pronounced.

For the model of Peaceman [26] (Model 1), it is possible to observe that the permeability value directly influences the magnitude of the numerical artifact in the initial moments. The higher the permeability, the smaller the size of the artifact (Fig. 10). It is physically consistent because when the permeability is higher, the lower the flow resistance in the porous medium. Therefore, it reaches the transient regime in the porous medium more quickly, as well as for border effects. It is worth noting that since permeability has a value considered low for this model of a well-reservoir system, the numerical artifact has a longer duration. Thus, if we intend to study the phenomena that occur in the initial moments (or even for longer times) with this model, the results will not be accurate.

As an illustration, in Fig. 10, for the lowest permeability ($k$=0.25×10$^{-3}$ Darcy), the numerical artifact impacted almost all results. The pressure difference, comparing the two models, was 376 psi at $t$=2 days of production and 54.6 psi at $t$=70 days. For $k$=1.00×10$^{-3}$ Darcy, the magnitude of the numerical artifact was smaller, but not negligible since, after 0.6 and 19 days of production, there was a pressure difference of about 94 and 10 psi, respectively.

It was also possible to observe that for these low values of permeability, besides the duration of the numerical artifact being longer, in some cases, it was not possible to capture the border effects. It is relevant in the context of the analysis of pressure tests, as it indicates the real need for long-duration tests when it is necessary to determine boundary effects. We know that it is due to the great difficulty of the fluid to flow through the porous medium and, therefore, it will take longer to perceive the reservoir boundary effects (Fig. 10). Therefore, we can conclude that the transient well-reservoir coupling model presented the best results since we were able to prevent the appearance of the numerical artifact. Besides that, the use of the expression of Segletes [34] to calculate $E_1$ allows us to obtain results in a range in which other formulas failed.

Contrary to what happens for the permeability variation, for the conventional model [26] (Model 1), the numerical artifact has a longer duration and magnitude as the viscosity increases (Fig. 11). Therefore, the time of occurrence and the magnitude of the artifact vary depending on the viscosity. Outside the region associated with the numerical artifact, the behavior of the results of the conventional model qualitatively tends to be physically correct. Also, we know that border effects occur more quickly for lower viscosity values. Regardless, we did not detect the boundary effects for any of the viscosity values proposed in our test.

## VI.   CONCLUSION

The objective of this work was to implement a model for the transient well-reservoir coupling in a reservoir simulator to correctly describe the pressure behavior in the well in the initial production times. We also investigated the effects of the mesh refinement and the size of the time step on the results.

As well known, the traditional well-reservoir coupling model of Peaceman [26] is still widely used nowadays. However, we saw that it has a flaw that leads to numerical storage at the beginning of the simulation. Nevertheless, it is simple, and we can correctly determine the wellbore pressure in a wide range of applications except for the initial instants of production. We must also emphasize that we were able to detect the border effects with this technique, without the need for a specific criterion to change the calculation of the equivalent radius.
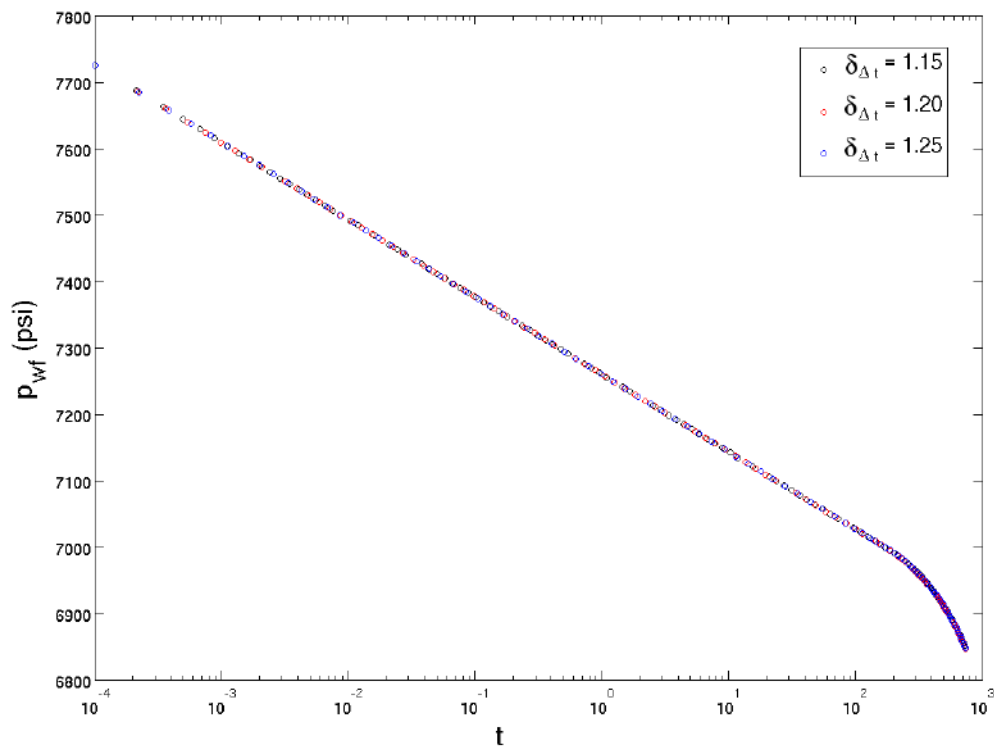
Fig. 8: *Results for different $\delta_{\Delta t}$ growth ratios. Specialized plot.*
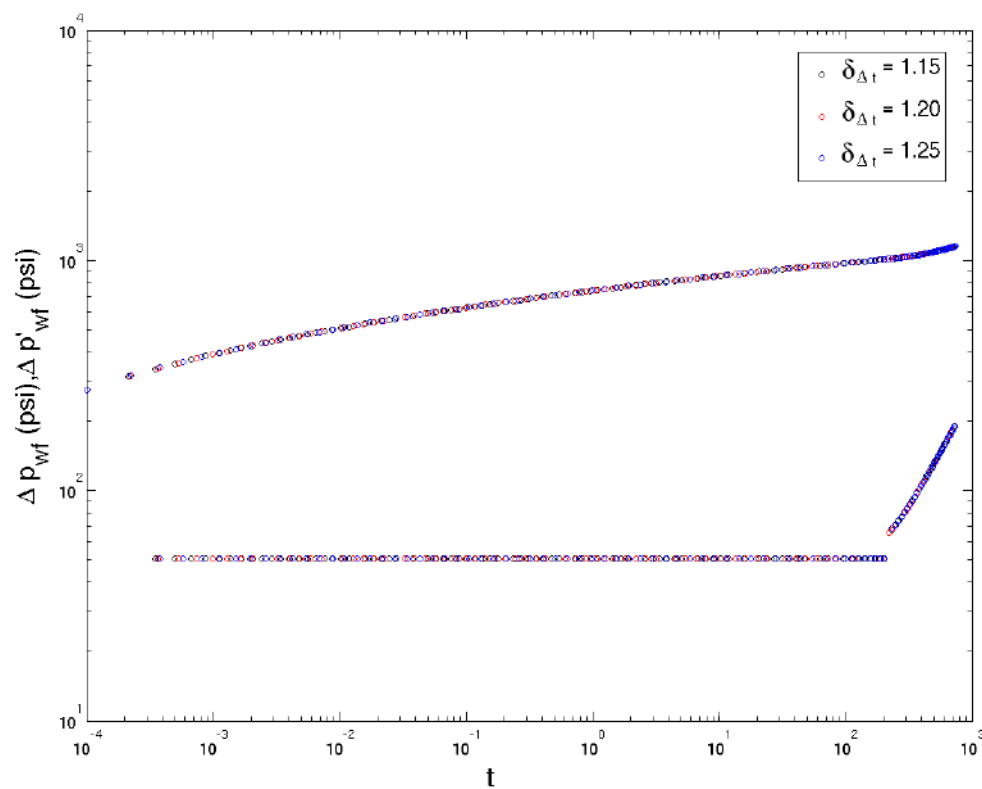


Fig. 9: *Results for different $\delta_{\Delta t}$ growth ratios. Diagnostic plot.*
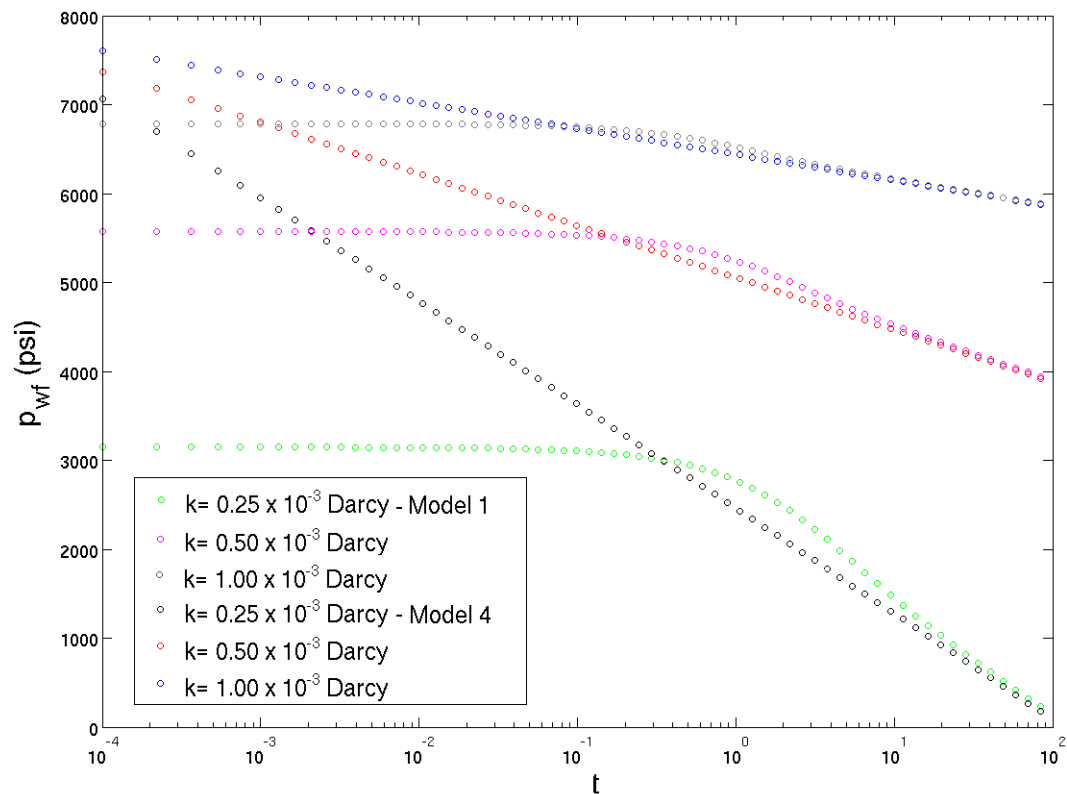
Fig. 10: *Results for different low permeabilities. Specialized plot.*
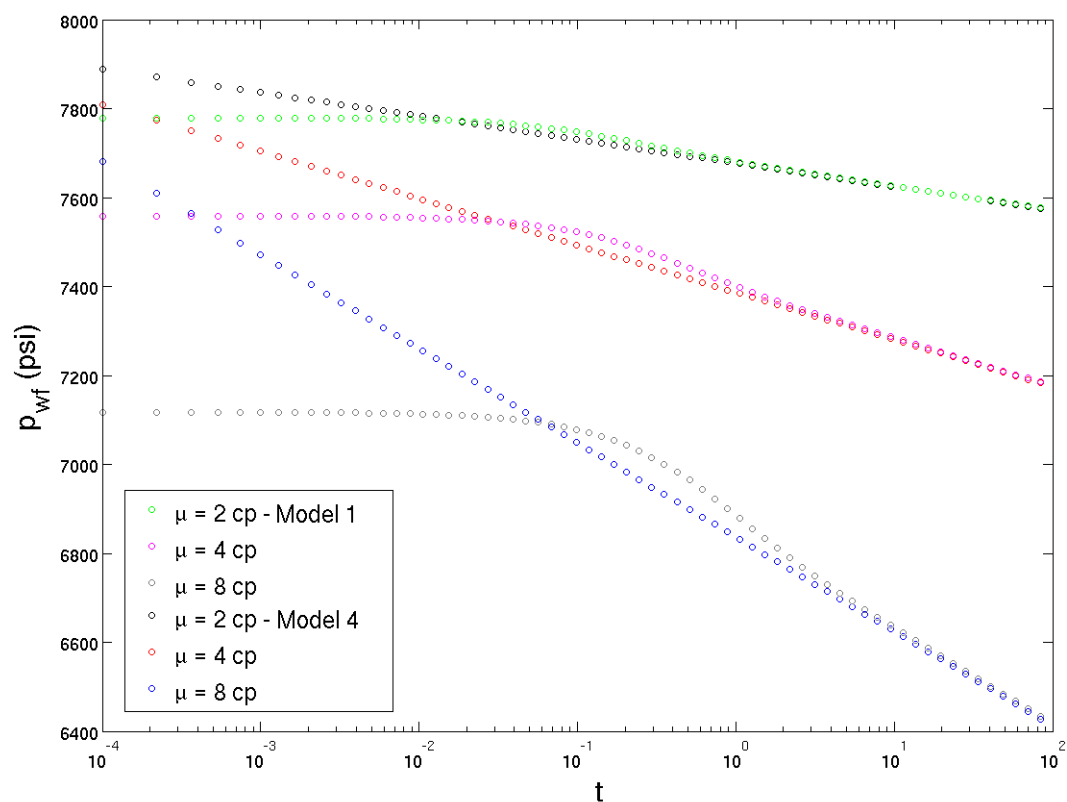


Fig. 11: *Results for different high viscosities. Specialized plot.*

In addition to physical properties, the numerical artifact is also affected by mesh refinement. The refinement can be used, in some cases, to mitigate the non-physical storage, but it leads to an increase in computational cost. On the other hand, despite the qualitatively and quantitatively correct results that we obtained with Model 4, its numerical convergence must be better understood, as already pointed out by other authors. However, this is not a big problem, because we have not to use refined computational meshes when considering Model 4, as we could see in this work. Nevertheless, this issue deserves further studies.

We must also stress that the use of the expression proposed by Segletes [34] to calculate the exponential integral, allowed us to consider flows with low permeabilities, high viscosities, and short production time. Sometimes, this is not possible when we apply other expressions available in the literature.

## REFERENCES

[1] Aguilar, C., Ozkan, E., Kazemi, H., AL-KOBAISI, M., and Ramirez, B. A. (2007). Transient behavior of multilateral wells in numerical models: A hybrid analytical-numerical approach. Society of Petroleum Engineers Middle East Oil and Gas Show and Conference, Paper SPE 104581-MS.

[2] Al-Mohannadi, N., Ozkan, E., and Kazemi, H. (2007). Grid-system requirements in numerical modeling of pressure-transient tests in horizontal wells. *Society of Petroleum Engineers Journal, Paper SPE 92041-PA*, 10(2):122–131.

[3] Aziz, M. and Settari, A. (1990). *Petroleum Reservoir Simulation*. Elsevier Applied Science, New York, USA.

[4] Babu, D. K., Odeh, A. S., Al-Khalifa, A. J., and McCann, R. C. (1991a). Numerical simulation of horizontal wells. Bahrain. Society of Petroleum Engineers Annual Technical Conference and Exhibition, 16-19 November, Paper SPE 21425.

[5] Babu, D. K., Odeh, A. S., Al-Khalifa, A. J., and McCann, R. C. (1991b). The relation between wellblock and wellbore pressures in numerical simulation of horizontal wells. *Society of Petroleum Engineers Reservoir Engineering, Paper SPE 20161*, 6(3):324–328.

[6] Babu, D. K., Odeh, A. S., Al-Khalifa, A. J., and McCann, R. C. (1991c). Supplement to paper SPE 20161, The relation between wellblock and wellbore pressure in numerical simulation of horizontal wells – General formulas for arbitrary well locations in grids. *Society of Petroleum Engineers Journal, Paper SPE 23525*.

[7] Barrett, R., Berry, M., Chan, T., Demmel, J., Donato, J., Dongarra, J., Eijkhout, V., Pozo, R., Romine, C., and Vorst, H. (2006). *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*.

[8] Barry, D. A., Parlange, J. Y., and Li, L. (2000). Approximation for the exponential integral (Theis well function). *Journal of Hydrology*, 227(1):287–291.

[9] Blanc, G., Ding, D., Ene, A., Estebenet, T., and Ranhon, D. (1999). Transient productivity index for numerical well test simulations. *Reservoir Characterization-Recent Advances, R. Schatzinger and J. Jordan, eds.*, pages 163–174.

[10] Bourdet, D. (2002). *Well Test Analysis: the use of advanced interpretation models*. Elsevier, Amsterdam, The Netherlands.

[11] Bourdet, D., Ayoub, J. A., and Pirard, Y. (1989). Use of pressure derivative in well test interpretation. *Society of Petroleum Engineers Formation Evaluation*, 4(2):293–302.

[12] Chaudhry, A. U. (2004). *Oil Well Testing Handbook*. Elsevier, Burlington, USA.

[13] Chen, Z. and Youqian, Z. (2009). Well flow models for various numerical methods. *International Journal of Numerical Analysis and Modeling*, 6(3):375–388.

[14] Craft, B. and Hawkins, M. (1991). *Applied petroleum reservoir engineering*. Englewood Cliffs, NJ:. Prentice Hall,.

[15] Darcy, H. (1856). *Les fontaines publiques de la ville de Dijon. Exposition et application des principes à suivre et des formules à employer dans les questions de distribution d'eau*. Victor Dalmont.

[16] Dumkwu, F., Akand, I., and Carlson, E. S. (2012). Review of well models and assessment of their

impacts on numerical reservoir simulation performance. *Journal of Petroleum Science and Engineering*, pages 174–186.

[17] Ertekin, T., Abou-Kassem, J., and King, G. (2001). *Basic Applied Reservoir Simulation*. Society of Petroleum Engineers, Richardson, USA.

[18] Hawkins Jr., M. F. (1956). A note on the skin effect. *Journal of Petroleum Technology, Trans., AIME*, 8(12):65–66.

[19] Hestenes, M. and Stiefel, E. (1950). Methods of conjugate gradients for solving linear systems. *Journal of Research of the National Bureau of Standards*, 49(6):409–436.

[20] Horne, R. N. (1990). *Modern Well Test Analysis*. Petroway, Inc., Palo Alto, USA.

[21] Millikan, C. V., Sidwell, V., et al. (1931). Bottom-hole pressures in oil wells. *Transactions of the AIME*, 92(01):194–205.

[22] Mochizuki, S. (1995). Well productivity for arbitrary inclined well. San Antonio, Texas, USA. Society of Petroleum Engineers Reservoir Simulation Symposium, 12-15 February, Paper SPE 29133 MS.

[23] Mrosovsky, I. (1978). Discussion of paper SPE 6893, Interpretation of Well-Block Pressures in Numerical Reservoir Simulation. *Society of Petroleum Engineers Journal, Paper SPE 6988*, 18(3):1–5.

[24] Olver, F. W. J. (2010). *NIST handbook of mathematical functions*. Cambridge University Press.

[25] Ozkan, E. (2008). *Applied Mathematics of Fluid Flow in Porous Media*.

[26] Peaceman, D. (1978). Interpretation of well-block pressures in numerical reservoir simulation. *Society of Petroleum Engineers Journal*, 18(3):183–194.

[27] Peaceman, D. W. (1983). Interpretation of well-block pressures in numerical reservoir simulation with nonsquare grid blocks and anisotropic permeability. *Society of Petroleum Engineers Journal, Paper SPE 10528*, 23(3):531–543.

[28] Peaceman, D. W. (1990). Interpretation of well-block pressures in numerical reservoir simulation: Part 3 – off-center and multiple wells within a well-block. *Society of Petroleum Engineers Reservoir Engineering, Paper SPE 16976*, 5(2):227–232.

[29] Peaceman, D. W. (1993). Representation of a horizontal well in numerical reservoir simulation. *Society of Petroleum Engineers Advanced Technology Series, Paper SPE 21217-PA*, 1(1):7–16.

[30] Rosa, A., Carvalho, R., and Xavier, J. (2006). *Engenharia de reservatórios de petróleo*. Interciência.

[31] Rosário, R. C. D. (2016). Simulação Numérica de Reservatórios de Óleo Incoporando Efeitos Transientes no Índice de Produtividade. Master's thesis, Universidade do Estado do Rio de Janeiro, Nova Friburgo, Brazil. In Portuguese.

[32] Saad, Y. (2003). *Iterative Methods for Sparse Linear Systems*. SIAM, Philadelphia, 2 edition.

[33] Sclater, K. C., Stephenson, B. R., et al. (1929). Measurements of original pressure, temperature and gas-oil ratio in oil sands. *Transactions of the AIME*, 82(01):119–136.

[34] Segletes, S. B. (1998). A compact analytical fit to the exponential integral $E_1(x)$. Technical report, DTIC Document.

[35] Souza, G. (2013). *Acoplamento Poço-reservatório na Simulação Numérica de Reservatórios de Gás*. PhD thesis, Universidade Estadual do Norte Fluminense. In Portuguese.

[36] Stehfest, H. (1970). Numerical inversion of Laplace transforms. *Communications ACM*, 13(1):47–49.

[37] Theis, C. V. (1935). The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage. *Eos, Transactions American Geophysical Union*, 16(2):519–524.

[38] Tseng, P. H. and Lee, T. C. (1998). Numerical evaluation of exponential integral: Theis well function approximation. *Journal of hydrology*, 205(1):38–51.

[39] Van, Poollen, H. K., Breitenbach, E. A., and Thurnau, D. H. (1968). Treatment of individual wells and grids in reservoir modeling. *Society of Petroleum Engineers Journal, Paper SPE 2022-PA*, 8(4):341–346.

[40] Whitaker, S. (1986). Flow in porous media I: A theoretical derivation of Darcy's Law. *Transport in Porous Media*, 1(1):3–25.

[41] Whitaker, S. (1999). *The Method of Volume Averaging*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

# Qualitative and Quantitative Videofluoroscopic Analysis of Basic Temporomandibular Movements

Ricardo De Bonis[1], Sergio A. L. de Souza[2], Hilton Koch[3], Milton Costa[4]

[1,2,3]Department of Radiology, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil
[4]Biomedical Sciences Institute, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

*Abstract— Background: The temporomandibular joint (TMJ) is a synovial condylar articulation with freedom of movement resulting from bilateral side morphological interrelations. Its basics movements to attend its main function are rotation and translation.*

*Material and Methods: A videofluoroscopic study of the left posterior oblique incidence comprising 23 healthy volunteers of both sexes was conducted to qualify and quantify the displacement of the mandible over the temporal surface. This evaluation was performed without using any artificial contrast medium.*

*Results: From maximum occlusion to maximum mouth opening, three spaces defined as LL1, LL2 and LL3 were established and used to qualify and quantify the limits of mouth opening. Seventeen volunteers could be classified as normal free (NF) and six as suspicious (S) based on this function.*

*Conclusion: The NF and S groups statistically differed in their mouth opening capabilities (p < 0.0001). Measured values for LL3 greater than LL2 as well as positive values for L3-L2 can be considered NF and negative values for L3-L2 can be considered S with a significance of p < 0.0001. L2 was statistically confirmed as a good parameter for the distinction between normal and suspicious TMJ functioning.*

*Keywords— temperomandibular joint, pterygoid muscles, temporal bone.*

## I. BACKGROUND

The temporomandibular joint (TMJ) is classified morphologically as a synovial condylar articulation, wherein one side interferes with the other, allowing interdependent articulation [1,2]. In theory, the condylar morphology and interdependence [3] may limit its movement pertaining to the opening and closing of the mouth. However, the dynamics of the TMJs allow freedom of movement beyond typical condylar movements. Beside the basic functions of rotation and translation, the jaw is also able to protrude, retract and move laterally both sides owing to spherical articulation to facilitate chewing [4,5,6].

The freedom of movement of TMJ results in bilateral morphological interrelation of the temporal articular surface (temporal fossa and tubercle) with the condyloid process of the jaw and fundamental articular disc interposition [7]. In the resting position, the free interocclusal space, a point at the centre of the condyloid process, is located near the middle projection of the temporal fossa [8], and during mouth opening, the condyloid process moves over the temporal tubercle until an unknown limit. In general, maximum mouth opening is evaluated by measuring the space between the superior and inferior tooth arcade with a ruler [9], a pachymeter [10], or the fingers [11] using the occlusal surface of the right superior and inferior incisors as a reference [10]. This inconsistent methodology suggests that the maximum normal mouth opening varies between 45 and that 60 mm in a normal adult and values <40 mm are indicative of pathology [12]. However, values between 40 and 45 mm, independent of sex, are considered the normal maximum limit of mouth opening [13].

The contract action of the chewing muscles, is the responsible for the displacement of the condyloid process in

all directions. However, the lateral pterygoid muscles (LPMs) are primarily responsible for mouth opening through two basic movements: rotation and translation [14,15]. Rotation refers to the displacement of the condyloid process into the mandibular fossa of the temporal bone from the centric occlusion until a functional rest position, and translation, which occurs following rotation, is the projection of the condyloid process over the temporal tubercle. Only after the initiation of translation, it is possible for the TMJ to freely produce other movements during chewing.

Into the temporal fossa, the condyloid process cannot achieve free displacement, possibly because of mechanical impairment. Over temporal tubercle, without mechanical impairment, the condyloid process, which is covered by the articular disc, is able to produce all chewing movements in association with the action of other muscles [16,17].

The LPMs have a biceps morphology where the superior and inferior heads function synergistically in three functional directions acting over the jaw in a sequential traction to open the mouth [18,19]. Jaw movement during mouth opening is initiated by the superior head of LPM, which moves the condyloid process forward and upward that leads to an impact on the inferior disc medial concavity, thereby generating a condyle-disc unit, which remains affected during the entire duration of the jaw being displaced. From this time, the intermediate muscular fascicles of both heads of LPM tract the condyle-disc unit forward and in sequence based on the inferior and more strong fascicle of LPM that tracts the condyle-disc unit forward and downward, which determines jaw displacement and consequent mouth opening. In this manner, mouth opening results from three vectorial-associated actions produced by sequential contraction of the LPM heads [20-23].

The temporomandibular morphofunctional disarrangement (TMD) can be defined as 'with reduction' or 'without reduction', which reinforces the functional concept of this articulation described above. In TMD with reduction, the condyle-disc unit is displaced forward because of its dysfunction, which allows the disc to escape the posterior direction by traction produced by the elastic bi-laminar zone. In TMD without reduction, the disc usually goes ahead of the condyloid process, which impairs normal mouth opening because of the limited space occupation by the disc. Sometime this condition can produce condyloid process impactation over the disc atypically posicioned [2,5,23,24].

Because there is no simple clinical method to evaluate TMJ dysfunction, a comprehensive evaluation is necessary to more clearly elucidate normal and abnormal mechanisms. The videofluoroscopic method is useful to evaluate normal and pathologic dynamics of TMJ with reasonable quality. This radiological method involves low-level X radiation, allowing dynamic measurements in the magnetic media. The analysis and re-analysis of registered dynamics phenomena are the advantages of this method [25-27].

The dysfunction of TMJ, among another problems, produces headache, dizziness and tinnitus, which compromises the quality of life of about 40% of the world population [5,23]. Videofluoroscopic evaluation is a useful method for imaging examinations in TMJ studies and does not required the injection of contrast agents [2].

The objective of this study was to establish, via a videofluoroscopic method, a qualitative pattern of basic TMJ dynamics and to generate quantitative values of functional mouth opening throughout the displacement of the intra-articular condyloid process. This dynamic in TMJ articulation can be non-invasively assessed without using additional contrast agents with a method that is suitable even in non-sophisticated medical centres.

## II. MATERIALS AND METHODS

TMJ dynamics were observed by the videofluoroscopic method in 23 volunteers (18 females, 5 males and age range, 19–51 years) who were self-declared as healthy with respect to chewing and swallowing. All volunteers underwent clinical evaluations to observe the structural and functional integrity of the dental arcades, freedom of movements of TMJ and tonus and sensibility of the chewing muscles. Complaints and alterations during the clinical evaluation were not considered sufficient to exclude any of the volunteers.

The videofluoroscopic evaluations were performed in a seated position on a specially equipped chair [28] fitted with radiologic equipment (BV-22 C-Arm, 100 KV, 25 mA, Phillips Corporation, Hanover, MD, USA) and a B/W Progressive Scan CCD Remote Head Video Camera (Mythos, 400 resolution lines, $31 \times 31$, 0.1 lux, f 3.6 mm, Sony Corporation, Tokyo, Japan). The exams were registered in digital media using a DVD recorder (DVDR3455H HDD & DVD Player/Recorder, Phillips Corporation).

The videofluoroscopic images of the left posterior oblique (LPO) incidence were captured over about $15^0$ degrees, as

estimated from a coupled protractor over the specially equipped chair. The contrasts registered in the obtained images were because of regional densities. No other type of contrast was used.

TMJ dynamics were assessed throughout rotation and translation of the condyloid process over the articular surface of the temporal bone (fossa and temporal tubercle) obtained by requesting mouth opening movements. At least five mouth opening and closing movements from intercuspation (centric occlusion) to maximum opening were registered.

The displacement of the condyloid process over the articular temporal surface was measured in millimetres using Vidiomed software (1-16-9.2002, Multimedia Lab, Computer Centre Electronics, Federal University of Rio de Janeiro). This software was used to for the qualitative and quantitative assessment. An acrylic plate marked with radiopaque squares of $2 \times 2$ cm$^2$ was fixed over the left side of the face of each volunteer as a metric reference to calibrate the software.

Qualitative and quantitative analyses of rotation and translation during basics movements of TMJ were performed. The extent of condyloid process displacement was measured based on the selected images of the series. These selected DVD images were converted to MPEG-4 (Moving Picture Experts Group) using Adobe Premiere Pro CS5 5.5.2 software (Adobe Systems Incorporated, San Jose, CA, USA) and a personal computer (Pentium D 820, 2800 MHz, Intel Corporation, Santa Clara, CA, USA) with a Microsoft Windows system (Microsoft Corporation, Redmond, WA, USA).

The measured values were obtained from the maximum occlusion to maximum mouth opening produced after solicitation of the volunteers. As a pattern to analyse the condyloid process displacement over the temporal surface, a horizontal line (line H) was projected over the TMJ level and subdivided into three spaces, defined as LL1, LL2 and LL3 (Figure 1*)*
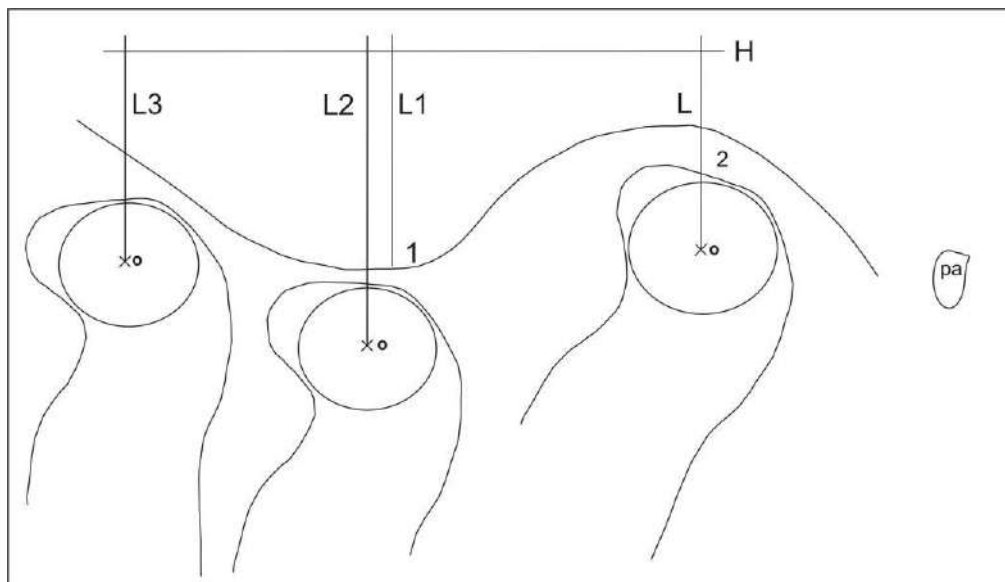


*Fig.1: Draw representing   the open mouse displacing with definitions of the points and lines  to be used to  quantify  TMJ displacement.*

LL1 represents the condyloid process displacement from line L (perpendicular from the mandibular condyle centre during the maximum occlusion position to line H) to line L1 (perpendicular from the temporal tubercle middle convexity to line H).

LL2 represents a displacement 5% in excess of LL1. Mouth opening until this individual point was considered to be an

indication of the adequate possibility of TMJ free chewing movements because the condyloid process is already liberated from the temporal fossa and can freely accomplish other chewing movements.

LL3 represents condylar displacement obtained by maximum mouth opening after the solicitation of volunteers. LL3 is the value in millimetres from line L to line L3 (perpendicular

from the mandibular condyle centre during maximum mouth opening to line H). Note that this value can be much larger or smaller than that of LL2.

A representation of displacement of mouth opening with definitions of the points and lines for quantification of TMJ displacement where pa = acustic porus, 1 = articular tubercle of the temporal bone, 2 = mandible fossa, 0 = mandibular condyle centre, H = horizontal line traced above the TMJ displacement surface, L = perpendicular line traced from the mandibular condyle centre, during the maximum occlusion position, to line H, L1 = perpendicular line traced from the temporal tubercle middle convexity to line H, L2 = perpendicular line traced to be 5% in excess of the LL1 value and L3 = perpendicular line traced from the mandibular condyle centre, during maximum mouth opening, to line H.

The methodology and purpose of the research as well as details of the videofluoroscopic study were fully explained to each volunteer. Written informed consent was obtained, and the study was performed in full compliance with the ethical tenets of the World Medical Association (WMA) Declaration of Helsinki, adopted by the 18th General Assembly, Finland, June 1964 and complemented by the 61a General Assembly of the WMA in Fortaleza, Brazil, 2012.

All statistical analysis were performed using the Mann–Whitney U test with GraphPad Prism version 4.00 (GraphPad Software, Inc., La Jolla, CA, USA). A probability ($p$) value of <0.05 was considered statistically significant.

## III. RESULTS

Anamnesis and physical evaluation of the stomatognathic system were performed for all 23 volunteers, preliminary self-declared to be healthy and without any chewing or swallowing dysfunction. Distinct abnormalities, not considered sufficient for exclusion, were observed by direct evaluation in 11 of the volunteers (2 males and 9 females and age range, 19–51 years). Complaints included discreet pain during maximum mouth opening, clicking of TMJ, pain during the deep palpation of the temporal muscle and parotideomasseteric region, teeth clenching and wear, absence of two teeth (first molar and canine), absence of one teeth (first molar or canine) and crossbite (Table 1).

| Table 1 - Functional and structural founds | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Clinical evaluation** | | | | | | | | | |
| Volunteers | Sex | age | found A | found B | found C | found D | found E | found F | found G |
| 5 | F | 28 | X | X | X | X | | | |
| 7 | M | 50 | | | | | | X | |
| 9 | F | 21 | | X | | | | | |
| 10 | F | 24 | | X | | | | | |
| 15 | F | 21 | | X | | | X | | |
| 16 | F | 24 | X | | X | X | | | X |
| 17 | F | 20 | | | | | X | | X |
| 18 | F | 20 | | X | | | | | |
| 21 | F | 19 | X | | X | X | | | |
| 22 | F | 22 | | | | X | | | |
| 23 | M | 51 | | | | X | X | X | X |
| | Total | | 3 | 5 | 3 | 5 | 3 | 2 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Percent* | *27%* | *45%* | *27%* | *45%* | *27%* | *18%* | *27%* |

*Table 1: obtained from clinical evaluation accomplished before video fluorsocopic study where was found functional and structural alterations considered as not able to exclude the volunteers because all of them refers no difficult in its chewing and swallow. The observed founds were A= dificult or discret pain during the maximum open mouth , B= complain of the eventual click in the TMJ, C= Pain complain during temporal and parotideomasetrin region palpation ,D= teeth clenching or teeth wear, E= absence up two teeth that no first molar and canine , F= Absence of the first molar or of the canine ( occlusion keys), G= crossbite*

LPO incidence was selected for the videofluoroscopic study because it allows the decomposition of the high-density profile produced by TMJ superposition with a clear identification of displacement of the mandibular condyle over the temporal surface, which can easily change the structural TMJ identification during mouth opening to identify and analyse the movement of the mandibular condyle over the temporal surface.

Qualitative analyses from the maximum occlusion to maximum mouth opening produced after solicitation of the volunteers were performed to establish a horizontal line (H) over the TMJ level. Three spaces, defined as LL1, LL2 and LL3, were used to qualify the limits of mouth opening. These three spaces were also used to quantify basic movements of TMJ (Figure 2*).
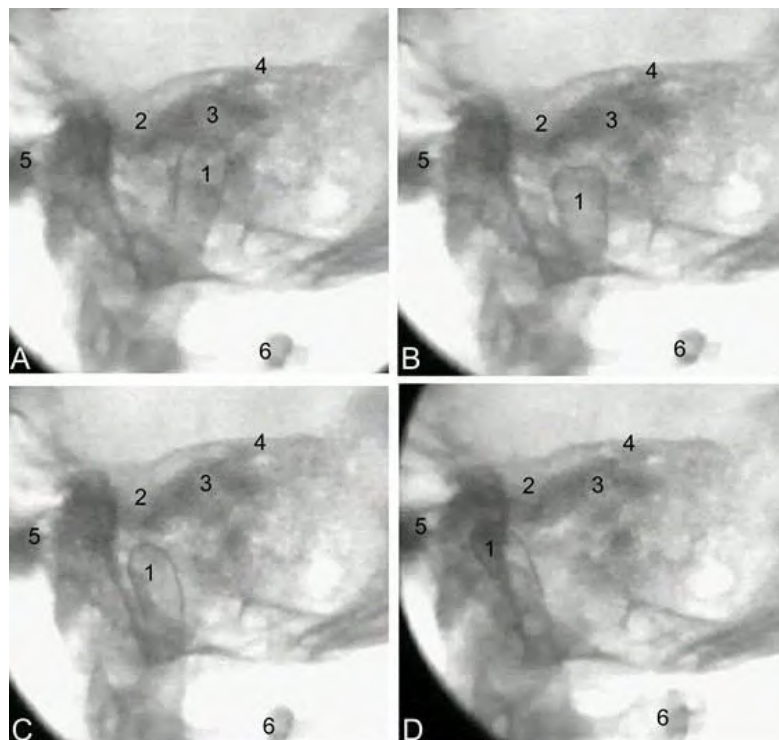


*Fig.2. Oblique left profile images obtained from healthy volunteer video fluoroscopic exam in video pause where (A), the maxim intercuspidation (B and C) open mouse with TMJ displacement (D) maximum open mouth. 1- articular tubercle of left temporal bone , 2- mandible fosse of left temporal bone, 3- left condilus of mandible bone. There are A,B,C and D didactic accentuation of the mandible condilus outline.*

A static video fluoroscopic image of occlusion was used to quantify condyle displacement (maximum intercuspid relation) after translation movement as well as other abnormalities possibly produced by maximum mouth opening (Figure 3*)*
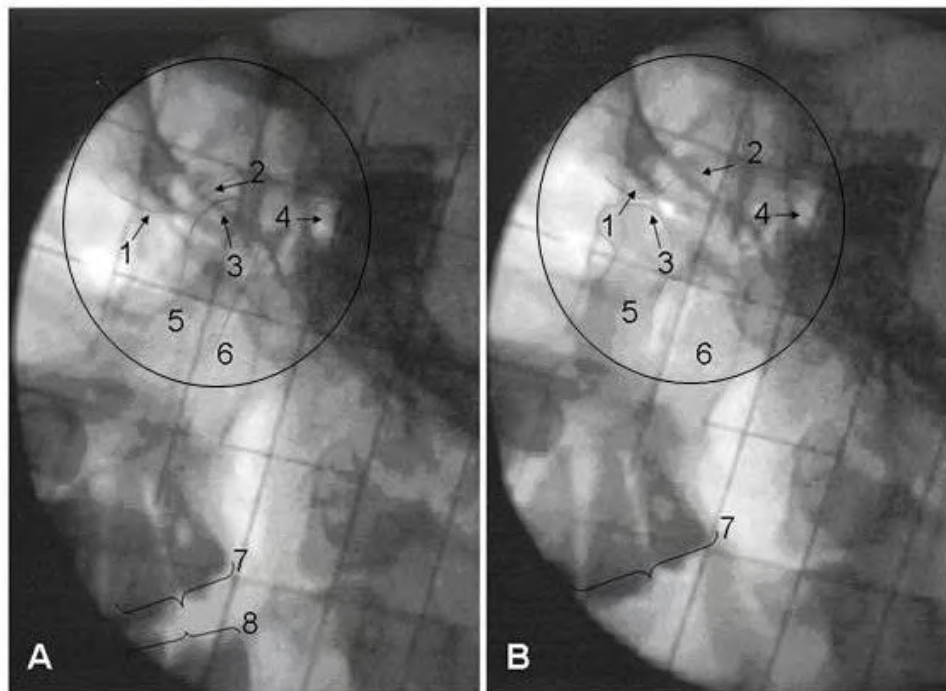


*Fig.3:* Oblique left profile images ($180^0$ rotated) obtained from healthy volunteer videofluoroscopic exam  in video pause  where (A), the maxim intercuspidation (B)  maximum open mouth;  where  1- articular tubercle of  left temporal bone ,  2- mandible fosse of left temporal bone, 3- left condilus of  mandible bone, 4- left acoustic pore, 5- Left ascending branch of the jaw, 6- right ascending branch of the jaw, 7- projection of  superior dental arcade and 8- projection of inferior dental arcade.  See   overlapping of acrylic plate  with 2X2 cm squares used to metric calibration. There are A and B didactic accentuation of mandible condilus and temporal surface outline.

The video fluoroscopic study of mouth opening included a reference point at the central projection of the mandibular condyle, in the 17 volunteers, from line L, maximum inter-cuspid relation, to line L3. A line beyond L2, which is 5% (in millimetres) larger than line L1, is a perpendicular line that passes through the centre of the mandibular tubercle of the temporal bone. These volunteers were considered to be normal free (NF).

Six volunteers with a displacement of less than L2 were considered to be suspicious with respect to function (Table 2).

| Table 2-volunters quantification displacement | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Volunteers** | **Sex** | **Age** | **LL1** | **LL2          = LL1 + 5%L1** | **LL3** | **LL3 - LL2** | **Function** |
| V1 | **M** | 50 | 11,90 | 12,50 | 15,19 | 2,70 | **NF** |
| V2 | **M** | 22 | 13,21 | 13,87 | 16,57 | 2,70 | **NF** |
| V3 | **F** | 19 | 12,28 | 12,89 | 12,28 | -0,61 | **S** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| V4 | F | 27 | 11,64 | 12,22 | 16,00 | 3,78 | **NF** |
| V5 | F | 28 | 9,84 | 10,33 | 13,12 | 2,79 | **NF** |
| V6 | M | 23 | 13,22 | 13,88 | 16,51 | 2,63 | **NF** |
| V7 | M | 50 | 15,82 | 16,61 | 16,72 | 0,11 | NF |
| V8 | F | 21 | 12,51 | 13,14 | 13,99 | 0,85 | **NF** |
| V9 | F | 21 | 16,84 | 17,68 | 18,01 | 0,33 | NF |
| V10 | F | 24 | 11,25 | 11,81 | 12,53 | 0,72 | **NF** |
| V11 | F | 20 | 12,25 | 12,86 | 14,44 | 1,58 | NF |
| V12 | F | 23 | 13,17 | 13,83 | 15,41 | 1,58 | **NF** |
| V13 | F | 19 | 12,81 | 13,45 | 10,29 | -3,16 | **S** |
| V14 | F | 24 | 13,17 | 13,83 | 15,21 | 1,38 | **NF** |
| V15 | F | 21 | 8,77 | 9,21 | 5,84 | -3,37 | **S** |
| V16 | F | 24 | 13,02 | 13,67 | 16,74 | 3,07 | **NF** |
| V17 | F | 20 | 11,99 | 12,59 | 9,03 | -3,56 | **S** |
| V18 | F | 20 | 15,56 | 16,34 | 19,30 | 2,96 | **NF** |
| V19 | F | 27 | 17,01 | 17,86 | 18,52 | 0,66 | NF |
| V20 | F | 25 | 12,47 | 13,09 | 10,63 | -2,46 | **S** |
| V21 | F | 19 | 11,88 | 12,47 | 12,55 | 0,08 | NF |
| V22 | F | 22 | 13,24 | 13,90 | 12,68 | -1,22 | **S** |
| V23 | M | 53 | 11,63 | 12,21 | 14,81 | 2,60 | NF |

V - 23          M - 5          F - 18          NF -17          S - 6

*Table 2- Quantification table where , (LL1)- it is  the individual measure, in millimeters, of the mandible condilus displacement from  the maxim occlusion (L) until the  perpendicular line traced  over temporal tubercle meddle  convexity L1, (LL2)- LL1 value with  5% in excess, LL3-  individual measure, in millimeters, of the obtained condilus displacement  in the maxim open mouth*, L3-L2 value when positive means functial normality of TMJ displacement function . When negative possible  TMJ functional limitation,  *V – Volunteers, M – Male, F – Female, NF - Normal Free, S – Suspicious.*

Of the 17 volunteers with TMJ considered to be NF, nine had no complaints during mouth opening, whereas eight did. Of these eight volunteers, four had measurements of 1.58 mm larger than L2, two complained of masseter muscle compression pain maximum during mouth opening and two complained of clicking and crashing (bruxism).

Pain during mouth opening or digital compression of the masseter muscle also was detected in one of four volunteers determined to be NF with a measurement of less than 1.58 mm larger than L2. In this group, a second volunteer presented with crossbite and absence of the first molar and

crashing (bruxism). The third and fourth volunteers complained of TMJ clicking. Of the six volunteers with a measurement of less than L2, considered to be suspicious (a measurement less than that expected as functional), three had no complaints and the other three complained of crashing, crossbite and clicking.

Of the 17 volunteers considered to be NF, nine had no complaints during mouth opening and eight did. Of six volunteers with a measurement of less than L2 (considered to be suspicious pertaining to their mouth opening function),

three had complaints. The presence or absence of complaints does not necessarily define normal or limited TMJ function.

The Mann–Whitney U test, a non-parametric test, revealed a clear distinction in the LL3 values between the NF and suspicious groups ($p < 0.0001$). Significance was also confirmed by the values L3-L2 ($p < 0.0001$). The measured L1 values and corresponding L2 values (with a 5% increase) showed no distinction between the NF and suspicious groups according to the maximum mouth opening results (GRAPHIC 1, 2)

GRAPHIC 1  -  Displacement from L to L3
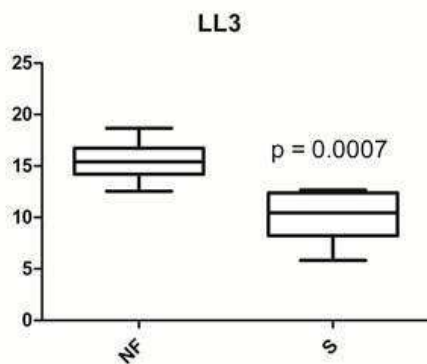


GRAPHIC 2  -  Displacement  >/< to LL2
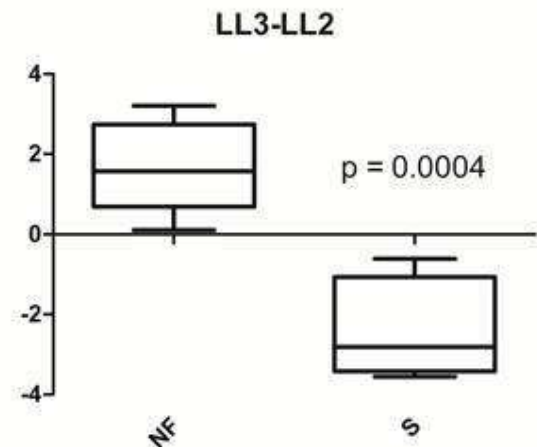


## IV.     DISCUSSION

TMJ disturbances produce headache, dizziness and tinnitus, among other discomforts. Pain, in the projection of the TMJ, is a common complaint, affecting approximately 40% of the world adult population [9,29]. Women experience TMJ disturbances more frequently than men in a proportion that varies from 3:1 to 8:1. However, factors responsible for this predominance remain unknown [30,31].

Our study cohort included 23 volunteers of both sexes with none citing spontaneous clinical complaints or difficulties regarding chewing or swallowing. However, the preliminary evaluation found that 47.83% of the volunteers had some structural or functional abnormalities, not previously noticed by the volunteers. We did not exclude any of the volunteers from the study to compare volunteers with and without TMJ structural or functional abnormalities.

None of the selected volunteers had complaints, particularly pertaining to pain when chewing. However, six of the volunteers experienced pain because of the digital compression of the the masseter muscle or maximum mouth opening during clinical evaluation (26.08%), which was less than the 40% reported in the literature [9]. On the other hand, some structural or functional abnormalities with the possibility of interfering with TMJ function were detected in 47.83% of the volunteers.

Our cohort comprised 78.26% females and 21.73% males, thus comparisons between sexes could not be well established. However, alterations were detected in 50% of the 18 woman who initially declared no alterations or complaints. Of the five men, alterations were found in 40%. Although there was no statistical significance, TMJ dysfunction was predominant among females in the literature [30,31].

The videofluoroscopic method with low radiation exposition [25-27] and without contrast injection into TMJ allowed in the LPO incidence showed that the density of the mandibular condyle from the occluded centric was relative to the maximum mouth opening in each of the 23 studied volunteers.

Dynamic function of TMJ was evaluated by analysing rotation and translation movements of the mandibular condyle over the articular surface of the temporal bone. The concept of mandibular condyle displacement is that motion is limited until beyond the middle line of the articular tubercle of the temporal bone. Motion beyond this limit is considered subluxation when TMJ returns to the previous position either spontaneously or by luxation, during which the return may require external help [31]. The articular tubercle of the temporal bone is considered a mechanical barrier that is able to block the displacement of the mandibular condyle [32]. Displacement of the mandibular condyle beyond the maximum limit of natural mouth opening can occur in a forced manner. This condition is typically present among persons predisposed to subluxation [31].

Based on the anatomical description of TMJ, we do not consider the articular tubercle of the temporal bone to be a mechanical obstacle pertaining to condyle displacement. Both the mandibular condyle and articular tubercle of the temporal bone are joined with the articular disk and other structures by the articular capsule of TMJ. Thus, the temporal tubercle surface is necessarily in a relation with the articular disk and consequently with the mandibular condyle, as already stated.

Qualitative analyses of mandibular condyle displacement over the articular temporal surface was used to create a diagram of mouth opening movements with specific marks as reference quantification of movement, as described in the Materials and Methods section.

Seventeen volunteers of both sexes (74% female) were able, without any discomfort, to undergo videofluoroscopy. Condyle displacement was beyond 5% of the temporal tubercle middle line (L2). A central mark in the mandibular condyle went beyond L2 from 0.08 to 3.78 mm (average, 1.79 mm). Of these 17 volunteers, L2 was extended by at least 1.38 mm in 11. Free and natural displacement of the mandibular condyle over the articular tubercle of the temporal bone was observed in all 17 volunteers. Moreover, all were able to easily close their mouths without any discomfort and none reported a history of luxation or any discomfort when chewing or mouth opening and closing.

Quantitative analyses of mandibular condyle displacement over the temporal bone articular surface, as already observed by qualitative analysis, showed that displacement beyond what is considered as usual was limited by the temporal tubercle not passing L1, which includes the temporal tubercle centre. Mandibular condyle centre displacement from the maximum intercuspid relation of at least 5% more than L1 was observed in all 17 volunteers. This new point, called L2, was considered normal and functional and could less likely to limit condylar centre displacement (NF).

Of the 17 volunteers with normal and functional mouth opening (NF), L2 was greater than 1.58 mm in 10. Only two of these 10 volunteers and one more with normal and functional displacement less than 1.58 mm complained of pain during maximum mouth opening or pressure at the masseter region. Fourteen volunteers had no complaint, indicating that mouth opening beyond L2 is (with statistical significance) normal and functional.

Of the 23 studied volunteers, six had suspected function with mouth opening, as condyle displacement was equivalent or less than L1. However, none complained of difficulty during chewing or swallowing. The clinical evaluation results showed that three of the volunteers had no problems with mouth opening, whereas three other present troubles also observed at volunteers classified as normal and functional. Although mouth opening classified as NF could be considered as desired, TMJ functionality was not significantly compromised if the mandibular condyle displacement reached the temporal bone articular tubercle without impairment. However, persons with suspicious condilar displacement and NF persons with clinical founds must, both, pay larger professional attention.

Mouth opening is TMJ dependent. However, TMJ efficiency can be indirectly measured according to the space between the superior and inferior incisors, resulting in conflicting values several times [12,13]. The mandibular condyle, in its normal course during maximum mouth opening in health

volunteers can be displaced, and should not be considered as indicative of TMJ subluxation or predisposition to luxation. It is possible that this flawed theory was because of indirect observation of TMJ function, which is nowadays visualized by videofluoroscopy, a dynamic radiological method that allows necessary revision of this erroneous concept.

## V. CONCLUSIONS

Although fundamental, the clinical evaluation with slight structural abnormalities and complaints does not represent functional limitations of TMJ, as observed by the videofluoroscopic study. Comparative analysis of the clinical and videofluoroscopic results showed that the videofluoroscopic exam is a useful method to evaluate TMJ function and clarified that clinical complaints do not define functional limitations of TMJ that was classified as normal in 17 (74%) of the 23 volunteers.

The non-parametric statistical analyses using the Mann–Whitney U test revealed significant differences in mouth opening capability between the NF and suspicious groups ($p < 0.0001$). Measured values for LL3 greater than LL2 as well positive values for L3-L2 can be considered as NF and negative values for L3-L2 can be considered as suspicious, with a significance of $p < 0.0001$. L2 was statistically confirmed as a good parameter for the distinction of normal and suspicious functionality of TMJ.

## REFERENCES

[1] Lindauer SJ, Sabol G, Isaacson RJ, Davidovitch M. Condylar movement and mandibular rotation during jaw opening. Am J Orthod Dentofacial Orthop 1995;107:573-7.

[2] Cascone P, Nicolai G, Vetrano S, Fabiani F. TMJ biomechanical constraints: the disc and the retrodiscal tissue. Bull Group Int Rech Sci Stomatol Odontol 1999;41:26-32.

[3] Bravetti P, Membre H, El Haddioui A, et al. Histological study of the human temporo-mandibular joint and its surrounding muscles. Surg Radiol Anat 2004;26:371-8.

[4] Okeson JP. Anatomia funcional e biomecânica do sistema mastigatório. In: Tratamento das Desordens Temporomandibulares e Oclusão. 4a ed. São Paulo: Artes Médicas; 2000. p.163-5.

[5] Phanachet I, Whittle T, Wanigaratne K, Murray GM. Functional properties of single motor units in inferior head of human lateral pterygoid muscle: task relations and thresholds. J Neurophysiol 2001;86:2204-18.

[6] Madeira MC. Anatomia da Face, Bases Anatomo-funcionais para a Prática Odontológica. São Paulo: Ed. Sarvier; 1995. p. 81-90.

[7] Matos JLF. Avaliação do espaço articular na posição mandibular de repouso, em pacientes sintomáticos e assintomáticos nas desordens temporomandibulares. (Tese de Doutorado), Piracicaba, Universidade Estadual de Campinas; 2001. p. 15.

[8] Aguiar ASW, Oliveira ACX, Martins PC, et al. Evaluation of the degree of mouth opening and postoperative pain after. Cir Traumatol Buco-Maxilo-Fac Camaragibe 2005;5:57-64.

[9] Cattoni DM, Fernandes FDM. Distância interincisiva máxima em crianças na dentadura mista. Dental Press Ortodon Ortop Facial 2005;10:117-21.

[10] Renouard F, Rangert B. Fatores de risco no tratamento com implantes. São Paulo: Quintessence Editora; 2001. p. 18.

[11] Bianchini EMG, Marchesan IQ. Mastigação e ATM: avaliação e terapia. In: MARCHESAN, I. Q. Fundamentos em fonoaudiologia: aspectos clínicos da motricidade oral. Rio de Janeiro: Guanabara Koogan; 1998. p. 37-49.

[12] Rodrigues L. Avaliação odontológica. In: Bianchini, EMG (Org.): Articulação temporomandibular: implicações, limitações e possibilidades fonoaudiológicas. Carapicuíba: Pró-fono; 2000. p. 133-66.

[13] Costa, MMB, Canevaro LV, Koch HA, et al. Videofluoroscopy chair for the study of swallowing and related disorders. Radiol Bras 2009;42:179-84.

[14] Costa MMB, De Bonis R, Pamplona D, et al. The open mouth mechanism: anatomical and videofluoroscpic study. Braz J Morphol Sci 2007;24:229-38.

[15] Donlon WC, Moon KL. Comparison of magnetic resonance imaging, arthrotomography and clinical surgical findings in temporomandibular joint internal derangements. Oral Surg Oral Med Oral Pathol 1987;64:2-5.

[16] Learreta JA, Bono AE, Maffia G, Beas J. The identification of temporomandibular joint disease through the masticatory cycle. Int J Orthod Milwaukee 2005;16:11-5.

[17] Gillespy III T, Richardson MD. TMJ Anatomy & Function. Anatomy Modules. University of Washington Department of Radiology. www.rad.washington.edu/anatomy/modules/TMJ/TMJ.html (Consultado em 19/03/2007)

[18] Miralles R, Manns A, Pasini C. Influence of different centric functions on eletromyographic activity of elevator muscles. Cranio 1988;6:26-33.

[19] Costa MMB. Deglutição & Disfagia: bases morfofuncionais e videofluoroscópica: Fase oral da deglutição. In: LIVRO, Medbook, Rio de Janeiro; 2013.

[20] Güvem O. A clinical study on temporomandibular joint ankylosis in children. J Craniofac Surg 2009;19:1263-9.

[21] Koolstra JH, van Eijden TM. Influence of the dynamical properties of the human masticatory muscles on jaw closing movements. Eur J Morphol 1996;34:11-8.

[22] Mapelli A, Galante D, Lovecchio N, Sforza C, Ferrario VF. Translation and rotation movements of the mandible during mouth opening and closing. Clin Anat 2009;22:311-8.

[23] Naidoo LC. Lateral pterygoid muscle and its relationship to the meniscus of the temporomandibular joint. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;82:4-9.

[24] De Bonis, R: Articulação temporomandibular: estudo anatômico e videofluoroscópico. [dissertação - mestrado], Rio de Janeiro: Faculdade de Medicina, Universidade Federal do Rio de Janeiro; 2007.

[25] Costa MMB, Canevaro LV, Azevedo, ACP. Análise dosimétrica do método videofluoroscópico aplicado ao estudo da dinâmica da deglutição. Radiologia Brasileira, São Paulo 2000;33:353-7.

[26] Elias FM. Validade da Ultra-sonografia para o diagnóstico de deslocamento do disco da articulação temporomandibular com redução, (Tese Doutorado), São Paulo: Faculdade de Odontologia da Universidade de São Paulo; 2005.

[27] Katzberg RW, Westesson PL, Tallents RH, Drake CM. Anatomic disorders of the temporomandibular joint disc in asymptomatic subjects. J Oral Maxillofac Surg 1996;54:147-53.

[28] Costa MMB. Videofluoroscopy: The gold standard exam for studying swallowing and its disfunction.(editorial). Arquivos de Gastroenterologia (Impresso) 2010;47:327-8.

[29] Costa MMB, Canevaro LV, Koch HA, et al. Videofluoroscopy chair for the study of swallowing and related disorders. Radiol Bras 2009;42:179-84.

[30] Tavares SSS, et al. Tratamento cirúrgico da luxação recidivante da articulação temporomandibular com utilização de mini-âncoras "Mitek". Int J Dent 2010;9:198-201.

[31] Gutierrez LMO, Grossmann TK, Grossmann E. Anterior jaw head displacement: diagnosis and treatment. Rev Dor 2011:65-6.

[32] Okeson JP. Tratamento das Desordens Temporomandibulares e Oclusão. 64a ed. Rio de Janeiro: Elsevier; 2008.

# Optimizing the process of extraction and acid hydrolysis for Amazon and Cerrado biomass

Debora Cristina de Freitas Romão[1]*, Cláudio Carneiro Santana Junior[1], Mateus Rodrigues Brito[1], Amanda Oliveira Queiroz[2], Gabriel de Sousa Silva[2], Magale Karine Diel Rambo[1], Michele Cristiane Diel Rambo[2]

[1]Programa de Pós-Graduação em Ciências do Ambiente, Universidade Federal do Tocantins (UFT), Tocantins, Brazil.
[2]Instituto Federal de Educação, Ciência e Tecnologia do Tocantins (IFTO), Tocantins, Brazil.
*Corresponding author

*Abstract* — *We investigated the effect of the reaction variable (time) on the extraction and hydrolysis process. The data showed that the methodologies of the National Renewable Energy Laboratory (NREL) must be adequate for each type of biomass and each regional reality. For the contents of total sugars in the biomass of green coconut, babassu and Brazil nut shell epicarp, the highest yields were found under different conditions from those proposed by NREL. In the total lignin content, the highest yields obtained were those proposed by the NREL method for all biomasses. In the content of extracts for coconut and babassu, the use of longer extraction time provided greater removal. For the chestnut fractions, shorter times led to higher yields. It is important to note that, with the optimized results, these biomasses can be used in the production of high value-added bioproducts with higher yields.*

*Keywords* — *NREL, babassu, Brazil nut, green coconut.*

## I. INTRODUCTION

Lignocellulosic biomass is one of the most abundant renewable resources in the world and it is an economical and environmentally friendly alternative for the production of bio-derived chemical products [1,2]. Due to its high composition of carbohydrates, this type of biomass has great potential for the production of biofuels and is considered one of the potential substitutes for fossil fuels in the chemical industry [3,4].

Several pretreatment methods have been studied such as physical, chemical, physical-chemical, biological, and combined pre-treatments to obtain a greater recovery of fermentable carbohydrates from sugar degradation [5,6]. The procedures for implementing these methods are mostly based on methodologies established by the National Renewable Energy Laboratory.

According to the National Renewable Energy Laboratory [7], the acid hydrolysis occurs in two-step to fractionate biomass components. The samples were kept at 30 °C for 1 h in the first step and autoclaved for 1 h at 120 ºC in the second step. For the extractives analysis, [8] the reflux for 8-24 hours in 95% ethanol using the Soxhlet apparatus is recommended.

The extraction procedure is important by removes possible interferents, that can may affect the hydrolysis performances [8]. The acid hydrolysis is used to convert the polymers into polymeric carbohydrates and lignin (acid-insoluble lignin and acid-soluble lignin), that can be used for biorefining industries. Thus, both concentrated and diluted acid hydrolysis has been used to obtain sugars free from highly complex pre-treated lignocellulosic biomass [9].

However, these methodologies are used for standard biomasses from Europe (miscanthus), the United States (corn straw) or sugarcane bagasse from Brazil [10,11,12].

New biomasses from the Amazon region and the Cerrado have shown potential in the context of biorefineries, both for their chemical composition and for the amount of waste generated and discarded in the environment [13,14]. Many of these biomasses, such as coconut husk, Brazil nut husk, and outer shell, babassu endocarp and mesocarp have high levels of carbohydrates and lignin, which can be converted into high value-added products [15,16,17,18]

Therefore, this study aims *to optimize the best conditions to maximize yield in extraction and hydrolysis*

*processes concerning Brazilian biomasses from Cerrado and Amazon regions,* mainly of their major constituents (cellulose, hemicellulose, and lignin), which have been increasingly employed in biorefining processes.

## II. MATERIALS AND METHODS

### 2.1 Samples

Three typical biomasses from the Cerrado and Amazon regions of Brazil were properly collected between 2018 and 2019. The evaluated feedstocks were the following: *Cocos nucifera* (green coconut, whose mesocarp was used), *Orbygnia phalerata* (babassu, whose mesocarp was used) and *Berthollitia excelsa* H.B.K. (Brazilian nut, whose epicarp and endocarp was used). These samples were kept frozen in plastic bags awaiting the next steps of the process. After dried at room temperature, they were ground in a cutting mill (MA 580, Marconi) and sieved in an automatic sieve shaker (VP-01, Bertel), until particles of 355 μm in diameter (45-mesh sieve).

### 2.2 Soxhlet extraction

A Soxhlet extractor was used, and extraction cartridges received 3g of each biomass. After that, they were covered with cotton wool and then taken to the extractor, with 190 mL of ethanol (90%), for 8, 12, and 24 hours in reflux [8].

After the end of the reflux, the cartridges were taken and placed on Petri dishes on the counter for 48 hours to be dried. After 48 hours, the moisture content of the extracted sample was determined again, so that the extractives content was calculated according to the weight loss after the extraction, deducting the moisture.

### 2.3 Acid hydrolysis

The acid hydrolysis step was performed according to the methodology of the National Renewable Energy Laboratory [7] for the determination of structural carbohydrates and lignin in biomass. Pressure tubes were used, in which 300 mg of the extracted biomass were placed, and 3.0 mL (4.91 g) of $H_2SO_4$ at 72% (m/m); then, the tubes were taken to a water bath (TE 056, Technal) for 120 min at 30 ℃ and shaken every 10 min. This is the primary hydrolysis step. Subsequently, 84 mL of deionized water was added so that the concentration of sulfuric acid was reduced to 4% (m/m); the tubes were then taken to an autoclave (AV 18, Phoenix) for 1 hour at 120 ℃ (secondary hydrolysis step).

In our conditions, we tested two different methodologies: primary hydrolysis with 60 min and secondary hydrolysis with 1h, and also primary hydrolysis with 180 min and secondary hydrolysis with 1.5h.

After this step, the hydrolyzed solution was filtered in crucibles of medium porosity (10 to 15 μm) using a vacuum pump (NOF-650). The solids retained in the filter crucibles were taken to an oven at 105 ℃ so that the content of acid-insoluble residue (AIR) was determined, and then kept in a muffle furnace for 4 hours at 575 ℃ to obtain the acid-insoluble ash (AIA). From the difference between AIR and AIA, the content of insoluble lignin – also known as Klason Lignin (KL) – was determined. The filtrate (hydrolysate) contains the acid-soluble lignin (ASL) and any other soluble acid components of the biomass, such as the hydrolyzed sugars.

### 2.4 UV spectroscopy

The ASL is determined using a UV-Vis spectrophotometer (DR 5000, HACH). The hydrolysate was placed in a quartz cuvette and diluted when necessary, and the UV spectra were collected using a wavelength of 205 nm at molar absorptivity of 113 $M^{-1}cm^{-1}$ [19]. The blank was a solution of $H_2SO_4$ at 4% (m/m).

### 2.5 Carbohydrate content

The absorbance of reducing sugars at 540 nm was measured in a UV–Vis spectrophotometer (Varian, Cary 4000) to quantify the sugar content. Total reducing sugar (ART) concentrations were calculated based on the standard curve of D-glucose. The hydrolysate was boiled in the 3,5-dinitrosalicylic acid (DNS) solution for 5 min and cooled in an ice-water bath.

A test kit (LAB TEST) was used to measure the enzymatic activity by the amount of glucose formed glucose oxidase enzyme (GOD/POD) is a flavoprotein used in these kits, was used for glucose determination. The reaction is:

$$\text{Glucose} + O_2 \xrightarrow{GOD} \text{gluconic acid} + H_2O \quad (1)$$

$$2H_2O_2 + \text{Phenol} + \text{4-Aminoantipyrine} \xrightarrow{POD(Peroxidade)} \text{quinone} + 4H_2O \quad (2)$$
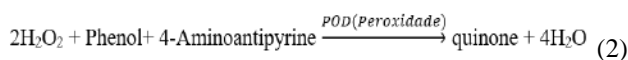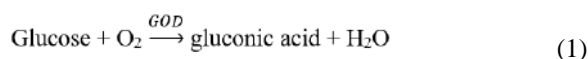
The analytical procedure was to add to 1.0 mL of the hydrolyzed sample and 1.0 ml of the enzyme glucose reagent solution. The aliquots formed were taken to a water bath (37 °C) for 15 min [20]. Afterward, the absorbance of the samples at 500 nm was measured in a spectrophotometer (Varian, Cary 4000).

### 2.6 Cellulose, hemicellulose and lignin analysis

The acid detergent fiber (ADF) and cold neutral detergent (FDN) according to Trujillo, Marichal, and Carriquiry [21], were used to determine hemicellulose content, while the lignin was determined by NREL methodologies and cellulose by difference.

### 2.7 X-ray diffraction

Through x-ray diffraction, the crystallinity reference values were determined. The diffractograms were recorded on the XRD-7000 Shimadzu diffractometer, with Cu Kα radiation, a voltage of 30 kV, and a current of 10 mA. The scan was carried out in the angle range of 5º <2Ө> 99.98º.

## III. RESULTS AND DISCUSSIONS

Table 1 shows the values of the approximate analysis. The biomass of babassu and coconut showed percentages considered low in moisture (<10%). The fractions of Brazil nuts had higher percentages and may interfere in future raw material handling and transport processes [22], also, to affect combustion processes [23].

The ash percentages were all low, which is essential in processes involving biorefineries. Both volatile matter and fixed carbon are in line with what is expected for lignocellulosic biomass [16].

*Table.1: Approximate analysis of lignocellulosic biomass.*

| Analysis (%) | Raw sample | | | |
|---|---|---|---|---|
| | **Babassu mesocarp** | **Green Coconut mesocarp** | **Brazil nut shell epicarp** | **Brazil nut shell endocarp** |
| *Moisture* | 7,25 ± 0,07 | 5,22 ± 0,02 | 13,9 ± 0,00 | 11,35 ± 0,70 |
| *Ashes* | 1,70 ± 0,14 | 2,82 ± 0,04 | 6,75 ± 0,49 | 0,9 ± 0,28 |
| *Volatile Matter* | 86,7 ± 0,14 | 90,78 ± 0,28 | 75,02 ± 0,71 | 77,45 ± 0,35 |
| *Fixed Carbon* | 4,35 ± 0,01 | 1,18 ± 0,01 | 4,33 ± 0,01 | 10,3 ± 0,01 |

As for the extraction process (table 2), longer extraction times (24h) favored the removal of coconut and babassu constituents, while in the Brazil nut fractions, shorter times were more efficient in removing possible interferents. High levels of extractives were found for the green coconut (average value of 15.3%), while for the other biomasses, low values were determined (average value <3.5%). These values are the following data found by other authors [24,25].

*Table 2: Extractive yield at different times.*

| Analysis (%) | Babassu mesocarp | Green Coconut mesocarp | Brazil nut shell epicarp | Brazil nut shell endocarp |
|---|---|---|---|---|
| *Extractives (8h)* | 2,12 | 12,16 | 3,43 | 3,33 |
| *Extractives (12h)* | 1,32 | 14,13 | 4,13 | 1,53 |
| *Extractives (24h)* | 2,37 | 19,83 | 2,59 | 2,64 |

The three different primary and secondary hydrolysis methodologies for the content of polysaccharides and their respective monosaccharides were tested and figure 1 shows their results.

Intermediate times in both stages showed the maximum cellulose yields, except for the Brazil nut shell epicarp. In the same way for ART, except for the nut shell with the highest percentage of ART in 1h for both primary and secondary hydrolysis. Glucose also showed higher yields in intermediate times, except for the Brazil nut shell epicarp, with higher levels (5.81%) in more drastic conditions (2h and 1.5h).
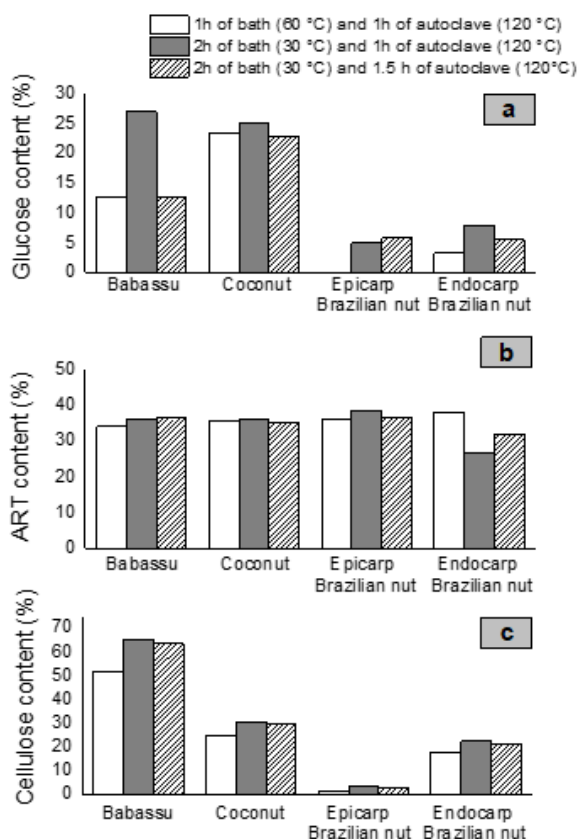
*Fig. 1: Content of glucose, ART e cellulose.*

Figure 2 shows the results of soluble, insoluble, and total lignin after different hydrolysis conditions. Unlike carbohydrates, for soluble lignin, the shortest reaction times favor the best results, except for the Brazil nut shell epicarp. Also, the trend followed for insoluble lignin (Klason), in which the highest yields were in less severe conditions. The total lignin that is the sum of the soluble and insoluble lignin obtained the same result.
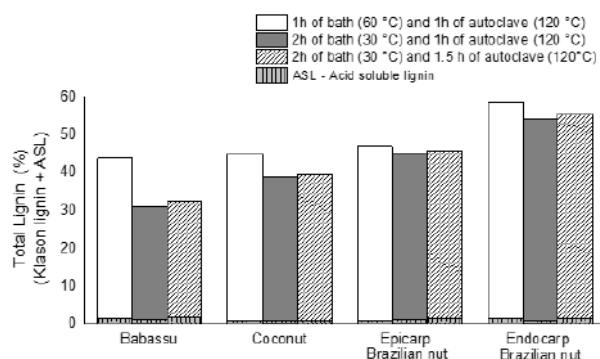


*Fig. 2: Content of total lignin after different conditions.*

These results show the high potential of these biomasses, as levels above 28% of ART were found and

above 30% for lignin, which strongly suggests that they can be used in biorefineries industries.

Figure 3 shows the X-ray diffractograms of the raw samples and the samples extracted at different extraction times. No major changes were observed between samples. We observed that, in general, after extraction some peaks became more prominent, increasing the crystallinity content of the samples.

The data obtained show that the biomasses presented crystalline cellulose percentages that varied between 25 and 40.0%; associated respectively with Brazil nut endocarp and with babassu extracted (24 and 12h). Has been reported a relation between a higher level of crystallinity and hydrolysis yields, which is given by the content of carbohydrates (ART); this indicates that the variation range of crystallinity affects the yield of hydrolyses. For example, Brazil nut endocarp, with less crystallinity, also had lower levels of ART and glucose. On the other hand, babassu, with higher levels of crystallinity, also had the highest values of glucose and ART.
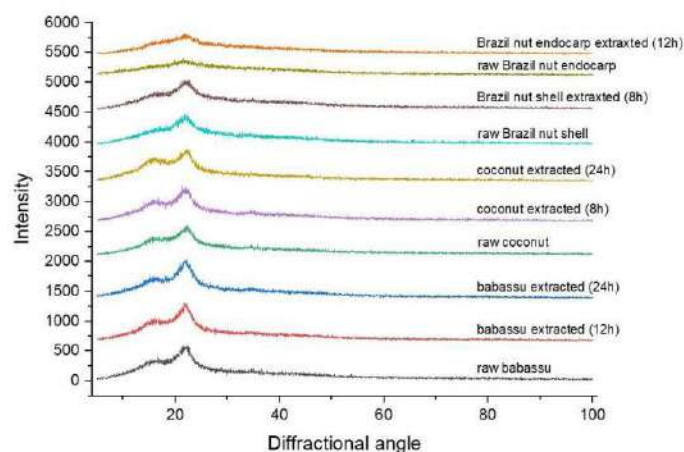


*Fig. 3: Raios-x diffractograms.*

## IV.     CONCLUSION

Given these results, we conclude that the NREL methodology needs to be adapted for each lignocellulosic biomass, as a considerable difference was found in optimizing primary and secondary hydrolysis. Extractive content also needs to be corrected for each specific biomass. High levels of polysaccharides were found in all fractions (except for the Brazil nut shell epicarp), showing that the residual biomasses of the Amazon region and the Brazilian Cerrado can provide a range of valuable products.

## REFERENCES

[1] Ji Q., Yu X., Yagoub A. E. A., Chen L., Zhou C. (2020). Efficient removal of lignin from vegetable wastes by ultrasonic and microwave-assisted treatment with ternary deep eutectic solvent. Industrial Crops & Products, 149, 112357. Doi: https://doi.org/10.1016/j.indcrop.2020.112357.

[2] Shen F., Xiong X., Fu J., Yang J., Qiu M., Qi X., Tsang D. C. W. (2020). Recent advances in mechanochemical production of chemicals and carbon materials from sustainable biomass resources. Renewable and sustainable energy reviews, 130, 109944. Doi: https://doi.org/10.1016/j.rser.2020.109944.

[3] Sindhu R., Gnansounou E., Binod P., Pandey A. (2016). Bioconversion of sugarcane crop residue for value added products: An overview. Renewable Energy, 98, pp. 203–215. Doi: http://dx.doi.org/10.1016/j.renene.2016.02.057.

[4] Han X., Guo Y., Liu X., Xia Q., Wang Y. (2019). Catalytic conversion of lignocellulosic biomass into hydrocarbons: A mini Review. Catalysis Today, 319, pp. 2–13. Doi: https://doi.org/10.1016/j.cattod.2018.05.013.

[5] Kumari D., Singh R. Pretreatment of lignocellulosic wastes for biofuel production: A critical Review. (2018). Renewable and Sustainable Energy Reviews, 90, pp. 877-891. Doi: https://doi.org/10.1016/j.rser.2018.03.111.

[6] Rezania S., Oryani B., Cho J., Talaiekhozani A., Sabbagh, F., Hashemi B., Rupani P. F., Mohammadi A. A. (2020). Different pretreatment technologies of lignocellulosic biomass for bioethanol production: an overview. Energy, 117457. Doi: https://doi.org/10.1016/j.energy.2020.117457.

[7] Sluiter A., Hames, B., Ruiz R., Scarlata C., Sluiter J., Templeton D., Crocker D. NREL/TP-510-42618: Determination of Structural Carbohydrates and Lignin in Biomass. National Renewable Energy Laboratory (NREL): Golden, USA, 2008.

[8] Sluiter B., Ruiz C., Scarlata J., Sluiter D., Templeton D. NREL/TP-510-42619: Determination of extractives in Biomass. Laboratory Analytical Procedure (LAP). National Renewable Energy Laboratory (NREL): Golden, USA, 2008.

[9] El-Zawawy W. K., Ibrahim M. M., Abdel-Fattah Y. R., Soliman N. A., Mahmoud M. M. (2011). Acid and enzyme hydrolysis to convert pretreated lignocellulosic materials into glucose for ethanol production. Carbohydrate Polymers, 84, pp. 865–871. Doi:10.1016/j.carbpol.2010.12.022

[10] Kim J-Y., Hwang H., Oh S., Choi J. W. (2015). Structural features of lignin-rich solid residues obtained from two-step acid-hydrolysis of Miscanthus biomass (Miscanthus sacchariflorus Benth.). Journal of Industrial and Engineering Chemistry, 30, pp. 302–308. Doi: http://dx.doi.org/10.1016/j.jiec.2015.05.037.

[11] Kim S. M., Dien B. S., Tumbleson M. E., Rausch K. D., Singh V. (2016) Improvement of sugar yields from corn stover using sequential hot water pretreatment and disk milling. Bioresource Technology, 216, pp. 706–713. Doi: http://dx.doi.org/10.1016/j.biortech.2016.06.003.

[12] Gomes G. R., Rampon D. S., Ramos L. P. (2018). Production of Furan Compounds from Sugarcane Bagasse Using a Catalytic System Containing ZnCl2/HCl or AlCl3/HCl in a Biphasic System. Journal of the Brazilian Chemical Society, 29 (5), pp. 1115-1122. Doi: http://dx.doi.org/10.21577/0103-5053.20180014.

[13] Rambo M. K. D., Rambo M. C. D., Melo P. M., Oliveira N. M. L., Nemet Y. K. S., Scapin E., Viana G. C. C., Bertuol, D. A. (2020). Sustainability of Biorefinery Processes Based on Baru Biomass Waste. Journal of the Brazilian Chemical Society, 31 (2), pp. 273-279. Doi: http://dx.doi.org/10.21577/0103-5053.20190169.

[14] Scapin E., Rambo M. K. D., Viana G. C. C., Borges M. S., Rambo M. C. D., Carneiro C. (2020) Production of Furanic Compounds and Organic Acids from Brazilian Pequi (*Caryocar brasiliensis* Camb.) Residues Using Green Chemistry. Journal of the Brazilian Chemical Society, 31 (7), pp. 1383-1391. Doi: http://dx.doi.org/10.21577/0103-5053.20200023.

[15] Leandro R. I. M., Abreu J. J. C., Martins C. S., Santos I. S., Bianchi M. L., Nobre J. R. C. (2019). Elementary, Chemical and Energy Characteristics of Brazil Nuts Waste (Bertholletia excelsa) in the State of Pará. Floresta e Ambiente, ISSN 2179-8087 (online), 26(Spec nº 2): e20180436. Doi: https://doi.org/10.1590/2179-8087.043618.

[16] Rambo M. K. D., Alexandre G. P., Rambo M. C. D., Alves A. R., Garcia W. T., Baruque E. (2015). Characterization of biomasses from the north and northeast regions of Brazil for processes in biorefineries. Ciência e Tecnologia de Alimentos (Online), 35(4), pp. 605-611. Doi: http://dx.doi.org/10.1590/1678-457X.6704.

[17] Cabral M. M. S., Abud A. K. S., Silva C. E. F., Almeida R. M. R. G. (2016). Bioethanol production from coconut husk fiber. Ciência Rural, 46 (10), pp. 1872-1877. Doi: http://dx.doi.org/10.1590/0103-8478cr20151331.

[18] Cardoso Z. S. (2017). Avaliação das características químicas e eletroquímicas do etanol obtido do mesocarpo de coco babaçu para uso em células a combustível. Dissertação (Mestrado em Química) – Universidade Federal do Maranhão, São Luís.

[19] Sluiter J. B., Ruiz R. O., Scarlata C. J., Sluiter A. D., Templeton D. W. (2010). Compositional Analysis of Lignocellulosic Feedstocks. 1. Review and Description of Methods. Journal of Agricultural Food Chemistry, 58, pp. 9043–9053. Doi: 10.1021/jf1008023.

[20] Visvanathan R., Jayathilake C., Liyanage R. (2016). A simple microplate-based method for the determination of $\alpha$-amylase activity using the glucose assay kit (GOD method). Food Chemistry, 211, pp. 853-589. Doi: http://dx.doi.org/10.1016/j.foodchem.2016.05.090.

[21] Trujillo A. I., Marichal M. J., Carriquiry M. (2010). Comparison of Dry Matter and Neutral Detergent Fiber

Degradation of Fibrous Feedstuffs as Determined with in Situ and in Vitro Gravimetric Procedures. Animal Feed Science and Technology, 161, pp. 49-57.

[22] Charlton A., Elias R., Fish S., Fowler P., Gallagher J. (2009) The biorefining opportunities in Wales: Understanding the scope for building a sustainable, biorenewable economy using plant biomass. Chemical Engineering Research and Design, 87(9), pp. 1147–1161, 2009. Doi: 10.1016/j.cherd.2009.06.013.

[23] Macedo L. P. R., Rambo M. K. D. (2017). Biorrefinarias: caracterização de biomassas residuais do Tocantins por espectroscopia NIR aliada a Quimiometria visando a obtenção de insumos químicos e condicionadores de solo. Desafios, 3(especial), pp. 49-54. Doi: http://dx.doi.org/10.20873/uft.2359-3652.2016v3nespp49.

[24] Rambo, M. K. D., Almeida K. J. C. R., Rambo M. C. D., Baruque E A. (2016). The Response Surface Methodology as a tool to optimize the extraction and acid hydrolysis processes applied to babassu residues. RBPG. Revista Brasileira de Pós-Graduação, 13(32), pp. 807-825.

[25] Rambo M. K. D., Melo P. M., Ferreira M. M. C., Rambo M. C. D., Bertuole D. A., Mota V. L. (2020). Optimization of Alkaline, Acidic, Ionic Liquid and Oxidative Pretreatments for Coconut Waste Conversion into Fermentable Sugars. Journal of the Brazilian Chemical Society, 31(5), pp. 904-915. Doi: https://doi.org/10.21577/0103-5053.20190254.

# Nursing Assistance and Fragilities in Tuberculosis Diagnosis: Integrative Literature Review

Ana Caroline Guedes Souza Martins[1], Elidiane de Carvalho Ribeiro[2], Anderson Lineu Siqueira dos Santos[3], Tatyellen Natasha da Costa Oliveira[4], Michele Monteiro Sousa[5], Luceme Martins Silva[6], Maria Carolina Oliveira de Lima Santa Rosa[7], Hellen de Paula Silva da Rocha[8], Wesley Brandão Dias[9],Eris Felipe Santos da Silva[9], Felipe Macedo Vale[9], Hector Brenno da Silva Cagni[9], Larissa Maria Soares Ribeiro[9], Ana Luisa Lemos Bezerra[9], Mário Roberto Tavares Cardoso de Albuquerque[10], Alda Lima Lemos[11], Thamyres da Silva Martins[12], Wilker Silva Alves[13], Aline do Socorro Braga Figueiredo[14], Soraya Galvão Martins[15], Monaliza de Souza Damasceno[16], Suelen Trindade Correa[17], Larissa Lima Figueira Freire[18], Tereza Cristina Abreu Tavares[19], Ana do Socorro Maia de Moraes[20], Alex de Oliveira Vasconcelos[21], Tayana Patrícia Santana Oliveira de Sá[22], Antônia Margareth Moita Sá[23]

[1]Nurse, Master in Health Education in the Amazon at the State University of Pará (UEPA).  PhD Student Doctorate in Clinical Research in Infectious Diseases at National Institute of Infectious Diseases-FIOCRUZ. Professor at the UEPA, Belém, Pará, Brazil.E-mail: carolguedes.devs@hotmail.com

[2]Nurse. Post-Graduation in Occupational Nursing, Permanent Health Education, Oncology Nursing and Adult Intensive Care Nursing, Belém, Pará, Brazil.

[3]Master in Nursing and PhD Student Doctorate in Parasitic Biology pela UEPA, Belém, ParáBrazil.

[4]Master in Parasitic Biology in the Amazon and PhD student Doctorate Parasitic Biology in the Amazon, Instituto Evandro Chagas, Belém, ParáBrazil.

[5]Nurse. Post-Graduation in Oncology, Obstetrics and Natural and Holistic Therapies. State Secretariat of Public Health of Pará. (SESPA), Belém, Pará Brazil.

[6]Nursing Student at the University of the Amazon (UNAMA), Belém, Pará, Brazil.

[7]Nurse at UEPA. São Joaquim Family Health Unit at SESMA, Belém, Pará, Brazil.

[8]Nurse. Post-Graduation in Health Systems Audit at the University of the Amazon.  Health care nurse at the Hapvida. Belém, Pará, Brazil.

[9]Nursing Student at the State University of Pará (UEPA), Belém, Pará, Brazil.

[10]Doctor. Master in Health Education in the Amazon at UEPA. Specialist in Family and Community Medicine, Professor of Community Health at University Center of Pará (CESUPA). Belém, Pará, Brazil.

[11]Master in Health Education in the Amazon at UEPA, Professor at UEPA, Belém, Pará, Brazil.

[12]Master in Health Education in the Amazon at the State University of Pará, Belém, Pará, Brazil.

[13]Nurse at UFPA, Post-Graduation in Health policy management at Sírio Libanês. Nurse atEmergency Care Unit in Marituba andnursing supervision atEmergency Care Unit in Jurunas, Belém, Pará, Brazil.

[14]Nurse. Post-Graduation in Family Health multiprofessional residence modality, Belém, Pará, Brazil.

[15]Nurse at the State University of Pará, Belém, Pará, Brazil.

[16]Nurse at Benfica, Benevides Polyclinic. Professor inTechnical Nursing Course at EFAE and Preceptor at UEPA, Belém, Pará, Brazil.

[17]Nurse. Master in Collective Health at the Federal University of Pará. Professor at the UEPA, Belém, Pará, Brazil.

[18]Nurse at UEPA.Resident in women's and children's health at UEPA, Belém, Pará, Brazil.

[19]Nurse at Metropolitan University Center of the Amazon(UNIFAMAZ), Belém, Pará, Brazil.

[20]Nurse. Master in Education Sciences at the FIAVEC. Professor at the State University of Pará. Belém, Pará, Brazil.

[21]Nurse. Master and scholarship holders inClinical Research in Infectious Diseases at National Institute of Infectious Diseases-FIOCRUZ. Post-Graduationin Occupational Nursing and Health Services Auditing, Cafarnaum, Bahia, Brazil.

[22]PhD Student Doctorate in Clinical Research in Infectious Diseases at National Institute of Infectious Diseases-FIOCRUZ.Nurse inTesting and Counseling Center and Specialized Assistance Service for STIs/HIV and Viral Hepatitis e ProfessoratBahia State School and Faculty AGES, Senhor do Bonfim, Bahia, Brazil.

[23]Nurse, PhD in Nursing at Federal University of Rio de Janeiro. Permanent member of the faculty in the Stricto Sensu Graduate Program, Master and Professional Doctorate in Education and Health in the Amazon at UEPA, Belém, Pará, Brazil.

*Abstract*—*Objective: This study aims to analyze scientific publications on nursing care and fragilities in diagnosis of tuberculosis. Method: It is an integrative review of the literature by searching the databases, with the time frame between the years 2015 to 2020. For the treatment of the data, the technique of content analysis was used, with categorization of the findings. Seven complete original articles were selected that answer the central question of the research, which were grouped in tables according to author, title, journal, year of publication, indexing base, objectives, methodologies and evidence. Results: The analysis of the literature made it possible to elaborate three categories based on relevant points, namely: Category 1- Primary Health Care as a gateway to the diagnosis of tuberculosis; Category 2 - Qualification of nursing actions in the diagnosis of tuberculosis and Category 3 - Factors of delay in diagnosis related to the patient. Conclusion: This study made it possible to understand about the magnitude of the problems inherent to society as a whole, of a political and social order, as well as the health system and the organization of the health services that comprise it and influence the delay in diagnosis. However, the importance of the nurse's performance in the context of Primary Health Care in the process of decentralization of services and in equitable and comprehensive access to the patient is emphasized.*

*Keywords*—*Tuberculosis. Diagnosis.Fragilities. Nursing.*

## I. INTRODUCTION

Tuberculosis (TB) is still a serious and challenging global public health problem. Worldwide, in 2018, about ten million people became ill from TB and 1.5 million people died from it, with TB being the leading cause of death from a single infectious agent. The disease disproportionately affects males, young adults and low-income countries, pointing to the association between the occurrence of TB and socioeconomic factors (Brasil, 2020).

The disease has affected 8.6 million people worldwide, of which three million have not been diagnosed because they do not have access to health services, which worries the world's health authorities. WHO data revealed that these people were not diagnosed for various reasons, the main ones being the lack of resources to travel to health services, the lack of understanding of the disease, as well as its signs and symptoms, the lack of knowledge of where to seek care and as a result social stigma, which still stands out in some communities (Popolin et al., 2015).

The delay in diagnosis is an important factor for the worsening of the clinical picture, hinders proper management and favors a poor prognosis. The disease has been diagnosed late, in an advanced stage and by hospital institutions, which results in high mortality. According to the national health policy, the responsibility for the

diagnosis and treatment of the disease lies with the Primary Health Care teams (Salzani et al., 2017).

The delay in the diagnosis of TB has been the subject of reflection and the subject of debate about the quality and opportunity of patients' access to health care, in which two types of delay can be linked: the "patient's delay", which refers to duration between the onset of symptoms until the first visit to a health service, and the "delay of the health system", related to the time elapsed between the first contact with a care unit and confirmation of the TB diagnosis (Trigueiro et al ., 2014).

The early diagnosis of TB cases and the immediate start of treatment are the main tools and strategies for controlling the disease, however, the delay in these strategies becomes a challenge to health professionals working in AB, considering that they have a responsibility to effectively promote pathology control. Therefore, there is a need for a diagnosis without delay in order to minimize the damage to the health of the individual and the population (Lafaiete et al., 2013).

One of the reasons for the delay in diagnosing TB is due to the delay in suspecting comorbidity. In this way, the health education of the population and the continuous training of health professionals are essential to reduce the delay in diagnosing TB. Lafaiete et al. (2013) states that knowledge is a variable that causes a significant delay in

the search for a health service. TB education helps individuals to seek health services earlier, in order to contribute to early diagnosis.

In this sense, there is the importance of conducting research in this area, in order to expand knowledge, not only of the epidemiological characteristics of the disease, but also to identify determining factors for the diagnosis and treatment of TB, since, if you create strategies or actions that aim to break the transmission chain, to provide control of this endemic disease (Lafaiete et al., 2013).

Most studies demonstrate that there is a delay in making the diagnosis of TB, taking into account both health services and the patient. According to Belkina et al. (2014) the average delay for patients was 27 days; for the 7-day health service; and the average total delay was almost 2 months. While by Saifodine et al. (2013) the average total delay; health system delay and patient delay was 150 days, 61 days and 62 days, respectively, values which are unacceptable.

For Barrêto et al. (2013) as one of the members of the health team, the nurse is an important professional to carry out TB care as he manages the control actions and understands the complexity involved in this process.

Thus, this study aimed to analyze scientific publications on nursing care and weaknesses in the diagnosis of tuberculosis.

## II. METHOD

The research is of the integrative review type, which has the purpose of gathering and synthesizing research results on a delimited theme, in a systematic and orderly manner, being an instrument for the deepening of knowledge about the investigated theme, allowing the synthesis of multiple published studies and general conclusions about it (Polit; Beck; Hungler, 2011).

Although there are variations in the conduct of methods for the development of integrative reviews, there are standards to be followed. In carrying out this review, six steps were used: selection of hypotheses or guiding questions for the review; selection of studies that will compose the sample; definition of the characteristics of the studies; categorization of studies; analysis and interpretation of results; and, report of the review (Mendes; Silveira; Galvão, 2008).

The guiding question for the elaboration of this integrative review was: What are the scientific productions available on nursing care and weaknesses in the diagnosis of tuberculosis?

The survey of bibliographic studies took place during the month of August 2020 and five databases were chosen: Latin American and Caribbean Literature in Health Sciences (LILACS), Database in Nursing (BDENF), in Scientific Electronic Library Online (SCIELO) and Medical Literature Analysisand Retrieval System Online (MEDLINE).

Following, the validated DECS descriptors were used: "Tuberculosis"; "Diagnosis"; "Fragilidades" and "Enfermagem", using the Boolean operators AND, in Portuguese and English, in the last 06 years, published in the period from 2015 to 2020. A total of 12,776 articles were found, which after reading the titles and abstracts and arrived to the number of 7 articles that showed similarities with the object of this study. These were organized in alphanumeric codes, from TB01 to TB07, for better presentation and understanding of the results.

For data collection, it was decided to use the instrument validated by Ursi (Mendes; Silveira; Galvão, 2008). The analysis of the selected studies took place in a descriptive manner, in order to enable the observance and description of the data, thus, it was possible to gather the synthesized knowledge on the subject in question. From this, three empirical categories were elaborated, which will be presented and discussed below, in which Bardin's content analysis method was used to explore the content. To guarantee the success of this study, it was decided to describe and distribute the results in tables, highlighting the main findings of each research. As for the discussion, it was carried out in a descriptive way, in order to achieve the objectives of building an integrative review.

## III. RESULTS AND DISCUSSION

Tables 1 and 2 show the characteristics of these studies, in which articles in Portuguese (100%), with a qualitative approach (71.4%), published in national journals (100%) and indexed in the BDENF database, predominate. (57.1%). In the present integrative literature review, a total of seven original scientific articles were analyzed, which strictly met the selection of the sample previously established.

*Table 1: Distribution of studies.*

| Nº | Base | Author. Title. Periodic. Year | Objective | Methodology |
|---|---|---|---|---|
| TB01 | SciELO | SÁ, Lenilde Duarte de. et al. ENTRY DOOR FOR TUBERCULOSIS DIAGNOSIS IN ELDERLY PEOPLE IN BRAZILIAN MUNICIPALITIES. Rev Bras Enferm. 2015. | To analyze the factors associated with the gateway to health systems in Brazilian municipalities for the diagnosis of tuberculosis in the elderly. | Survey-type study, with a sample of 91 elderly people, in a population of 706 cases of tuberculosis. Data collection made using an instrument based on the Primary Care Assessment Tool (PCAT) adapted for TB care, with emphasis on the variable gateway. The variables were categorized and compared between the Primary Health Care (PHC) and specialized care (AE) services. Bivariate analysis and Chi-square association test were used. |
| TB02 | BDENF-LILACS | CECILIO, Hellen Pollyanna Mantelo, TESTON, Elen Ferraz, MARCON, Sonia Silva. ACCESS TO TUBERCULOSIS DIAGNOSIS FROM THE HEALTH PROFESSIONALS 'VIEWS. Texto Contexto Enferm, 2017. | To know the aspects that influence access to the diagnosis of tuberculosis and from the perspective of health professionals. | Descriptive, exploratory, qualitative study. The data were collected in the months of June and July 2013, through semi-structured interviews, with 20 nurses and ten doctors working in the control of TB in the municipalities belonging to the 15th Regional Health of Paraná and, later, submitted to content analysis, thematic modality. |
| TB03 | SciELO | Juliana Teixeira Jales Menescal Pinto, Cláudia Helena Soares de Morais Freitas. PATHWAYS CHILDREN AND ADOLESCENTS WITH TUBERCULOSIS IN HEALTH SERVICES.Texto Contexto Enferm, 2018. | To know the paths taken by people under 15 years of age in search of the diagnosis and treatment of tuberculosis. | Exploratory, descriptive study with a qualitative approach, carried out from March to July 2015 in priority municipalities for TB control. 11 caregivers of people under the age of 15 with TB and 11 nurses from basic health units participated in this research, intentionally selected. For data collection, semi-structured interviews were recorded and transcribed, organized in the Atlas.ti Software, analyzed by thematic content analysis. |
| TB04 | BDENF-LILACS | MELO, Lucila de Sousa Olímpio de. et al. STEPS AND DISCOMPANTS IN THE CARE PROCESS FOR TUBERCULOSIS PATIENTS IN PRIMARY CARE.Enferm. Foco, 2020. | Carry out a diagnosis of the situational reality regarding the monitoring of users with tuberculosis and develop educational workshops focusing on the vulnerabilities detected in the care process. | Research / intervention carried out with eleven nurses in the municipality of Ibiapina-Ceará. The focus group was the technique used to collect the information, which was organized and synthesized with the support of the thematic analysis. |
| TB05 | BDENF | ALVES, Jemylle Carla de França, et al. SOCIOECONOMIC-CULTURAL BARRIERS THAT DELAY THE TUBERCULOSIS | Identify socioeconomic and cultural barriers that delay the diagnosis of tuberculosis. | Descriptive-exploratory study, with a quantitative approach, developed with 42 professionals from the Family Health Strategy, in Parnamirim-RN. The collection instrument was based on The Primary Care Assessment Tool, using the |

| | | | | |
|---|---|---|---|---|
| | | DIAGNOSIS. Rev enferm UFPE on line, 2016. | | Likert Scale. |
| TB06 | BDENF-LILACS | RÊGO, Clara Ceci Diógenes. NURSE'S WORK PROCESS WITH TUBERCULOSIS IN PRIMARY HEALTH CARE.Revista Baiana de Enfermagem, 2015. | The aim of this article is to describe the nurse's work process in primary health care for people with tuberculosis. | It is a qualitative research of a descriptive nature, involving 11 nurses working in Primary Health Care Units in the city of Natal-RN. A semi-structured questionnaire was used with questions related to the directly observed treatment, records, human resources, integration between programs and the assistance process. Data were collected from November 2013 to January 2014. Thematic content analysis was used. |
| TB07 | SciELO | VALENÇA, Mariana Soares. et al. THE PROCESS OF DETECTION AND TREATMENT OF TUBERCULOSIS CASES IN A BUILDING. Ciência & Saúde Coletiva, 2016. | The study aims to analyze the process of detecting and treating cases of tuberculosis (TB) in a prison in southern Brazil. | An active and passive search was carried out to estimate the magnitude of TB among a population of 764 inmates. Simultaneously with the detection strategies and the clinical follow-up of the 41 confirmed cases, participant observation and field diary records were carried out, which made it possible to analyze the potential and limitations of the detection and treatment of prison TB. |

**Source:** Research protocol, 2019.

*Table 2: Evidence from the studies.*

| Nº | Evidence |
|---|---|
| TB01 | A statistically significant association was found between the first health service sought and the unit that diagnosed TB, showing a better performance of specialized care services for the diagnosis. We conclude that it is necessary to improve primary health care services to combat the delay in diagnosing TB in the elderly. |
| TB02 | Three categories emerged that show the factors that positively influence access to diagnosis, the weaknesses in this access and the characteristics of the organization of this service. It also points out that the performance of the Family Health Strategy favors early diagnosis, although professionals report difficulties in identifying patients with signs and symptoms of the disease, either due to unpreparedness or due to the population's lack of knowledge about the disease. It is considered essential to inform the community about the disease and strengthen the multidisciplinary work. |
| TB03 | Construction of two categories, namely: In search of diagnosis at the various entry points into the health system, presenting the services used by caregivers and the aspects that involved the care of these people in these places; and Paths taken for TB treatment, showing the accessibility to the Health Care Network in the search for the diagnosis and treatment of TB by these people. The gateway for urgent and emergency services, the diagnosis at levels of greater complexity in the network and the monitoring by nurses and doctors of two services concomitantly show the fragility of the family bond with primary care. It also emphasizes the need to strengthen the family health strategy in TB control actions and the dissemination in health units of points of care in the network for the proper referral of people under 15 with TB. |
| TB04 | The professionals have difficulties in the development of recommended strategies for the control and combat of TB. Issues related to structural and logistical problems also arose, such as limitation of places for exams, lack of materials or equipment, inexistence of a connection between services, as well as fear of contagion of the disease. The study allowed to subsidize decision making and the definition of intervention strategies, helping to overcome the weaknesses of health services. |
| TB05 | Search for the service closest to home "Ever" (47.6%); expense by the user with transportation to the health |

| | |
|---|---|
| | service and difficulty in traveling "Never" and "Sometimes" (28.6%); difficulties in convincing the user to collect sputum for sputum smear microscopy "Almost always" (33.3%). Resistance to the practice of exams and acceptance of the disease in the face of signs and symptoms are social and cultural factors to delay the diagnosis of TB, which is fundamental in the treatment of the disease. |
| TB06 | The results showed weaknesses related to the records used; absence of a computerized system; absence of periodicity in carrying out the Directly Observed Treatment; overload of the nurse's work and difficulty in articulating the team's actions, which compromises the work process and its results. It was concluded that these weaknesses can interfere with adherence to health policies related to TB prevention and control actions. |
| TB07 | The development of search strategies, the use of questionnaires to detect symptomatic patients, the fragility of the clinical follow-up of TB cases, the involvement of different workers and the articulation between prison and health services are discussed. Potentials for TB control are to use active search as an inducer of passive detection and screening for symptoms, which, even though interfered by inmates' perceptions of TB symptoms, allowed for increased detection. The prison's functional dynamics make it difficult to insert health routines and may limit actions to control TB and other diseases. In the process of TB control in prisons, the feasibility of effective detection methods is as important as planning it based on the conditions of illness, the network of services and the workers involved. |

**Source:** Research protocol, 2019.

The analysis of the literature found enabled the development of three categories based on relevant points, namely: Category 1- Primary Health Care as a gateway to the diagnosis of tuberculosis; Category 2 - Qualification of nursing actions in the diagnosis of tuberculosis and Category 3 - Factors of delay in diagnosis related to the patient, which will be developed below.

**Category 1- Primary Health Care as a gateway to the diagnosis of tuberculosis**

The article **TB01** shows that the Primary Health Care (PHC) services have limitations to act as a gateway to the health system, especially with regard to the suspicion of TB cases in the elderly and for the early diagnostic confirmation of the disease. The fact that most TB diagnoses in the elderly have been carried out by specialized services is contrary to health policy guidelines in Brazil, since it places the disease as a strategic area of PHC (Sá, et al., 2015).

The organization of care in the health system does not have effective mechanisms to meet the different demands and needs of the elderly population, which requires the definition of management strategies and communication mechanisms between the different services to access TB diagnosis, considering habits and the context where he lives to overcome the fragmented focus of care. It is recommended that health services be reorganized in order to strengthen PHC services as a gateway to the population over the age of 60, which is a vulnerable group to TB (Sá, et al., 2015).

The **TB02** article shows that the early diagnosis of TB may be related to the type of health service sought by the user as a gateway. Thus, for early diagnosis to occur, it is

essential that nurses are able to identify suspected cases, diagnose and treat patients, and have a good integration and knowledge of the service's routine and functioning. In addition, it is necessary to offer adequate services and the availability of diagnostic tests (Cecílio; Teston; Marcon, 2017).

It is pointed out that the rotation of professionals, regardless of the reason, reinforces the precariousness and / or absence of links with patients and the community, in addition to interfering in the process of training and continuing education of professionals, in which the actions are not completed. The new dynamism and the structuring of health services and actions proposed by the PHC, show it as a differential in relation to traditional programs, so that the foundation of the Family Health Strategy is the reorientation of the care model, with the objective of strengthening the preventive care, prioritizing health promotion and education, in addition to reorganizing health services in the search for compliance with SUS guidelines, occupying a privileged place to meet individuals, identify problems and risk situations and provide comprehensive care to families (Cecílio; Teston; Marcon, 2017).

Attention to patients with suspected TB needs a unique offer of actions that enable quick access to diagnosis. Still in this sense, the care for TB patients becomes complex and specific, as it requires a different look due to the magnitude of a socially produced disease.

In order to guarantee good assistance, it is essential that nurses understand the actions inserted in care management, which comprises three dimensions: professional, organizational and systemic. In the first, there is a meeting between worker and user in order to solve the needs listed by the user. The second is understood as a space for the

technical and social division of work, with the implications and professional practices of care. And finally, the systemic dimension, refers to the set of services with their different functions and degrees of technological incorporation and their flows for service with quality and resolution (Cecílio; Teston; Marcon, 2017).

For this, access must be easy and must provide adequate and resolving attention, in addition to ensuring continuity of assistance in specialized services when necessary. Thus, it is essential to develop, through services, the capacities to welcome, hold responsible, resolve and autonomize, incorporating light technologies that materialize in relational practices, such as welcoming and bonding (Cecílio; Teston; Marcon, 2017).

He also reports that some studies have pointed out that TB patients often seek health services and are treated for other ills. It is a vicious circle of repeated visits to the healthcare network without obtaining a correct diagnosis, which results in non-specific antibiotic treatment, delayed diagnosis and difficulty in accessing specialized services (Cecílio; Teston; Marcon, 2017).

The **TB03** article allowed to know the paths taken by people under 15 years of age with TB in health services, according to reports from their caregivers and nurses from the Basic Health Units (UBSs). The main gateway to the health system was through the urgency and emergency services of hospitals and Emergency Care Units (UPAs), and the diagnosis of TB occurred in the hospitalization sector of children's hospitals, by means of image exams and pediatric infectologist. The distribution and control of medications were carried out by nurses at UBSs and the monitoring of cases was carried out in two health services concomitantly, since medical consultations were carried out in the services where the diagnosis of TB was made. Some of these aspects show the difficulty of professionals in urgent and emergency services to suspect and carry out confirmatory tests for TB in this age group and the fragility of the family bond with PHC (Pinto; Freitas, 2018).

It is also necessary to strengthen PHC actions by training nurses at different levels of care to increase suspicion and gain a better understanding of specific tests for the diagnosis of childhood TB. In addition, it is necessary to reinforce the importance of PHC as a gateway to the system, with users and professionals, with investments in dissemination, with UBS, to points of attention in the network, essential for the proper referral of people under 15 years with TB (Pinto; Freitas, 2018).

**Category 2- Qualification of nursing actions in the diagnosis of tuberculosis**

The **TB02** article addresses the nurse's care practices in which she must promote the active search for Respiratory Symptomatics (SR), as it is considered a public health activity and must be carried out permanently by all health professionals. However, the need to prepare these professionals to perform their work within the programmed actions of the policy is evident. Thus, often, TB patients go unnoticed in services due to excessive demand and the lack of doctors in some teams, or due to the lack of training of professionals to identify SR (Cecílio; Teston; Marcon, 2017).

When analyzing the article **TB04**, it was found that, in most cases, TB care and control actions are limited to consultations carried out in offices and often individually. The assistance provided to this patient comes from spontaneous demand or referral of secondary care, which is considered inefficient to interrupt the transmission chain, since the control is based on the search for cases, early and adequate diagnosis, its treatment until the cure, avoiding possible illnesses. This observation leads to the reflection that health actions need to be intensified from the perspective of comprehensiveness, allowing the expansion of care for users with TB, considering the complexity of the health-disease process and its various dimensions (Melo, et al., 2020).

Regarding strategies aimed at controlling and combating TB, it is important to note that the World Health Organization has established policies and strategies to strengthen the response capacity against TB. The most recent of these is the Directly Observed Treatment (DOT), the main objectives of which are patient compliance to standardized treatment with supervision of medication taking, social support, prevention of the appearance of drug-resistant strains, reduction of abandonment cases and increased probability of the patient's cure (Melo, et al., 2020).

In this sense, health actions need to be intensified from the perspective of comprehensiveness, allowing the expansion of care for users with TB, considering the complexity of the health-disease process and its various dimensions (Melo, et al., 2020).

The difficulty in seeking SR in the demand for services is directly associated with the way in which assistance is provided, in the lack of commitment, involvement and lack of dialogue with the user, with symptoms unnoticed (Melo, et al., 2020).

It is understood that the incorporation of TB control activities, especially the active search for SR, is not performed efficiently as a routine in the service. Therefore,

it is necessary that the teams start to have TB control incorporated into their daily work routine. If this search is not done, there is no way to close the cycle of early detection, treatment and cure (Melo, et al., 2020).

The lack of input can delay the diagnosis and the start of treatment, in addition to prolonging the time of transmission. The availability of inputs, therefore, is considered of vital importance to the sustainability of DOT, especially with regard to the viability of bacilloscopy. Sometimes TB treatment is hampered by the nurse's difficulty in dealing with his limitations, such as fear of acquiring the disease, either because he does not know how to face it, because of prejudice or because he does not have specific knowledge of the disease (Melo, et al., 2020).

In general, for the work of the PHC nurse to be qualified, based on the priority care for health promotion and disease prevention at all levels, it is necessary that this professional improves his knowledge with the incorporation of advanced practice which strictly monitors people with chronic diseases and tenuous acute pathologies, according to pre-established protocols (Melo, et al., 2020).

The results of this study reflect a practice that needs to be strengthened through permanent education, since inequities are still present among professionals in relation to instructional levels in Brazil, thus requiring a greater role for this subject in the face of attitudes and decision making. PHC decision-making in the context of disease prevention and health promotion, executing what is ideal, as opposed to the real, always instigating evidence-based practice (Melo, et al., 2020).

The **TB06** article addresses the description of the nurse's work process, in which the development of managerial and care actions and activities carried out with people with TB is identified. These actions and activities are often restricted to this professional category, due to the absence of involvement of other categories, mainly in relation to DOT, the recording of information in the green book and the holding of consultations (Rêgo, et al, 2015).

With regard to DOT, it was identified in the study by Rêgo et al. (2015), which is considered unnecessary by nurses to adhere to treatment. As a consequence, according to the guidelines of the Ministry of Health (2011), this can lead to a decrease in cases of cure, an increase in abandonment, resistance to the medication and, mainly, the rupture of the patient / professional bond. It was also observed that access to information through the records made by nurses is available to everyone on the team.

However, the fact that the records used are not computerized in all health units hinders the interaction between the reference services and the units in the patient care process. There was also difficulty in articulating the team's actions and overload of the nurse's work, with compromised care provided (Rêgo, et al, 2015).

It was concluded that the description of the nurses 'work process in PHC with the person with TB showed weaknesses, as well as nurses' work overload, which can interfere in adherence to health policies related to preventive and disease control actions (Rêgo, et al, 2015).

The **TB07** article highlights the potentialities of the TB control process within prisons where nurses must be engaged in strategic activities such as active search, as an instrument to increase passive case detection, as well as adequate communication of results. laboratories aiming at the immediate beginning of the treatment. For this, clinical evaluation was used by means of a questionnaire, which contributed to triple the detection of TB cases, which made it possible to recognize the weaknesses of this type of screening (Valença, et al, 2016).

The difficulties encountered in the implementation of the TB control process were linked to the interaction between prison and other health services, especially for exams and clinical follow-up inside and outside the prison, which inevitably had a negative impact on the closure of cases (Valença, et al, 2016).

The assumption that the control of TB, when approached by the detection and treatment of cases, has the planning of its actions contextualized to the particularities inherent to a specific prison environment, as well as to the network of services and workers involved in the control and TB research in each municipality and / or macro-region (Valença, et al, 2016).

**Category 3- Patient-related diagnostic delay factors**

In the **TB05** article, it was observed that, currently, social, economic and cultural barriers still interfere in the search for care and consequently delay the diagnosis and treatment of TB. However, the fact that they have access to the care units within their district, with no need for expenses to get from the place of residence to the UBS, in addition to the support they receive from health professionals and mainly because they have free medicine during all treatment of the disease, exclusively in the unit, favors the reduction of other barriers mentioned (Alves; Paulo; Santos et al, 2016).

Accessibility is not only related to getting to the service, but, everything that professionals will do so that the user remains in the unit from diagnosis to the end of treatment. TB control is linked to the improvement of factors included in health services, such as a reliable information system, expansion of decentralized care that

allows the implementation of supervised treatment, training of professionals, strengthening of teamwork and optimization of referral and counter-referral. The results of the study state that the late diagnosis of TB occurs, mainly, due to cultural factors until the first search for medical assistance. For professionals, users choose to look for UBS as a gateway when presenting any symptoms, however there is little demand that prefers alternative therapies (Alves; Paulo; Santos et al, 2016).

Most of the time, what determines the search for UBS is the way users face the disease. For there to be contact with these units, it is necessary to have confidence and it is up to the health professional to interact with this individual, since there is almost always resistance to treatment adherence by the same and it will be up to health professionals, including nurses, offer the provision of qualified assistance. TB treatment attracts significant costs, both for the family and the patient, and each expense that arises represents a barrier of access linked to social and economic factors. In reality, the user is not always able to afford additional expenses, such as transportation, looking for a UBS that is close to their home, a fact presented in the results with the low percentage of the number of users who pay for transportation to arrive up to that unit (Alves; Paulo; Santos et al, 2016).

It was observed that the economic factor tends to minimally influence the early diagnosis of TB, considering that over the years improvements have been achieved that help the bearer of the disease to face expenses that may arise and difficulties faced related most of the time by excessive working hours or any other factor that does not allow you to attend the unit. Cultural and social aspects are more decisive, given that the user refuses to undergo basic tests to detect the disease, such as smear microscopy due to lack of knowledge resulting from few health education actions (Alves; Paulo; Santos et al, 2016).

As a way of easing barriers in treatment, it is proposed to practice workshops with FHS professionals in order to discuss the issue, raise possible critical nodes in care, plan interventions and give feedback to clients, who are the center of care (Alves; Paulo; Santos et al, 2016).

## IV.   CONCLUSION

From this study it was possible to understand about the magnitude of the problems inherent to society as a whole, of a political and social order, as well as the health system and the organization of the health services that comprise it and influence the delay in diagnosis. However, the importance of PHC in the process of decentralization of

primary care services and in equitable and comprehensive access to the patient is emphasized.

The professionals' speeches demonstrate that there are still obstacles to full access to TB diagnosis, largely due to the incompleteness of decentralization to the municipalities. Decentralization allows equitable and comprehensive access to patients close to their home, however, centralization has offered greater availability of resources for diagnosis. Among the other factors, the team's difficulty in suspecting TB is noted, even in the face of signs and symptoms, and in finding respiratory symptoms, whether due to lack of information from the population or the team's lack of preparation.

Furthermore, the need to pass on information about the disease to the general population is reiterated, more specifically about signs, symptoms, form of transmission and treatment, including emphasizing the possibility of a good prognosis when carrying out the appropriate treatment. Such clarifications are necessary to alleviate the population's stigma about the disease and reduce the patient's delay in seeking care, thus achieving a quick diagnosis and consequently treatment with fewer complications.

### REFERENCES

[1] Alves, J.C.F. et al. 2016. Barreiras socioeconômico-culturais que retardam o diagnóstico da tuberculose. Rev. enferm. UFPE on line, p. 4021-4027. DOI: 10.5205/reuol.9881-87554-1-EDSM1011201625 [Accessed: 04 set. 2020].

[2] Barrêto, A.J.R. et al. 2013. Gestão do cuidado à tuberculose: da formação à prática do enfermeiro. Revista Brasileira de Enfermagem, vol. 66, núm. 6, noviembre-diciembre, pp. 847-853 Associação Brasileira de Enfermagem, Brasília, Brasil. Disponível em: http://www.redalyc.org/articulo.oa?id=267029915006 [Accessed: 12 mar. 2020].

[3] Belkina, T. V. Delay in the diagnosis and treatment of pulmonar tuberculosis in Uzbekistan: a cross-sectional study. BMC Infectious Diseases. v. 14, n. 624, 2014. Disponível em: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4248454/ [Accessed: 12 mar. 2020].

[4] Brasil, Ministério da Saúde, Secretaria de Vigilância em Saúde, & Departamento de Vigilância Epidemiológica. (2011). Tratamento Diretamente Observado (TDO) da tuberculose na atenção básica: protocolo de enfermagem.

[5] Brasil. 2020. Secretaria de Vigilância em Saúde. Boletim Epidemiológico Especial. Tuberculose 2020. Ministério da Saúde. Brasília, DF. Available: <https://www.saude.gov.br/images/pdf/2020/marco/24/Boletim-tuberculose-2020-marcas--1-.pdf> [Accessed: 15 abr. 2020].

[6] Cecilio, H.P.M; Teston, E.F.; Marcon, S.S. Acesso ao diagnóstico de tuberculose sob a ótica dos profissionais de

saúde. Texto & Contexto-Enfermagem, v. 26, n. 3, 2017. [Accessed: 04 set. 2020].

[7] De Melo, L.S.O. et al. Passos e descompassos no processo de cuidado aos portadores de tuberculose na atenção primária à saúde. Enfermagem em Foco, v. 11, n. 1, 2020. [Accessed: 04 set. 2020].

[8] Lafaiete, R. S.; et al. The delay in diagnosis of tuberculosis. J. res.: fundam. care. Online. v. 5, n. 3, p. 174-180, 2013. Disponível em: http://www.scielo.br/pdf/jbpneu/v 37n4/ v37n4a14.pdf [Accessed: 12 mar. 2020].

[9] Mendes, K. D. S.; Silveira, R. C. C. P.; Galvão, C. M. 2008. Revisão integrativa: método de pesquisa para a incorporação de evidências na saúde e na enfermagem. Texto e Contexto Enferm., 17(4):758-64. Available: <https://doi.org/10.1590/S0104-07072008000400018> [Accessed: 15 jul. 2020].

[10] Pinto, J.T.J.M; Freitas, C.H.S.M. Caminhos percorridos por crianças e adolescentes com tuberculose nos serviços de saúde. Texto & Contexto-Enfermagem, v. 27, n. 1, 2018. [Accessed: 04 set. 2020].

[11] Polit, D.F.; Beck, C.T.; Hungler, B.P. 2011. Fundamentos de pesquisa em enfermagem: métodos, avaliação e utilização. 7ª Ed. Porto Alegre: Artmed.

[12] Popolin, M.P. et al. Conhecimento sobre tuberculose, estigma social e a busca pelos cuidados em saúde. Rev. Bras. Pesq. Saúde, Vitória, 17(3): 123-132, jul-set, 2015. Disponível em: http://periodicos.ufes.br/RBPS/article/viewFile/14144/9973 [Accessed: 12 mar. 2020].

[13] Rêgo, C.C.D. et al. Processo de trabalho da enfermeira junto à pessoa com tuberculose na Atenção Primária à Saúde. Revista Baiana de Enfermagem, Salvador, v. 29, n. 3, p. 218-228, jul./set. 2015. DOI: http://dx.doi.org/10.18471/rbe.v29i3.13038 [Accessed: 04 set. 2020].

[14] Sá, Lenilde Duarte de. et al. Porta de entrada para diagnóstico da tuberculose em idosos em municípios brasileiros. Rev Bras Enferm. 2015 mai-jun;68(3):467-73. http://dx.doi.org/10.1590/0034-7167.2015680313i [Accessed: 04 set. 2020].

[15] Saifodine, A. et al. Patient and health system delay among patients with pulmonary tuberculosis in Beira city, Mozambique. BMC Public Health. v. 13, n. 559, 2013. Disponível em: https://bmcpublichealth.biomedcentral.com/articles/10.1186/ 1471-2458-13-559 [Accessed: 12 mar. 2020].

[16] Salzani, M. G. B.et al. 2017. Diagnóstico de tuberculose: perspectiva do profissional de enfermagem da atenção primária. REFACS (online); 5(2):180-190. Available: <http://www.seer.uftm.edu.br/revistaeletronica/index.php/ref acs> [Accessed: 12 mar. 2020].

[17] Trigueiro, D.R.S.G. et al. A influência dos determinantes individuais no retardo do diagnóstico da tuberculose. Texto & Contexto Enfermagem, vol. 23, núm. 4, octubre-diciembre, 2014, pp. 1022-1031. Universidade Federal de Santa Catarina, Brasil. Disponível em: http://www.redalyc.org/articulo.oa?id=71433508025 [Accessed: 12 mar. 2020].

[18] Valença, M.S. et al. O processo de detecção e tratamento de casos de tuberculose em um presídio. Ciência & Saúde Coletiva, v. 21, p. 2111-2122, 2016. DOI: 10.1590/1413-81232015217.13822015 [Accessed: 04 set. 2020].

# Growth and accumulation of macronutrients in arugula

Eric George de Morais[1], Martiliana Mayani Freire[2], Anna Yanka de Oliveira Santos[3], Gualter Guenther Costa da Silva[4], Ermelinda Maria Mota Oliveira[5], Laís Barreto Franco[6], Gleyse Lopes Fernandes de Souza[7]

[1]Department of Agricultural and Forestry Sciences,Federal Rural University of the Semiarid Region, Brazil
[2]Department of Biosystems Engineering, University of São Paulo, Brazil
[2,3,4,5]Department of Agronomy, Federal University of Rio Grande do Norte, Brazil
[6]Department of Agricultural Engineering, Federal Rural University of Pernambuco, Brazil
[7]Department of Phytotechnics and Environmental Sciences, Federal University of Paraíba, Brazil

*Abstract—In Brazil, arugula is a vegetable often consumed in salads because it provides a flavorful option when paired with blander lettuces and because it is considered rich in vitamins A and C, potassium, sulfur and iron. However, several aspects of fertilization management for this crop must be studied further. Thus, the objective of this work was to determine the growth and accumulation of macronutrients within arugula, under field conditions. The experiment was conducted in four parcels (vegetable beds) with dimensions of 5.0 x 0.2 x 1.3 m, located within an experimental area of 54 m² (6.0 x 9.0 m). The Arugula cv. Cultivated, with seedlings produced in a protected environment. Standard fertilization was performed with 160 kg ha$^{-1}$ of N, 340 kg ha$^{-1}$ of P$_2$O$_5$, 160 kg ha$^{-1}$ of K$_2$O, 20 kg ha$^{-1}$ of S and 1 kg ha$^{-1}$ of B. The treatments were constituted by different collection times at 7, 14, 21, 28, 35 and 42 days after the arugula seedlings transplanting. Between 18 and 38 days after the transplanting of the seedlings, a significant increment in the accumulation of dry matter occurred. In the period between 20 and 30 days after the transplanting, the greatest demand for most macronutrients occurred. The order of macronutrient accumulation by arugula at 42 days was as follows: K > N >Ca> P > Mg > S.*

*Keywords—Eruca sativa Miller, Fertilization, Nutrient extraction.*

## I. INTRODUCTION

Arugula is a small herbaceous plant with elongated leaves and deeply cut limbus showing an average height of 10 to 30 cm in the harvest period. It has favorable development in mild temperatures with the harvest performed between 35 to 50 days after planting being able to do even 3 cuts depending on management conditions and variety [8], [27].

Although this plant is more adapted to temperate climate [8], arugula has important requirements for performance in the northeast region of Brazil given that its cycle and form of conduction resemble those of species widely cultivated in the region, like lettuce and coriander. In addition to the sharp growth in consumption when compared to other vegetables with a planted area of 6000 ha year$^{-1}$,being that 85% of this national production is concentrated in the southeast region [23].

Arugula production can be influenced by several factors linked to management strategies, as inappropriate irrigation blade, climate, cultural practices, pest and disease control, and, mainly, availability of nutrient for the plant due to adequate crop fertilization is one of the most important attributes for crop productivity [3]. In this sense, the knowledge of the number of nutrients accumulated in plants enables the adoption of strategies in the crop fertilization program [25].

A nutrient absorption march is a tool adopted in crops for informing in the form of response curves as a function of plant age, periods of higher nutrient absorption, as well as the largest quantities, indicating the times of greatest nutritional demand, thus constituting a tool of great importance for the management and fertilization of crops [32]. Some studies on growth and accumulation of nutrients in vegetables have been carried out on tomatoes [5], beet [25], eggplant [28], and lettuce [26].

Regarding the arugula, there is little information in the literature about the higher demand for nutrients required by the crop, as well as the total amount extracted of nutrients requiring research on the accumulation of nutrients, because this technique related to the productivity gain of the culture is understudiedin the country.

These surveys become even more important when carried out on soils that show wide variability in their physical characteristics, chemical and morphological. As is the case with QuartzarenicNeosols which according to the diversity of its source material and its low degree of pedogenetic development, there are soils that can have high, medium, and even low agricultural potential [24].

Given the above information, the present work was developed to determine the growth rate and accumulation of arugula macronutrients, during its production cycle, under field conditions.

## II.     METHODOLOGY

The experiment was carried out over February to April 2017 in an experimental area of the Soil Study Group at the Agricultural School of Jundiaí (EAJ), belonging to the Federal University of Rio Grande do Norte (UFRN), Macaíba/RN RN (5° 53' 35.12" latitude-S e 35° 21' 47.03" longitude-W).

The soil in the experimental area was classified in the Brazilian Soil Classification System as QuartzeneNeossol [24]. The chemical characterization of the soil (Table 1) was carried out following the procedures proposed by [30].The climate of the region, according to the Koppen classification is included between the types As' and BSh' featured with rainy and hot summer, and dry winter with an average annual temperature of 27.1 °C, an average maximum temperature of 32°C and an average minimum temperature of 21°C, and the average annual rainfall between 800 and 1,200 mm [10].

*Table 1. Soil chemical characterization of the experimental area before the implementation of the experiment.*

| Soilchemicalcharacterization | Collectiondepth (cm) | |
|---|---|---|
| | 0-10 | 10-20 |
| pH $H_2O$ | 4,9 | 4,28 |
| P (mg $dm^{-3}$) | 19 | 14 |
| K (mg $dm^{-3}$) | 166 | 117 |
| Na (mg $dm^{-3}$) | 46 | 40 |
| Ca (mg $dm^{-3}$) | 1,11 | 0,89 |
| Mg (cmolc $dm^{-3}$) | 0,6 | 0,45 |
| Al (cmolc $dm^{-3}$) | 0,05 | 0,1 |
| H+Al (cmolc $dm^{-3}$) | 2,39 | 2,22 |
| SB (cmolc $dm^{-3}$) | 2,34 | 1,81 |
| CTC (cmolc $dm^{-3}$) | 4,73 | 4,03 |
| V (cmolc $dm^{-3}$) | 49,42 | 44,97 |

The experiment was conducted in four plots with dimensions of 5.0 meters long, 0.2 meters high, and 1.30 meters wide, located within an experimental area of 54 $m^2$ (6.0 x 9.0 m). Arugula cv. Cultivated with seedlings produced in styrofoam trays of 200 cells, using organic compost as a substrate.

The seedlings remained in a protected environment, and at 21 days, counted from sowing, were transplanted in the definitive beds, using the spacing of 0.25 x 0.25 meters. The treatments consisted of different collection times (7, 14, 21, 28, 35 e 42 days after transplanting the seedlings), distributed based on the arugula cultivation cycle.

To increase the pH, it was necessary to correct (liming) the soil in the experimental area 30 days before the beginning of the experiment.The fertilization of foundation and cover was performed considering the analytical results of Table 1, applying in all experimental plots 160 kg $ha^{-1}$ of N, 340 kg $ha^{-1}$ of $P_2O_5$, 160 kg $ha^{-1}$ of $k_2O$, 20 kg $ha^{-1}$ of S and 1 kg $ha^{-1}$ of B, in the form of urea, triple superphosphate, potassium chloride, ammonium sulfate and FTE BR 12 (source of micronutrients), respectively.

The foundation fertilization was carried out at the time of transplanting the seedlings, applying 20% of total nitrogen and potassium, and 100 % of phosphorus and boron. The cover fertilization was divided into two applications at 11 and 21 days after transplanting, applying 40% of the total nitrogen and potassium in each fertilization. Fertilization was carried out in furrows, made manually with the aid of three-tooth rakes, 5.0 cm from the seedlings.

Irrigation was performed daily using a micro-sprinkler system. The reach of the micro-sprinklers was around 4.5 m, being installed along the beds, every 3.0 m so that all plots were equally irrigated. For the irrigation depth and the irrigation shift, the type of soil, the arugula development stage, and the region's climate were taken into account, applying 3.8 mm $day^{-1}$.

The evaluation of dry matter accumulation and macronutrient accumulation (N, P, K, S, Ca e Mg) was carried out from the collection of six healthy plants from each plot. The first collection was performed at 7 days after transplanting the seedlings (DAT), and the remainder with

an interval of 7 days for the next collection. Each collection was carried out randomly, always in the morning. In all, six collections were performed at 7, 14, 21, 28, 35, and 42 days after transplanting the seedlings. The plants were cut close to the ground with stainless scissors, placed in properly identified trays, and sent to the Gesolo laboratory. The estimate of the average height of the plants (cm) was made at all times of collection, measuring with the aid of a graduated ruler 6 plants in the central lines of each repetition.

In the laboratory, the plants were washed with distilled water, placed in paper bags identified according to the treatment, and then sent to the forced air circulation oven, at a temperature of 65 ºC, until reaching constant weight. After this period the samples had their dry matter estimated, using an analytical balance. With the dry matter values of each collection, together with the crop spacing used in this experiment, it was possible to determine the arugula dry matter accumulation in "t ha$^{-1}$" throughout its development cycle.

With the estimated dry matter, the rocket samples were ground in a Willey mill; and then sent to the plant tissue analysis laboratory of the Agricultural Research Corporation of Rio Grande do Norte (EMPARN), where they were subjected to chemical analysis to quantify the levels of macronutrients (N, P, K, S, Ca e Mg), following the methodology proposed by [17]. The accumulation of arugula nutrients over the growing cycle was calculated by multiplying the macronutrient (N, P, K, S, Ca e Mg) contents by the accumulation of dry matter.

The effects of the collection periods on the growth and accumulation of macronutrients were evaluated by regression analysis, using the statistical software Sisvar, version 4.6 [7]. To explain the behavior of the analyzed variables, non-linear regression models were used, using the sigmoidal function $\hat{y} = a/(1+e-(x-xo/b))$, where: $\hat{y}$ = dependent variable; a = maximum point of the curve; e = base of the Neperian logarithm, b = adjustment parameter; x = independent variable; and, xo = inflection point (point at which the maximum rate of variation of the function occurs).

The curves with the macronutrient accumulation rates were obtained using the first-order derivative of the equation, equal to zero [19], [6]. The points of minimum curvature (PCmin) and maximum (PCmax) were also evaluated, according to the method mentioned by [31], using the parameters of non-linear equations, where: PCmin = xo - 2b; e, PCmax = xo + 2b. The PCmim indicates the moment on the curve when expressive gains

begin in each analyzed variable. On the other hand, PCmax expresses the moment when these gains start to stabilize.

## III. RESULTS

Mineral fertilization showed good productive performance for the plant height and dry matter accumulation variables. When analyzing the growth variables along the productive cycle, it is observed, from the second day after transplanting the seedlings (DAT), a considerable increase in the height of the arugula plant up to 27 DAT, and after that period there was stabilization in the height increase, with an average of 25.82 cm plant$^{-1}$ (Figure 1A).



$$y = 29.3183/(1+\exp^{-((x-14.7065)/6.3187)})$$
$$R^2 = 0.99^{**}$$



$$y = 3.4998/(1+\exp^{-((x-27.8988)/5.0575)})$$
$$R^2 = 0,99^{**}$$
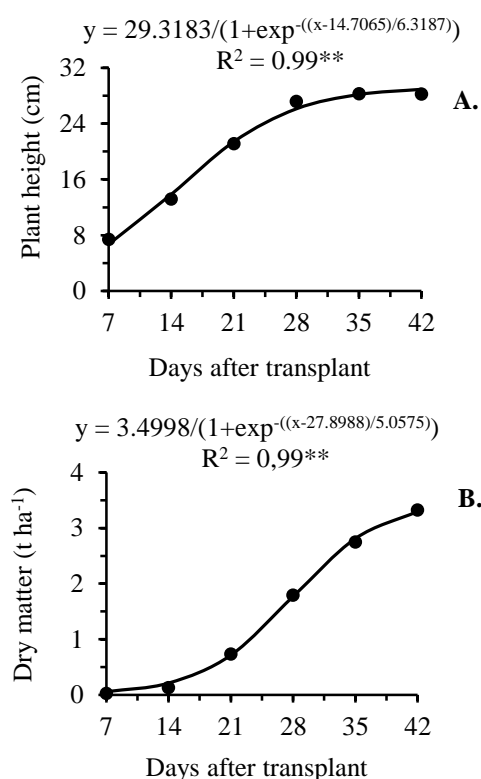
*Fig.1: Height (A) and dry matter accumulation (B) of arugula plants, as a function of different collection times*

In general, the number of nutrients accumulated by the rocket plants was directly related to the increase in height and accumulation of dry matter. It was observed that in the first days after the transplant, the accumulations are modest and similar. From the 20 DAT onwards, there was a marked increase in the accumulation of these nutrients, which increased considerably until the end of the cycle, with larger leaves and darker color.

At the beginning of the arugula development, dry matter gains occurred slowly, with relatively low values being observed up to 18 DAT(Figure 1B). After this period

it was possible to observe a rapid increase in the accumulation of dry matter (PCmin), with an average production of 416.88 kg ha$^{-1}$. At 38 DAT, the arugula dry matter accumulation began to stabilize (PCmax), with production around 3,080.33 kg ha$^{-1}$. During this period (18 to 38 DAT), there was an increase of 86% in the arugula dry matter accumulation.

Nitrogen was the second most accumulated nutrient by rocket plants, reaching a maximum of 536.16 kg ha$^{-1}$ at the end of the cycle (42 DAT). The accumulation of nitrogen was initially very slow, similar to that observed with the accumulation of dry matter (Figure 1B), but after 16 DAT (PCmin) nitrogen extraction was accentuated, tending to stabilize at around 29 DAT (PCmax) (Figure 2A). At around 23 DAT, the highest nitrogen accumulation rate occurred (45.64 kg ha$^{-1}$ day$^{-1}$) (Figure 2B).



$$y = 562.7085/(1+\exp^{-((x-22.6021)/3.0814)})$$
$$R^2 = 0.99**$$
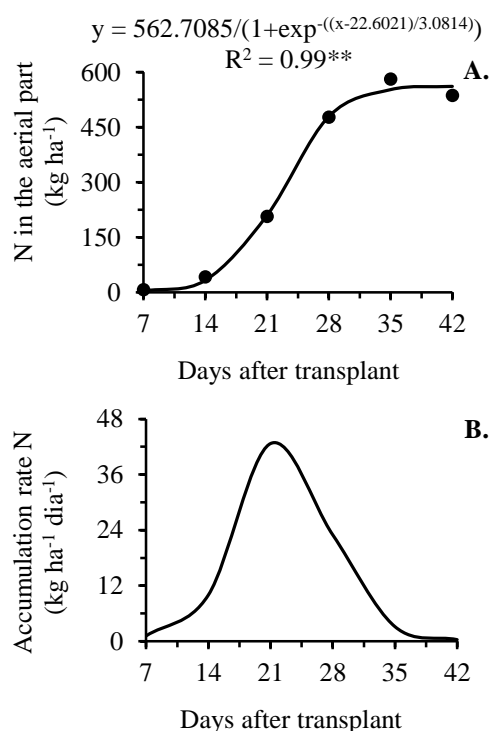
*Fig.2: Accumulation (A) and daily accumulation rate (B) of nitrogen from arugula plants, as a function of different seasons collections*

In decreasing order of accumulation of macronutrients in the aerial part of the arugula, analyzed in this work, phosphorus occupies the fourth place. PCmim and PCmax for this nutrient occurred at 21 and 41 DAP (Figure 3A), accumulating an average of 24.83 and 183.44 kg ha$^{-1}$, respectively. The highest demand for phosphorus by arugula plants occurred at 31 days (Figure 3B), with an accumulation rate of 10.49 kg ha$^{-1}$ day$^{-1}$; in that period the plant accumulated 104.13 kg ha$^{-1}$, corresponding to 55% of

the total accumulated by the plants at the end of the cycle at 42 DAT (Figure 3A).



$$y = 208.2640/(1+\exp^{-((x-30.6185)/4.9630)})$$
$$R^2 = 0.99**$$
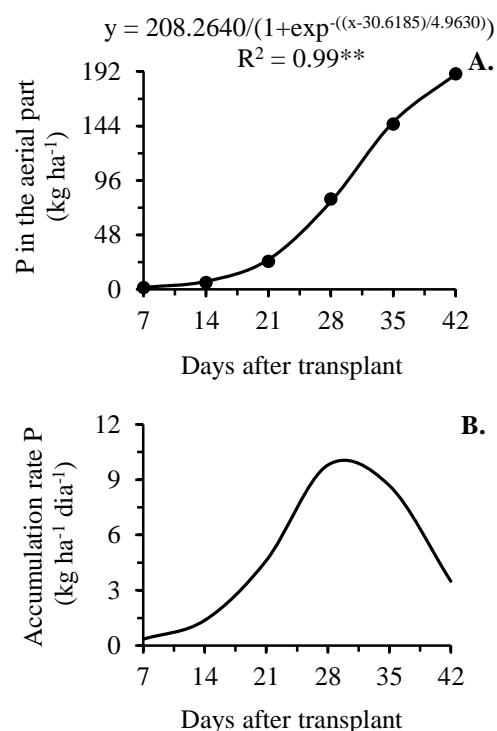
*Fig.3: Accumulation (A) and daily accumulation rate of phosphorus (B) from arugula plants, as a function of different seasons collections*

Throughout the development of arugula, potassium was the nutrient most extracted by plants (Figura 4A). Similar to that observed in Figure 2A, initially the accumulation of potassium was very slow, with the expressive gains starting at around 20 DAT (PCmim), accumulating about 153.23 kg ha$^{-1}$. At 33 DAT the accumulation of potassium started to stabilize (PCmax), with production around 1,132.32 kg ha$^{-1}$. The highest accumulation rate for this nutrient occurred around 27 DAT, accumulating an average of 99.12 kg ha$^{-1}$ day$^{-1}$ (Figure 4B).
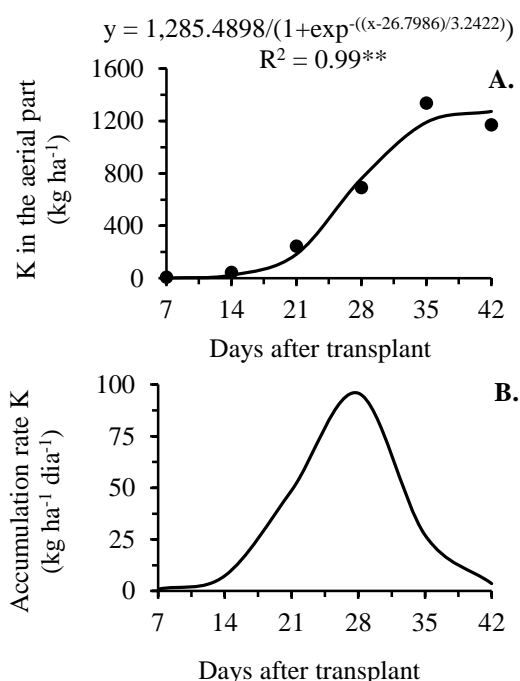
*Fig.4: Accumulation (A) and daily accumulation rate of potassium (B) from arugula plants, as a function of different seasons collections*

At the end of the cycle, at 42 DAT, sulfur was the least exported macronutrient by arugula plants. The largest accumulations of sulfur were observed in the period from 18 to 36 DAT, corresponding, respectively, to 15.99 and 118.18 kg ha$^{-1}$ (Figure 5A).
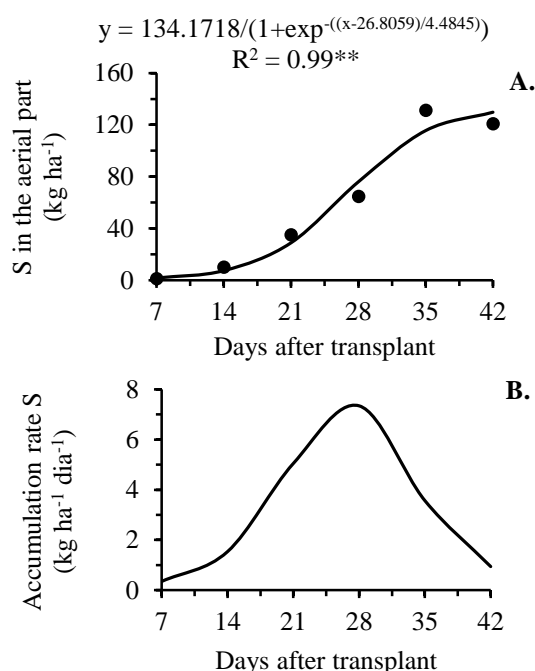


*Fig.5: Accumulation (A) and daily accumulation rate of sulfur(B) from arugula plants, as a function of different seasons collections*

The highest demand for sulfur by arugula plants occurred at 27 DAT, with an accumulation rate of 7.48 kg ha-1 day$^{-1}$(Figure 5B). At that time, at 27 DAT, the arugula plants accumulated 67.09 kg ha$^{-1}$, which corresponds to 55% of the total accumulated at the end of the cycle.

PCmim and PCmax for calcium occurred at 20 and 38 DAT (Figure 6A), accumulating an average of 42.42 and 313.46 kg ha$^{-1}$, respectively. The highest rate of calcium accumulation by arugula plants occurred at 29 DAT (20.34 kg ha$^{-1}$ day$^{-1}$) (Figure 6B), and at that time, around 53% of the calcium needed for the development of the crop accumulated (177.94 kg ha$^{-1}$) (Figure 6A); from that moment, the accumulation gradually decreased, reaching the end of the cycle (42 DAT) with 331.69 kg ha$^{-1}$, occupying the third place of the most accumulated macronutrient in the aerial part of the arugula.
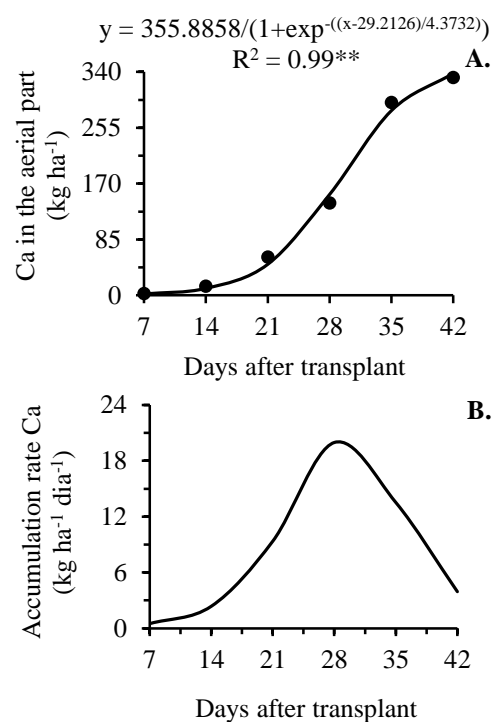


*Fig.6: Accumulation (A) and daily accumulation rate of calcium (B) from arugula plants, as a function of different seasons collections*

At 42 days after transplanting the seedlings, magnesium was the fifth macronutrient that most exported by arugula plants, with an average accumulation of 134.79 kg ha$^{-1}$ (Figure 7A). The significant increases in magnesium accumulation started at 21 DAT (PCmin), extracting about 17.15 kg ha$^{-1}$, and started to stabilize by 36 DAT, with 126.73 kg ha$^{-1}$. At 28 DAT, the largest export of magnesium to the aerial part of the arugula plants was observed, approximately 9.59 kg ha$^{-1}$ day$^{-1}$ (Figure 7B).

$$y = 143.8788/(1+\exp^{-((x-28.1741)/3.7503)})$$
$$R^2 = 0.99**$$

A.

B.
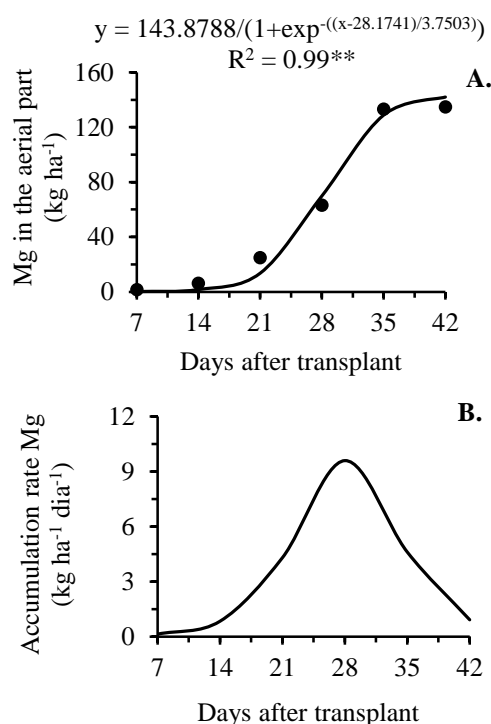
*Fig.7: Accumulation (A) and daily accumulation rate of magnesium (B) from arugula plants, as a function of different season's collections*

## IV. DISCUSSION

The positive performance of the plant height and dry matter accumulation variables was possibly due to the application of nitrogen since although arugula is not a large crop, it requires a large number of nutrients at the end of the cycle. Therefore, nitrogen fertilization promoted greater development of arugula plants, ensuring better characteristics of commercial interest to the vegetable such as the size and color of the leaves [25].

According to [12], it is common in leafy vegetables, the plants initially present a slow phase of dry matter accumulation, intensifying at the end of the cycle. [22], also found a low accumulation of dry matter at the beginning of the arugula cycle and intensified until 43 days after sowing. This behavior can be explained, probably, because at the beginning of the development, the leafy vegetables present a low supply of leaves and roots, consequently, a lower production of photoassimilates and absorption of nutrients, resulting in lower accumulation of dry matter.

The availability of nitrogen in the soil is almost always a limiting factor that influences plant growth more than any other nutrients [4]. This is because nitrogen is an essential constituent of many proteins and directly interferes with the photosynthetic process, due to its participation in the

chlorophyll molecule [16], hence the similarity between the nitrogen accumulation rate (Figure 2B) and the dry matter accumulation rate (Figure 1B).

Phosphorus is one of the essential nutrients for plant growth [11], as it plays a structural role and is linked to several important metabolic processes, such as energy transfer and storage, which can affect several others, such as protein and nucleic acid synthesis [29]. [14]when evaluating the effects of phosphorus doses on the arugula production, found that this nutrient provides an increase in the vegetative growth and productivity of this vegetable since P stimulates the growth and formation of the root system at the beginning of the development of cultivated plants.

Potassium, being the most accumulated macronutrient in vegetables [8], plays important roles, such as enzyme activation, photosynthesis, translocation of assimilates and protein synthesis, thus making it fundamental to plant growth and nutrition [12]. In general, the absorption of potassium, as well as nitrogen and phosphorus, follows the same trend as the biomass accumulation rate of the crop [13].

Sulfur influenced leaf color, playing a crucial role in the growth of arugula plants and adaptation to stress, also acting on the activation of the nitrate reductase enzyme, improving nitrogen metabolism, due to the synergistic action of sulfur and nitrogen [9], [27]. However, sulfur is considered to be an immobile nutrient in the plant, with a very low rate of redistribution after reaching some plant organs, such as old leaves [29].

When studying the sulfur cover fertilization in the arugula culture, similar to the present study, [27] observed that sulfur fertilization caused the greater intensity of green color in the arugula leaves, providing better product quality, making the arugula more attractive to the consumer, corroborating with [12] when studying the growth and accumulation of nutrients in coriander and arugula.

In agreement with what was found in this work, [12] reported that calcium was the third most exported macronutrient by arugula plants. As calcium is an element that has low mobility in the plant [20], its availability in the soil solution for plants, as well as its absorption by plants, is essential for maintaining the integrity of the plasma membrane [33]. Also, it plays a critical role in cell division and development, in the structure of the cell wall and, the formation of the middle lamella [15].

Magnesium is one of the most widely used macronutrients by plants, but in smaller portions than nitrogen and potassium. In general, it is similar to

phosphorus, sulfur, and calcium, as observed in this work. Of the existing nutrients, magnesium is essential in photosynthesis, since its main function is to be the central atom of the chlorophyll molecule, in the green leaves of plants. The amount of magnesium in the central atom of chlorophyll corresponds to 2.7% of its weight and represents around 15 to 20% of the total magnesium present in the plant [29].

In general, the results obtained in the present study show a greater demand for nutrients by the arugula plant as the end of the cycle approaches. This fact occurs due to the increase of matter and accumulation of nutrients that occur in hardwoods after the initial phase of the culture, whose period corresponds to about 2/3 of the cycle [12], as observed by [1] when studying the growth and accumulation of macronutrients in vegetables.

# V. CONCLUSION

Between 18 and 38 days after transplanting the arugula seedlings, there was a significant increase in dry matter accumulation from 0.42 to 3.08 t ha-1. The period of greatest demand for arugula in nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium was 23, 31, 27, 27, 29, and 28 days after transplanting the seedlings, respectively. Arugula plants accumulate nutrients in their shoot at 42 days after transplanting the seedlings in the following order: K (1.169,29 kg ha$^{-1}$) > N (536,16 kg ha$^{-1}$) >Ca (331,60 kg ha$^{-1}$) > P (189,95 kg ha$^{-1}$) > Mg (134,79 kg ha$^{-1}$) > S (120,91 kg ha$^{-1}$).

# REFERENCES

[1] Aguiar Neto, P.; Grangeiro, L. C.; Mendes, A. M. S.; Costa, N. D.; Marrocos, S. T. P.; Sousa, V. F. L. Crescimento e acúmulo de macronutrientes na cultura da cebola em Baraúna (RN) e Petrolina (PE). RevistaBrasileira de EngenhariaAgrícolaAmbiental, v.18, n.4, p.370–380,2014.

[2] Avalhães, C. C.; Prado, R. M.; Romualdo, L. M.; Rozane, D. E.; Correia, M. A. R. Omissão de macronutrientes no crescimento e no estado nutricional de plantas de repolho cultivado em solução nutritiva. Bioscience Journal, Uberlândia, v. 25, n. 5, p. 21-28,2009.

[3] Bhuvaneswari, G.; Sivaranjani, R.; Reetha, S.; Ramakrishan, K. Application of nitrogen fertilizer on plant density, growth, yield and fruit of bell peppers (*Capsicum annuum* L.). International Letters of Natural Sciences, v. 8, n. 2, p. 81-90,2014.

[4] Bredemeier, C.; Mundstock, C. M. Regulação da absorção e assimilação do nitrogênio nas plantas. Ciência Rural, Santa Maria, v. 30, n. 2, p. 365-372,2000.

[5] Félix, A. C. A.; Silva, F. A. C.; Guedes, I. M. R.; Lima, C. E. P.; Silva, J. Acúmulo e exportação de nutrientes pelo tomateiro BRS Nagai. In: XXXV Congresso Brasileiro de Ciência do Solo, Natal, Anais, p. 1-4, 2015.

[6] Fernandes, A. M.; Soratto, R. P.; Silva, B.L.; Souza-Schlick, G.D. Crescimento, acúmulo e distribuição de matéria seca em cultivares de batata na safra de inverno. PesquisaAgropecuáriaBrasileira, Brasília, DF, v. 45, n. 8, p. 826-835,2010.

[7] Ferreira, D. F. Sisvar: a Guide for its Bootstrap procedures in multiple comparisons. Ciência e Agrotecnologia, v.38, n.2, p.109-112,2014.

[8] Filgueira, F. A. R. Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças. Viçosa-MG: UFV, 412p.,2003.

[9] Forzani, C.; Duarte, G. T.; Meyer, C. The plant target of rapamycin kinase: a connecTOR between sulfur and growth. Trends in Plant Science, v. 23, n. 6, p. 472- 475, 2018.

[10] IDEMA. Instituto de Desenvolvimento Sustentável e Meio Ambiente do Rio Grande do Norte. Perfildo seu município, Macaíba-RN,2013. Acessado em 20 de abril de 2019. Disponível em: <http://adcon.rn.gov.br/ACERVO/idema/DOC/DOC000000 000016679.PDF>

[11] Irfan, M.; Khan, J. M.; Ali, A.; Jan, A.; Parveen, S. Effect of Phosphorus and Sulfur on the yield and nutrient uptake of maize. Agro-Science. Journal of Tropical Agriculture, Food, Environment and Extension. Volume 15, 2 May, pg. 1-8,2016.

[12] Grangeiro, L. C.; Freitas, F. C. L.; Negreiros, M. Z.; Marrocos, S. T. P.; Lucena, F. R. M.; Oliveira, R. A. Crescimento e acúmulo de nutrientes em coentro e rúcula. RevistaBrasileira de CiênciasAgrárias. Recife, v.6, n.1, p.11-16,2011.

[13] Kano C.; Cardoso A. I. I.; Villas Bôas, R. L. Acúmulo de nutrientes pela alface destinada à produção de sementes. HorticulturaBrasileira; v. 29, n. 1, 2011.

[14] Koetz, M.; Carvalho, K. S.; Bonfim-Silva, E. M.; Rezende, C. G.; Silva, J. C. Rúcula submetida a doses de fósforo em Latossolo Vermelho do cerrado. *EnciclopédiaBiosfera*, Centro CientíficoConhecer, Goiânia, v.8, n.15, p.1554,2012.

[15] MALAVOLTA, E. Manual de nutrição mineral de plantas. São Paulo: Agronômica Ceres, 631 p., 2006.

[16] Martuscello, J. A.; Majerowicz, N.; Cunha, D. N. F. V.; Amorim, P. L. ; Braz, T. G. S. Características produtivas e fisiológicas de capim-elefante submetido à adubação Nitrogenada. Archivos de Zootecnia, v. 65, n. 252, p. 565-570,2016.

[17] Miyazawa, M.; Pavan, M. A.; Muraoka, T.; Carmo, C. A. F. S.; Melo, W. J. Análise química de tecido vegetal. In: Silva, F.C. Manual de análises químicas de solos, plantas e fertilizantes. 2ª ed. rev., ampl. Brasília, Embrapa Informação Tecnológica, Cap. 2, p.191-233, 2009.

[18] Mota, J. H.; Yuri, J. E.; Resende, G. M.; Oliveira, C. M.; Souza, R. J.; Freitas, S. A. C.; Rodrigues Júnior, J. C. Produção de alface americana em função da aplicação de doses e fontes de fósforo. HorticulturaBrasileira. Brasília, v. 21, n. 4, out. / dez., p. 620-622,2003.

[19] Moustakasa, N. K.; Ntzanisb, H. Dry matter accumulation and nutrient uptake in flue-cured tobacco (*Nicotianatabacum* L.). Field Crops Research, Amsterdam, v. 94, n. 1, p. 1-13,2005.

[20] Quadros, B. R.; Magro, F. O.; Corrêa, C. V.; Cardoso, A. I. I. Teor de macronutrientes na parte aérea e sementes de plantas de alface em função de doses de composto orgânico com e sem adição de fósforo ao solo. *CiênciasAgrárias*, Londrina, v. 32, suplemento 1, p. 1725-1734,2011.

[21] Raij, B. V. Fertilidade do solo e manejo de nutrientes. Piracicaba: PNI, 420p.,2011.

[22] Rezende, B. L. A.; Cavarianni, R. L.; Cecílio Filho, A. B.; Coelho, R. L.; Purqueiro, L. F. V. Acúmulo de massa fresca e seca em rúcula, cultivada na primavera, em Jaboticabal-SP. In: Congresso Brasileiro de Olericultura, Recife. Anais. Recife: SOB, CD-Rom, 2003.

[23] Sala, F. C.; Rossi, F.; Fabri, E. G.; Rondino, E.; Minami, K.; Costa, C. P. Caracterização varietal de rúcula. In: 44 Congresso Brasileiro de Olericultura, Campo Grande, MS. Horticultura Brasileira. Brasília, v. 22. p. 405-405, 2004.

[24] Santos, H. G.; Jacomine, P. K. T.; Anjos, L. H. C.; Oliveira, V. A.; Lumbreras, J. F.; Coelho, M. R.; Almeida, J. A.; Araújo Filho, J. C.; Oliveira, J. B.; Cunha, T. J. F. Sistema Brasileiro de Classificação de Solos. 5.ed. revisada e ampliada. Brasília: Embrapa Solos. (E-book),2018.

[25] Silva, A. O.; Silva, E. F. F.; Klar, A. E. Acúmulo e exportação de macronutrientes em beterraba sob diferentes manejos de fertirrigação e salinidade. *Bragantia*, versão online, p. 1-10,2017.

[26] Silva, F. G. M.; Souza, W. S. ; Costa, T. G. A. Teor e acúmulo de N em diferentes cultivares de alface em sistema hidropônico. In: XII Encontro Brasileiro de Hidroponia e IV Simpósio Brasileiro de Hidroponia, Florianópolis, p. 41-43, 2018.

[27] Soares, M. M.; Bardiviesso, D. M.; Barbosa, W. F. S. ; Barcelos, M. N. Adubação de cobertura com enxofre na cultura da rúcula. *Revista de Agricultura Neotropical*, v. 4, n. 1, p. 49-52, 2017.

[28] Souza, A. H. C.; Rezende, R.; Lorenzoni, M. Z.; Santos, F. A. S.; Maller, A. Effect of fertigation with potassium and nitrogen on gas exchange and biomass accumulation in eggplant. *Pesq. Agropec. Trop*., v. 47, n. 3, p. 345-352,2017.

[29] Taiz, L.; Zeiger, E.; Moller, I.; Murphy, A. Fisiologia e desenvolvimento vegetal. 6.ed. Porto Alegre: Artmed, 888p.,2017.

[30] Teixeira, P. C.; Donagemma, G. K.; Fontana, A.; Teixeira, W. Z. Manual de métodos de análise de solo. 3. ed. Brasília: Embrapa Solos, 574 p.,2017.

[31] Venegas, J. G.; Harris, R. S.; Simon, B. A. A comprehensive equation for the pulmonar pressure-volume curve. Journal of Applied Physiology, V. 84, n. 1, p. 389-395,1998.

[32] Vidigal, S. M.; Pacheco, D. D.; Costa, E. L.; Facion, C. E. Crescimento e acúmulo de macro e micronutrientes pela melancia em solo arenoso. *Revista Ceres*, v. 56, n. 1, p. 112-118,2009.

[33] Yamamoto, E. L.; Ferreira, R. M.; Fernandes, P. L. O.; Albuquerque, L. B.; Alves, E. O. Função do cálcio na degradação da parede celular vegetal de frutos. *Revista Verde*(Mossoró/RN) v.6, n.2, p. 49-55,2011.

# Autism in Brazil: a study on the view of Basic Education teachers

Ms. Fabrizia Dias[1], Dr. Daniele Rodrigues[2], Dr. Carlos Henrique Medeiros de Souza[3]

[1]Master in Cognition and Language, Department of PGCL, North Fluminense State University (UENF), Brazil
[2]Doctor in Cognition and Language, Department of Business, Fluminense Federal University (UFF), Brazil
[3]Doctor in Communication and Culture, Post Graduate Department of Cognition and Language (UENF), Brazil
Coordinator of the Post Graduate Program in Cognition and Language at North Fluminense State University (UENF), Brazil

*Abstract— The United Nations highlights that the number of autistic people in the world is steadily increasing. In this context, schools continue to enroll autistic children, but are not prepared to provide the necessary care these students require. Objective: to verify teachers' views in relation to Autistic Spectrum Disorder and their need for professional development and training in order to better support these students and the challenges they face in school settings. Method: to support this study, we used a digital questionnaire, a bibliographic review and scientific articles by reference authors in the field. Thus, a study was carried out with 119 teachers in Basic Education, based on an online survey with five questions. Resulting data was presented by means of graphs generated by the digital questionnaire. Results: the results were demonstrated through five graphs and analyzed in a descriptive way, guided by reference authors in the field of study. Conclusion: Although there is a law that states the need for teacher training in inclusive education, in view of the diagrams exhibited in the present research, we concluded that most of the teachers approached do not have solid knowledge about ASD, which directly impacts the student in class.*

*Keywords— Autism, Brazil, Education. Teacher, Training.*

## I. INTRODUCTION

Autistic Spectrum Disorder (ASD) has been extensively studied, both in the area of education and health. People with ASD have the following characteristics: persistent and clinically significant deficits of communication and social interaction, restrictive and repetitive patterns of behaviors, interests and activities. According to each level, a child may present signs of mild, moderate, or more severe difficulties (DSM-V, 2013). In Brazil, there are no precise statistics about the number of autism cases in the country. It is estimated that there are approximately two million cases of ASD with the health sector defining the diagnosis of ASD as complex given the several etiologies and varying levels presented by the disorder (Cunha, 2017). Therefore, these individuals require specific support in the school environment. Within this framework, this research highlights important aspects of teacher training in ASD, demonstrating their current view on the subject.

Thus, this study is justified due to the growing number of students with ASD in Brazilian schools with the understanding that teachers are ill prepared to deal with this new reality, which in turn makes it difficult for them to adequately support the development of these individuals' school performance. The teacher, as an active participant in the classroom, wants all students to learn; individuals with ASD present different learning styles, requiring teachers to have precise information on how to best manage these students and their needs in order to enable them to develop intellectually and interactively. A well-prepared teacher can better contribute positively to continued improvement in their students' academic performance. The objective of this research is to verify the teacher's view and understanding of Autistic Spectrum Disorder and the need for professional development in relation to the disorder. The research methodology was based on an online survey, bibliographic review and scientific articles by reference authors on the subject, seeking to support the study's proposal.

Therefore, the present work intends to demonstrate the results of a study carried out with 119 teachers, from Basic Education, in order to verify their view in relation to Autistic Spectrum Disorder in a broader and deeper context. The study further analyzed the need for specific teacher training as it relates to ASD. Based on the results of the present research it will be possible to understand how public policies can be better applied to provide free ASD training to teachers of Basic Education which will consequently allow them to better provide for autistic students in school.

## II. OVERVIEW OF ASD IN SCHOOL AND LACK OF TRAINING FOR TEACHERS

The National Guidelines for Special Education in Basic Education, Resolution CNE/CEB n. 2/2001, in article 2, determines that "education systems must enroll all students. In addition, it is up to schools to ensure they are able to provide for students with special educational needs, offering an environment that allows for quality education for all." (MEC, 2008). The number of ASD children in school classes is increasing. Thus, the need for specific training of professionals who work with these children in the classroom is evident, especially given the unique needs inherent to their condition. Kirk and Gallagher (1987, p. 33), point out that "not all children learn and develop at the same pace, react emotionally in the same way, and see or hear equally. Autistic individuals need differentiated time to accomplish their tasks and process the most varied types of information that make up a teaching-learning process." The authors also point out that "the 'disabled' children withdrew from school because they could not compete with 'normal' or "typical" children and schools were not organized with their specific needs taken into account. As a result, the difficulties became even greater for individuals called "atypical" and their families, who had no legal backing to fight for their rights.

### a. Autism Spectrum Disorder (ASD)

ASD has been one of the most frequently studied disorders in both health and education, due to its high incidence and limited understanding of its real underlying causes.

The World Health Organization (WHO), estimates that autism affects one in 160 children worldwide. The incidence of autism is high in all regions of the world, while the lack of understanding about the disorder has a strong impact on individuals, their families and communities. The United Nations states that much scientific research suggests there are many contributing factors that could make children more prone to autism, including environmental and genetic issues (Edgard Junior, UN News-NY, 2017, p.1).

The term "autism" was first used by Swiss psychiatrist Eugen Bleuler in 1911. The researcher used the word "autism" to refer to his patients suffering from schizophrenia, seeking to explain the signs of escape from reality and an exacerbated intrinsic behavior. The etiology of the word "Autism" comes from the Greek "autós", which means "from oneself" (Ajuriaguerra, 1977). The term indicated loss of contact with reality, or those who lived in their own world. Later, Leo Kanner, in 1943, published papers revealing the issue of "autism" present in 11 children diagnosed with schizophrenia, using the expression "Authentic Contact Disorder" (Cunha, 2017). The following year, Hans Asperger published studies with children exhibiting behaviors similar to those described by Kanner, demonstrating that children with autism had a certain cognitive resourcefulness, with abilities for logic and abstraction, superior intelligence, presenting eccentric interests. Both descriptions were compared in 1981, when Lorna Wing translated Hans Asperger's papers and published it in an English language journal, using the term "Autism" (Assumption, 2015).

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V, 2013) of the American Psychiatric Association (APA), used by health professionals to diagnose psychiatric disorders, the terminology to characterize an autistic individual is Autism Spectrum Disorder (ASD). The DSM-V (2013) outlines the characteristics presented in ASD as: deficits in social interaction; deficits in verbal or non-verbal communication and behaviors with restricted, repetitive and stereotyped patterns, with unusual sensory aspects.

According to Cunha (2017), the individual with ASD may present difficulties in initiating and maintaining a conversation, early or late echolalia, and may also present significant sensory sensitivities that may impact their daily lives.

Law no. 12,764/12, which establishes the National Policy for the Protection of the Rights of Individuals with ASD, determines the characteristics to be observed for diagnosing the disorder as: difficulty in social interaction, communication, and the incidence of repetitive and restrictive behavior patterns, manifested by motor and verbal stereotyped movements. Thus, as described in the law: "persistent and clinically significant communication and social interaction disability, restrictive and repetitive patterns of behavior, interests and activities" (Brazil, 2012, Art. 1, § 1).

The ASD individual presents great resistance to breaking routines, demonstrating restricted and fixed interests, in an exaggerated manner. Healthcare professionals define the diagnosis of ASD as complex, because there are several etiologies and varying levels. ASD is classified, according to the Classification of Mental and Behavioral Disorders (ICD-10), as one of the Invasive Developmental Disorders, which can present itself in three different levels, denoting signs of a mild, moderate or more severe condition. In severe cases language and learning are extremely impaired (DSM-V, 2013).

Thus, in school settings, these individuals demand specific support appropriate to their needs, aligned with content that must be adapted by the teacher, in order for these students to obtain gains in their academic development.

**b. ASD in school and the need for teacher training**

Briefly, it can be said that the objectives of the National Policy on Special Education from the perspective of inclusive education are to ensure the absolute school inclusion of students with disabilities, global developmental disorders and high skills/gifted, guiding the education system in search of ensuring access to: a) regular education, with full participation at the highest levels of education; b)continuity of special education models from early childhood education to higher education; c) specialized educational support; d) training of teachers and other para-professionals in the field in specialized and inclusive education; e) full  family and community participation; f) architectural accessibility, in transportation, furniture, communications and information (Brazil, 2008).

Thus, teachers need greater structural support from their institutions and must endeavor to seek training that can support their effective performance and satisfaction in relation to the achievements and results of their autistic students.

In Decree number 7084/10, article 28, it was established that the Ministry of Education will adopt mechanisms to promote accessibility in academic programs for special education students and teachers of public basic education schools (Brazil, 2008).

Law no. 12.764/12 consolidates a set of rights for the individual with ASD, and in its article 7, prohibits refusal of enrollment to persons with any type of disability, establishing penalties for the school manager or competent authority that practices this discriminatory act.

Law no. 13.005/14, which establishes the National Education Plan - PNE, anchored in the deliberations of the National Education Conference - CONAE/ 2014, in its item III, paragraph 1 of Article 8, determines that States, the Federal District and Municipalities ensure the fulfillment of specific needs in special education, ensuring an inclusive educational system at all levels, stages and modalities. Therefore, the objective is to ensure comprehensive care of people with disabilities, global development disorders and high abilities/gifted, in the age group of 4 to 17 years, and guarantee access to basic education and specialized education. (Brazil, 2014). The existing framework confirms we are not lacking in legal documents to begin a process of training teachers on the academic needs of their students with ASD.

An inclusive educational modal creates new challenges for teacher training. It is no longer enough to ensure teachers aren't segregating ASD students, but rather to train them to work effectively in differentiated classrooms. To do so, it is necessary to develop a unique understanding of the specific knowledge, skills and attitudes to work with inclusive classes (Rodrigues, 2008).

There is an immediate demand for teachers who are more than just competent in their specific content and subject. Teachers must be competent in pedagogical and psycho-pedagogical application in teaching methodologies, group animation, respect for diversity, among requirements. There are also mounting expectations about the role of the teacher in promoting education in further fields, such as citizenship, civic, sexual, and community education, among others. For this reason, some scholars have called the mission of contemporary teachers as an "impossible mission" (Rodrigues, 2008).

Thus, in practice, teachers have limitations in reconciling their willingness to help these individuals with the demands generated by school's and society's high expectations. Consequently, it becomes increasingly difficult for children with educational disabilities to learn in a planned, structured and effective way that enables them to achieve proposed goals. This panorama is deteriorating every day, with the growing number of students with ASD in mainstream classes, coupled with the lack of training of professionals in the field of inclusive education.

As a result, the teacher finds it difficult to fulfill or meet all the expectations generated around his or her work and to be able to act more accurately in the face of the needs presented by a child with ASD.

## III.    METHODS

A freestyle and general online survey was conducted with a group consisting of 119 predominantly Brazilian teachers, of both genders, working in Basic Education. Participants were asked to answer just five questions via Google Forms Application after which it was possible to obtain reasonably unanimous responses on their views about ASD and the lack of training thereof. The questions asked were aimed at verifying teachers' level of contact with these students, as well as their understanding of the subject and the need for training in the area. Therefore, to support this study a bibliographic review was done searching reference authors in the field.

From the point of view of nature, this research can be considered applied; it generates knowledge for practical application, directed at a solution of a specific problem, that is, the training of teachers to better support autistic students. Regarding the approach to the problem, the research is qualitative and quantitative. It is qualitative, because it dealt with the interpretation of phenomena and assignment of meanings, as clarified by Kauark et al. (2010, p. 26): "The interpretation of phenomena and assignment of meanings are basic in the process of qualitative research. It does not require the use of statistical methods and techniques". Therefore, the research fits as qualitative, since it proposes a survey of information gathered from Basic Education teachers. The quantitative technique provides precise results, seeking to explain relationships among variables, through statistical correlations, incidences and frequency analysis (Michel, 2005). In this sense, the questionnaire used generated statistical data exhibited in explanatory graphs. As for technical procedures, this research can be classified as bibliographic, since it was prepared from several materials already published, such as books, newspapers, journal articles and materials available on the Internet (Kauark et al, 2010).

Thus, the methods applied delivered the subsequent results presented topic IV.

## IV.    RESULTS AND DISCUSSION

According to research done by the National Institute of Educational Research Anísio Teixeira (Inep, 2019, p.33), from 2014 to 2018, the percentage of students with disabilities, global developmental disorders or high skills enrolled in common classes has gradually increased in all stages of education. According to information contained in the Technical Summary Basic Education Census (2019), more than 88% of students with disabilities were included in mainstream classes in 2018, considering all stages of

basic education, with the largest increase, between 2014 and 2018, being 11.5%, observed in early childhood education. In 2019, there was a significant increase in the number of students with autistic spectrum disorder (ASD) who are enrolled in common classes in Brazil increased 37.27% in one year. In 2017, 77.102 children and adolescents with autism were studying in the same class as people without disabilities. This rate rose to 105.842 students in 2018. Both public and private school students are considered (Globo-online, 2020). In view of the frequency and increase of individuals with ASD in mainstream schools, this research is relevant because the results shown can impact new procedures in the field of education and the care of autistic students. On this basis, the following are the results:

**Diagram 1 – Question 1**



The diagram (1) presents that most teachers approached have already had prior contact with an autistic individual.

**Diagram 2 – Question 2**
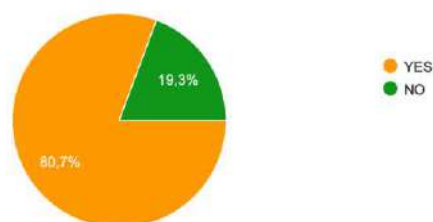


Diagram (2) confirms the information cited by this study regarding the increasing enrollment of these children in Brazilian schools. The majority of teachers answered that they have had prior contact with ASD individuals at school.

**Diagram 3 – Question 3**



Have you ever had any contact with autists in the classroom?
119 Answers
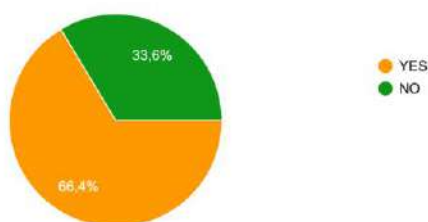
Diagram (3) presents a significant percentage demonstrating that more than 60% have already had ASD students in the classroom. This amount is compounded with 80% (2) of teachers that had contact with autistic individuals in school presents a worrisome reality.

In this sense, Gatti (2010, p.1360), highlights that "there is no consistency in professionalization without the constitution of a solid base of knowledge and forms of action" and states that we should move away from the idea of the "the teacher has to find his way without any training or being the purely technical teacher". The author believes that we should focus on a new concept of a professional in education who has "conditions to confront complex and varied problems, being able to build solutions, mobilizing his cognitive and affective resources". In this perspective, an insufficiently trained teachers can negatively impact the development and learning of ASD students.

Cunha (2012, p.90), emphasizes that "with proper training, educators are better equipped to evaluate the necessary support and interventions for students who do not achieve expected results in the school environment".

**Diagram 4 – Question 4**



Do you think the teacher needs more training on the subject?
119 Answers
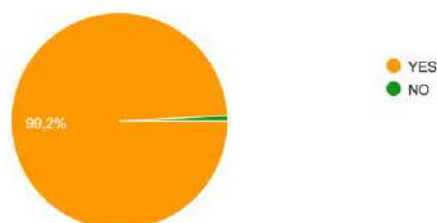
As more than 99% of teachers approached feel the need for training on the subject (4), it confirms our hypothesis regarding the need for specific training in ASD so that teachers will be better equipped to ensure impactful

improvements in the classroom with ASD students. In this sense, some research has demonstrated that most teachers have had their training based on a traditional model of teaching, which presents leveling and exclusionary educational practices, a model that associates disability with inability and incapacity (Mizukami, 1986; Glat, Ferreira, Olive Tree, Senna, 2003).

In this context, unpreparedness is inherent in the framework of teacher training designed or developed over the years. Therefore, laws have been adapted to the new reality in the classroom, where students with ASD are increasingly present, but teachers remain unprepared given their training to support these students.

**Diagram 5 – Question 5**



Have you ever taken a course on Autism?
119 Answers
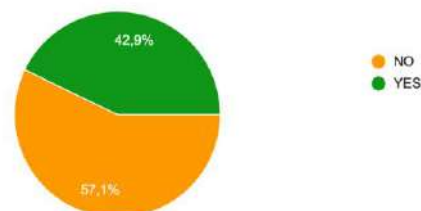
Diagram (5) shows that more than 55% of teachers that participated in this survey had never taken part in a course on ASD, confirming that they are unprepared to support these individuals in the classroom. However, most of the professionals approached would embrace working with autistic students.

Nóvoa (1995), emphasizes the importance of applying the expertise teachers acquire in their daily experience: "In the field of education, the objective of continuing education is to propose new methodologies and to carry out current theoretical discussions, with the intention of contributing to readjustments of the pedagogical praxis at school. Understanding new theories is part of the process of professional development, but it is not enough if these theories do not allow the teacher to relate them to their practical knowledge obtained in their day-to-day" (p. 27). Thus, teachers that seek to prepare for new situations in the classroom, such as establishing contact with autistic students, should always keep themselves informed. By staying updated with emerging theories and knowledge teachers are better prepared to modify their pedagogical practices when necessary.

Therefore, the research clearly establishes the need for teacher training due to the increasing number of individuals with ASD in Brazilian schools. As noted,

66.4% of teachers state having had students with ASD in the classroom and have further confirmed their willingness to engage in continued professional development to better support these individuals and their challenges. Teachers that participated in this research all indicated their enthusiasm to help these children with their learning needs, however, they feel poorly prepared to support ASD individuals according to this research.

## V. CONCLUSION

In a competitive, yet unequal society, education is one of the ways to disseminate the right to equality. By allowing all members of society equal access to knowledge and skills that broaden their possibilities to function in autonomous and practical ways, they can insert themselves into a market where equality prevails. The same should be true for teachers and students. In this context, inclusive education becomes a process that seeks to provide people with special educational needs with the potential of full development and growth. Thus, must include the different levels and degrees of the teaching system, and should further be based on theoretical references aligned to student's specific needs.

According to the authors and the results of this research, teachers are unclear as to how to adequately perform their roles when they come across an autistic student. Therefore, questions were formulated through an online survey in order to understand the level of teacher knowledge regarding ASD as well as their views on the lack of information regarding the subject. In this survey 99% of the teachers approached expressed willingness and need for training in ASD. All confirmed previous contact with autistic students, either inside or outside the classroom. In addition, they confirmed their limited understanding of how to best work with these students assist them in their difficulties and learning process given their inadequate training. Although there is a law that states the need for training for teachers in inclusive education, in view of the diagrams presented in this research, we concluded that most of the teachers approached do not have solid a solid understanding about ASD, which directly impacts the student in class. Finally, the results showed that the teacher's view of ASD is still limited and that teachers themselves feel the need for further training on the subject.

## REFERENCES

[1] Ajuriaguerra, J.; Manual de Psiquiatria Infantile; 2nd ed.; Barcelona: Toray-Masson, 1983.

[2] Assumption, F.B.J.; Child Autism: new trends and perspectives. 2nd ed.; São Paulo: Ed. Atheneu, 2015.

[3] Brazil, Law No. 12.764 of December 27, 2012. National Policy for the Protection of the Rights of Persons with Autism Spectrum Disorders. Presidency of the Republic, Civil House. Retrieved from http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12764.htm. Access on 10/05/2020.

[4] Brazil, 2nd National Conference on Education, CONAE, 2014. Retrieved from http://conae2014.mec.gov.br/images/doc/Sistematizacao/DocumentoFinal29012015. pdf.

[5] Brazil, Ministry of Education. Secretariat of Special Education. Political and Legal Milestones of Special Education from the Perspective of Inclusive Education. Brasília: Secretariat of Special Education, - 2010. Retrieved from http://pfdc.pgr.mpf.mp.br/atuacao-e-conteudos-de-apoio/publicacoes/educação/marcos-politico-legais.pdf

[6] Brazil, National policy for special education from the perspective of inclusive education. Brasília: MEC, 2008. Retrieved from http://portal.mec.gov.br/arquivos/pdf/politicaeducespecial.pdf

[7] Brazil. Lei no 13.005, de 25 de junho de 2014. Aprova o Plano Nacional de Educação - PNE e dá outras providências. *Diário Oficial da União*, Brasília, DF, 26 jun. 2014. Seção 1, p. 1.

[8] Cunha, E. Autism and inclusion: psycho-pedagogy educational practices at school and in the family. 7th ed. Rio de Janeiro: Wak, 2017.

[9] Cunha, E. Autism and inclusion: psycho-pedagogy and educational practices at school and in the family. Rio de Janeiro: Wak, 2012.

[10] DSM-V, Diagnostic and Statistical Manual of Mental Disorders. American Psychiatric Association, 2013.

[11] Edgard J. WHO states that autism affects one in 160 children worldwide. UN News. Retrieved from https://bit.ly/2yJFrjr.

[12] Garcia, Rosalba Maria Cardoso. Special education policy from an inclusive perspective and teacher training in Brazil. Revista Brasileira de Educação v. 18 n. 52 jan.-mar. 2013. Retrieved from http://www.scielo.br/pdf/rbedu/v18n52/07.pdf

[13] Gatti, B. A. Teacher training in Brazil: characteristics and problems. Revista Educação & Sociedade, Campinas, n. 113, p. 1355-1379, oct./dec., 2010.

[14] Glat, Rosana; FERREIRA, Júlio Romero; OLIVEIRA, Eloiza da S. Gomes; SENNA, Luís Antônio Gomes. National Panorama of Inclusive Education in Brazil. Technical consulting report, World Bank, 2003. Retrieved from <www.cnotinfor.pt/projectos/worldbank/inclusiva>. Access on 20/05/2020.

[15] Globo.com. channel online: Education News. Retrieved from:https://g1.globo.com/educacao/noticia/2019/04/02/numero-de-alunos-com-autismo-em-escolas-comuns-cresce-37percent-em-um-ano-aprendizagem-ainda-e-desafio.ghtml Access on 20.06.2020.

[16] Kauark, F. S.; Manhães, F. C.; Medeiros, C. H. Metodologia da pesquisa: um guia prático. Itabuna: Via Litterarum, 2010.

[17] Kirk, S. A.; Gallagher, J. J. Educação da Criança Excepcional. São Paulo: Martins Fontes, 1987.

[18] Michel, M. H. Metodologia e pesquisa científica em ciências sociais: um guia prático para acompanhamento da disciplina e elaboração de trabalhos monográficos. São Paulo, 2005: Atlas.

[19] Mizukami, Maria da Graça Nicoletti. Teaching: the process approaches. São Paulo: EPU, 1986. (Basic themes of education and teaching).

[20] National Institute of Educational Research Anísio Teixeira (INEP), 2019. Retrieved from: http://portal.inep.gov.br/web/guest/sinopses-estatisticas-da-educacao-basica Access on 20/05/2020.

[21] Novoa, A. Teacher training and teaching profession. In: Nóvoa, A. (coord.). The teachers and their training. Lisbon: Don Quixote, 1995.

[22] Rodrigues, David. Developing inclusive education: dimensions of professional development. In: Inclusion: Special Education Magazine. Inclusion: R. Educ. esp., Brasília, v. 4, n. 2, p. 1-58, jul./out. 2008.

[23] WHO: World Health Organization. CID-10: International Statistical Classification of Diseases and Related Health Problems; Porto Alegre: ArtMed, 1993.

# The Epidemiological Profile of Acute Chagas Disease in the State of Pará from 2013 to 2017

Robson Pantoja Portilho[1], Litiani de Souza Costa[1], Rosália Monteiro Barros[2], Elyade Nelly Pires Rocha Camacho[3], Joelma Sena Santos[4*], Luciana Conceição Ferreira da Silva Barbosa[5], Tereza Natália Bezerra de Lima[6], Patricia de Melo Farias[7], Thifanny Gonçalves de Lira[8], Patrícia Alves Maia[9], Teresa Kariny Pontes Barroso[10], Clerislene de Sousa Oliveira[11], Eimar Neri de Oliveira Junior[12], Diana Pinto Rocha de Oliveira[12], Tatiana Arimatéa Leal[13], Carla Amaro de Araujo[14], Maria Rute de Souza Araújo[15]

[1]Training Specialization in Sterilization Material Center and Surgical Center, at the Metropolitan University Center of the Amazon (UNIFAMAZ). Orcid: http://orcid.org/0000-0002-5848-3629; http://orcid.org/0000-0002-6007-5974. Belém, Pará, Brasil.

[2]Nurse, at the Metropolitan University Center of the Amazon (UNIFAMAZ). Orcid: http://orcid.org/0000-0002-8971-5365. Belém, Pará, Brasil.

[3]Obstetrical Nurse. Graduation in Nursing from University of the Amazon (UNAMA). Master and Doctorate degree in Nursing in Tropical Medicine Diseases from Universidade Federal do Pará (UFPA). Orcid: http://orcid.org/0000-0002-7592-5708. Belém, Pará, Brasil.

[4]Nurse. Graduation in Nursing from University of the Amazon (UNAMA). Postgraduate student in obstetric. orcid: http://orcid.org/0000-0002-9168-8394. Belém, Pará, Brasil.

[5]Nurse, Women's Health Resident of the Integrated Multiprofessional Health Residency Program at the Hospital das Clínicas. Orcid: https://orcid.org/0000-0003-1041-981X. Recife, Pernambuco, Brazil.

[6]Post-graduation by the multiprofessional residence in Collective Health. by the Faculty of Medical Sciences - FCM University of Pernambuco - UPE. Orcid: https://orcid.org/0000-0003-2735-6915. Recife, Pernambuco, Brazil.

[7]Nurse, Specialist in Hospital Epidemiology, Federal University of Sergipe. Orcid: https://orcid.org/0000-0002-6017-1640. São Cristóvão, Sergipe, Brazil.

[8]Nurse, Bachelor of Nursing, University of the Amazon - UNAMA. Orcid: https://orcid.org/0000-0002-6990-8776. Belém, Pará, Brazil.

[9]Post-Graduation in Intensive Care Nursing by Fanor Wyden University Center. Orcid: https://orcid.org/0000-0003-4263-8670. Fortaleza, Ceara, Brazil.

[10]Master in intensive care, by the University of Fortaleza. Orcid: https://orcid.org/0000-0002-3814-9447. Fortaleza, Ceara, Brazil.

[11]Nurse, Bachelor of Nursing, University of the Amazon - UNAMA. Orcid: https://orcid.org/0000-0003-2170-2450. Belém, Pará, Brazil.

[12]Nurse, Bachelor in Nursing, by Unifamaz. Orcid: https://orcid.org/0000-0002-6861-8996; https://orcid.org/0000-0002-7777-4181. Ananindeua, Pará, Brazil.

[13]Nurse, Specialist in Pediatric and Neonatal Nursing, from Universidade Federal de Sergipe - UFS. Orcid: https://orcid.org/0000-0002-0888-8599. Aracaju, Sergipe, Brasil.

[14]Nurse, MBA in Quality Management and Health Accreditation, at the Hospital Geral do Exercito in Fortaleza. Orcid: https://orcid.org/0000-0002-7921-0267. Fortaleza, Ceara, Brasil.

[15]Master in Health and Society and Endemics of the Amazon Federal University of Pará (UFPA)/ Federal University of Amazonas (UFAM). Research advisor and Professor at the Metropolitan University Center of the Amazon (UNIFAMAZ). Orcid: http://orcid.org/0000-0002-5586-5664. Belém, Pará, Brasil.

[*]**Corresponding Author**

*Abstract— Objective: This research aimed to know the epidemiological aspects of acute Chagas disease in the state of Pará between 2013 and 2017. Method: This is a descriptive and documental study, with a quantitative approach, based on data from the National Information System of Acute Notification (SINAN). Results: The health regions with the highest number of reported cases of Acute Chagas Disease were reported, and it was possible to investigate the epidemiological aspects in the regions of Tocantins, Marajó II and Metropolitan I, leading the municipalities of Ananindeua, Breves, Abaetetuba, Belém, Cametá,*

*Igarapé Miri; between the months of August and November, coinciding with the harvest of açaí in the State. The socioeconomic profile of the individuals that the disease most affects is the male gender, between 20 and 39 years, with prevalence in the brown race. The most frequent mode of transmission is oral, its confirmation by laboratory tests. Conclusion: With this, the areas where high numbers of cases of the disease are occurring were identified, which need greater attention from the Health Secretariats, to elaborate preventive and educational measures, becoming the biggest challenge when fighting Chagas Disease and its chronification in the State of Pará.*

*Keywords— Epidemiological Profile, Chagas Disease, Notification in SINAN.*

# I. INTRODUCTION

Chagas disease or American Trypanosomiasis is a parasitosis caused by the protozoan Trypanosoma cruzi; an anthropozoonosis of high prevalence and expressive morbimortality; it presents clinical manifestations resulting from the evolutionary process of infection, which are evidenced and characteristically described in two distinct stages, called acute phase and chronic phase (Brazil, 2017).

The mode of transmission of Chagas' disease so far detected are the most diverse, including the classic or vector form, which occurs when Trypanosoma cruzi is eliminated by triatomine feces after blood repast (Souza; Povoa, 2016). However, there are other forms of transmission called secondary, i.e., other routes outside the classic biological cycle of the parasite (Brazil, 2017).

The form of oral transmission of the disease is represented as the most serious medium, as it has a marked parasitic load in relation to the other contamination routes. As a result, the epidemiological profile assumes a new form due to the ingestion of food contaminated with the presence of the parasite or the presence of feces in the (core of) açaí, when there is not the proper sterilization of this food (Simões et al., 2017).

Thus, Barreto et. al. (2015), state that the disease affects 6-7 million people worldwide, with an annual incidence of 28,000 cases in the Americas; Chagas disease is endemic in 21 Latin American countries, but has spread to other continents due to the migration of infected people. Chagas disease presents an epidemiological profile in the state of Pará characterized by outbreaks of oral transmission in the municipalities of the state. This form of transmission shows the epidemiological complexity of this disease, whose records, from 2007 to 2014, identify 884 acute and chronic cases of the disease in 39 municipalities in the state, and in the microregion of Belém, about 130 new and autochthonous cases are reported annually (Júnior et al., 2017).

The Northern region of Brazil contributed with the highest percentage of cases in the country with 91.1% confirmed notifications of Chagas disease (CD), being registered in the state of Pará about 75% of all cases occurring in Brazil, and more than 50% of people manifest the onset of symptoms between the months of August and November because it is the period that corresponds to the harvest of açaí in the state of Pará (Brazil, 2015).

Epidemiological surveillance has detected cases of oral transmission, especially in the north of the country, where there is an increase in ecotourism by tourists from several countries. The Amazonian cuisine of indigenous origin is appreciated, among them açaí. Thus, many tourists may be being exposed to the risk of contracting Chagas disease, ultimately increasing the number of contaminated people in non-endemic countries (Ferreira; Branquinho; Leite, 2014).

From the problem in question, we bring as a question of research: what are the epidemiological aspects of acute Chagas disease in the state of Pará between 2013 and 2017?

The choice of the subject occurred during our research on the subject in general, when we realized that there were few scientific papers that addressed the epidemiological profile of Chagas disease in the country and especially in the northern region. In this sense, we were stimulated by the interest in the topic of conducting this research, which allowed us to have a current vision of CD disease in the state of Pará.

In this sense, the objective of this study was to know the epidemiological aspects of acute Chagas disease in the state of Pará between 2013 and 2017.

# II. METHOD

It is a descriptive study, of the documental type with quantitative approach, which had as scenario the state of Pará, which is situated in the North region of Brazil, with extensive area of rain forest, and tropical climate. The state has six Meso-regions comprising 22 Microregions, in a total of 144 municipalities. Pará has an area of 1,247,955.381 km² and an estimated 8,272,724 inhabitants in the year 2016 (IBGE, 2016).

The data collection was carried out through a documental research, using the database in the Aggravates Notification Information System (SINAN-NET) in the period 2013-2017, seeking to identify some variables such as: the number of cases notified and confirmed by municipalities, likely oral route infection and evolution of deaths, age group, race, likely site of infection, likely mode of infection (transfusion, vector, vertical and accidental).

The inclusion criterion used was all cases of Acute Chagas Disease (ACD) notified and confirmed in SINAN, which occurred in the state of Pará, during the period proposed by the survey; and exclusion of all cases notified unconfirmed from the ACD by SINAN; in addition to cases notified and confirmed outside the period proposed by the survey.

The data analysis was performed through a descriptive survey where a spreadsheet was used in the Microsoft Excel program of Windows version 2013 and the result plotted in tables and graphs.

Regarding the ethical and legal aspects, the study obeyed Resolution 510/16, which provides on the rules applicable to research in human and social sciences in its sole paragraph, which states that "will not be registered or evaluated by CEP/CONEP. Research using publicly accessible information, under the terms of Law No.

12,527/11", so there was no need for approval by the ethics committee.

The risks were not feeding the system with the notifications of cases for investigation of the disease and aggravated compulsory notification. The benefits of the research were to obtain information on the current epidemiological situation of Chagas disease in the state of Pará and to propose better preventive measures to reduce the number of cases.

## III. RESULTS

During the last 5 years analyzed here, the region with the highest number of reported cases of Chagas Acute disease was Tocantins, with 390 notifications during the survey period; followed by the Marajó II region with 272 cases (Graph 1).

*Graph 1: Presents the distribution of confirmed cases of Chagas Acute disease, according to the regions of reported occurrences between 2013 and 2017 (Pará, Brazil, 2019).*
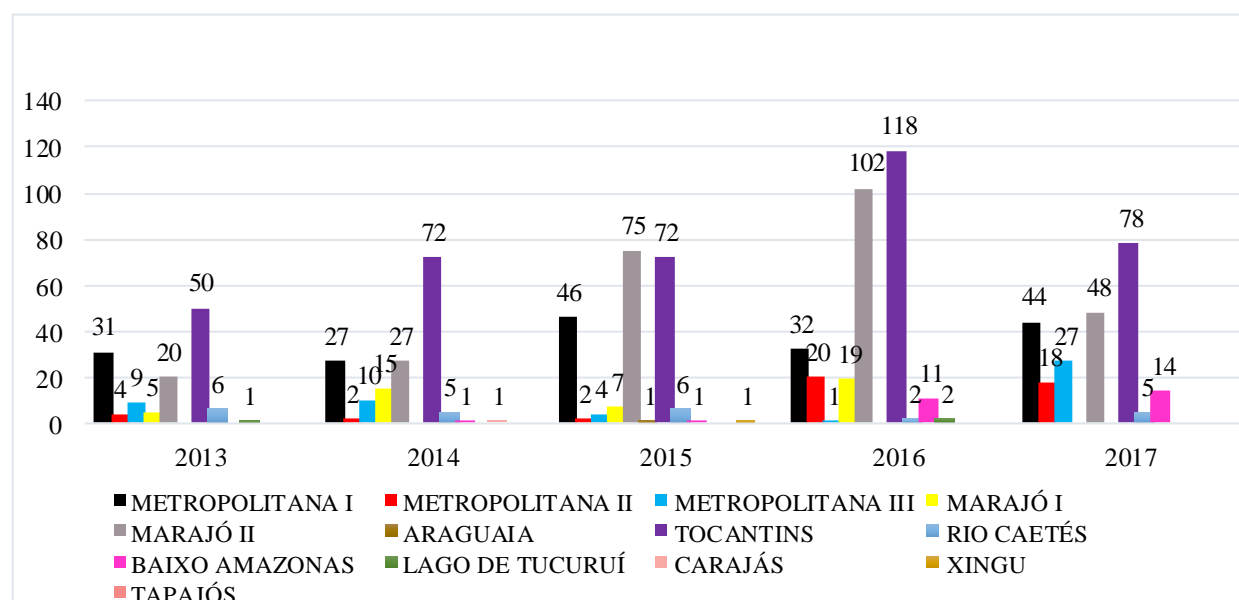


Source: Elaborated by the authors of the research, with data from the SINAN (2019).

Analyzing data from the municipalities of the health regions from 2013 to 2017, a higher number of notifications were found in the following municipalities: Ananindeua - with 294 cases, followed by Brief - 164 cases, Abaetetub - with 134 cases, Belém with 79 cases, Cametá with 48 cases, Igarapé-Miri with 44 cases; throughout the entire period studied (Graph 2).

*Graph 2: Distribution of Chagas' disease Acute, according to the municipalities in the health regions with the highest number of notifications: Metropolitan I, Marajó II and Tocantins in the period from 2013 to 2017. (Pará, Brazil, 2019).*
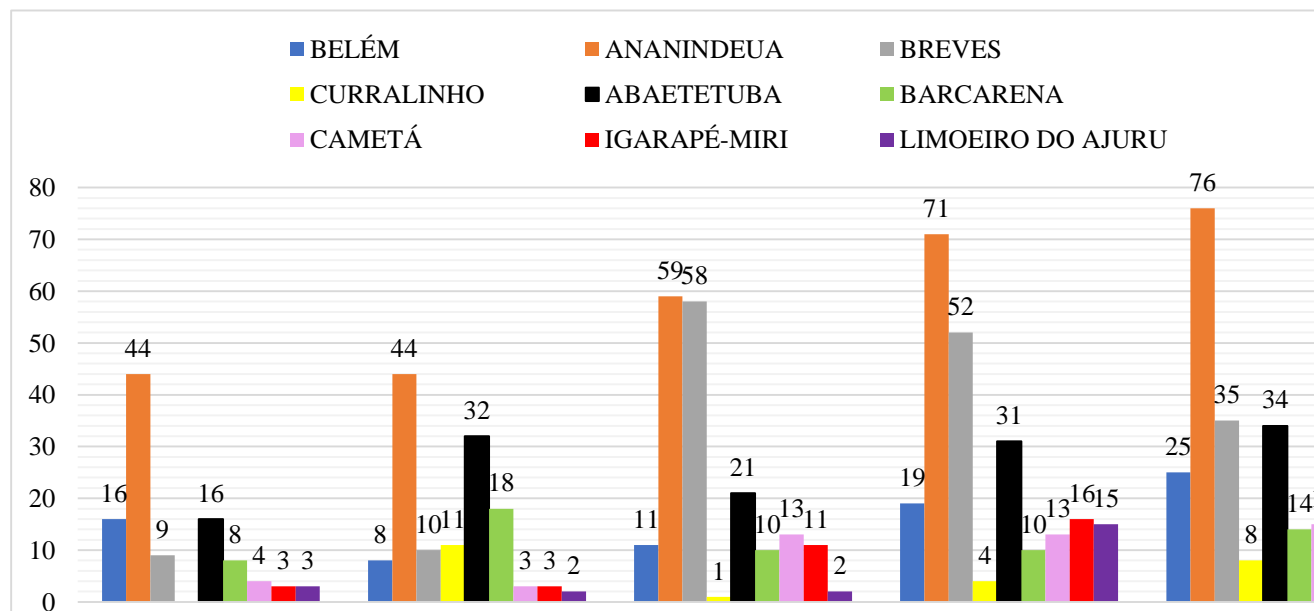


Source**:** Elaborated by the authors of the research, with data from the SINAN (2019).

According to graph 3, it is observed that the numbers of reported cases of Chagas Acute disease occur every year in the month of January, showing a high rate of notification of cases of the disease, and having a sharp drop over the months until April. From the month of May, there was a growing increase in the number of cases, and in the month of August to November there was the highest incidence of notifications in all the years studied.

*Graph 3: Distribution of confirmed cases of acute Chagas disease, notified in the period 2013 to 2017 according to the month of notification (Pará, Brazil, 2019).*
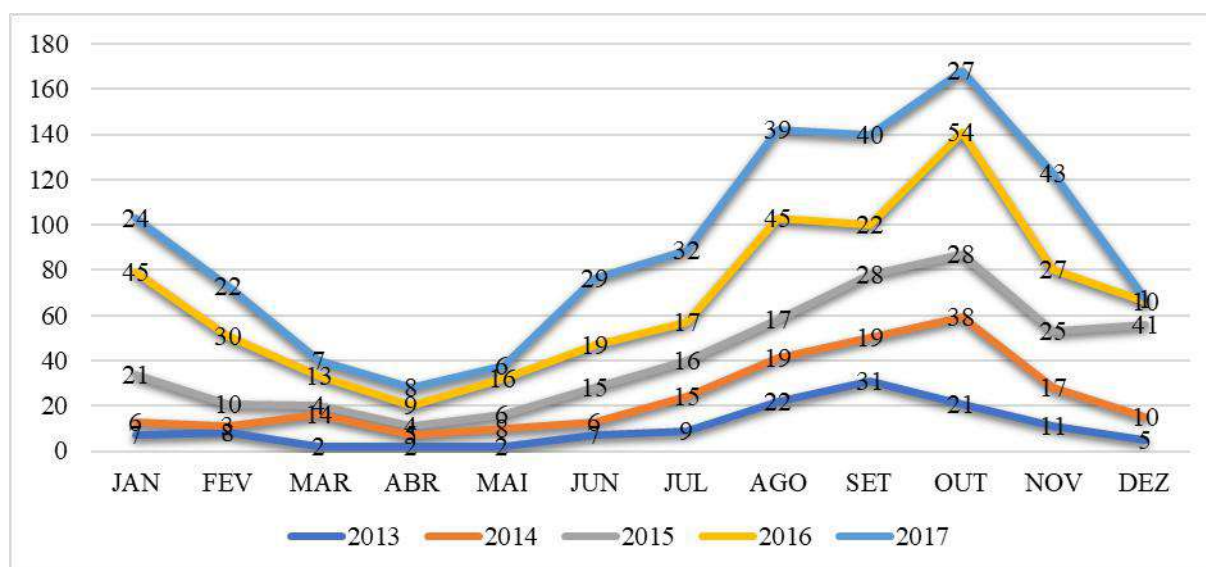


Source: Elaborated by the authors of the research, with data from Sistema de Informação de Agravos de Notificação - SINAN (2019).

Table 1 presents the distribution by gender, age group and race. It is observed that the disease reached more the male sex, with 608 cases; the female one registers 483 cases. In relation to the age group, it was observed that there was more occurrence in people between 20 and 39 years of age - with 385 cases; followed by the group from 1 to 19 years of age - with 314 cases; and the age group from 40 to 59, with 258 cases. In the issue related to racial ethnicity, the brown race was highlighted, with 682 cases; followed by the black race, with 269 cases; and the white race with 88 cases.

*Table 1: Sociodemographic profile of individuals reported with Chagas disease in Pará, according to the month and year of the first symptom, from 2013 to 2017 (Pará, Brazil, 2019).*

| Variables | 2013 | 2014 | 2015 | 2016 | 2017 | Total | % |
|---|---|---|---|---|---|---|---|
| **Gender** | | | | | | | |
| Male | 77 | 88 | 120 | 170 | 153 | 608 | 55,7% |
| Female | 49 | 72 | 95 | 137 | 130 | 483 | 44,3% |
| **Age range** | | | | | | | |
| White skin/Ign | - | - | - | - | - | - | - |
| <1 ano | 1 | 1 | 3 | 2 | - | 7 | 0,64% |
| 1 – 19 | 38 | 50 | 37 | 96 | 93 | 314 | 28,7% |
| 20 – 39 | 42 | 60 | 77 | 114 | 92 | 385 | 35,2% |
| 40 – 59 | 31 | 28 | 58 | 69 | 72 | 258 | 23,6% |
| 60 + | 14 | 21 | 21 | 26 | 26 | 108 | 9.89% |
| **Race** | | | | | | | |
| Ign/White skin | - | 4 | 7 | 6 | 2 | 19 | 1,74% |
| White skin | 11 | 19 | 13 | 26 | 19 | 88 | 8,06% |
| Black skin | 4 | 7 | 3 | 12 | 243 | 269 | 24,6% |
| Yellow skin | 1 | 2 | 1 | - | 1 | 5 | 0,45% |
| Brown Skin | 85 | 128 | 190 | 262 | 17 | 682 | 62,5% |
| Indigenous | 1 | - | 1 | 1 | 1 | 4 | 0,36% |

**SOURCE:** Elaborated by the authors of the research, with data from Sistema de Informação de Agravos de Notificação - SINAN (2019).

In table 2, it can be observed that the most frequent mode of transmission highlighted was through the oral route with 866 cases, having as confirmation criteria in its majority laboratory tests that count 1,145 cases. Thus, the disease presents a low lethality and a high morbidity and mortality.

*Table 2: Distribution of cases of acute Chagas' disease, according to: mode of infection, criteria for confirmation and evolution, reported from 2013 to 2017 (Pará, Brazil, 2019).*

| Variables | 2013 | 2014 | 2015 | 2016 | 2017 | Total | % |
|---|---|---|---|---|---|---|---|
| **Infection mode** | | | | | | | |
| Ign/ white skin | 31 | 31 | 17 | 41 | - | 120 | 10,9% |
| Transfusion | - | - | - | - | - | - | - |
| Vector | 11 | 17 | 23 | 5 | 26 | 82 | 7.51% |
| Vertical | - | - | - | - | - | - | - |
| Accidental | - | - | - | - | 1 | 1 | 0,91% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Oral | 83 | 112 | 175 | 260 | 236 | 866 | 79,3% |
| Other | 1 | - | - | 1 | - | 2 | 0,18% |
| **Criteria for confirmation** | | | | | | | |
| Ign/white skin | 3 | 3 | 2 | 9 | 4 | 21 | 1,92% |
| Laboratory | 119 | 151 | 205 | 393 | 277 | 1.145 | 104,9% |
| Clinical-epidemiological | 3 | 6 | 8 | 5 | 13 | 35 | 3,20% |
| In research | 1 | - | - | - | 3 | 4 | 0,36% |
| **Evolution** | | | | | | | |
| Ign/white skin | 12 | 11 | 15 | 21 | 42 | 101 | 9,25% |
| Alive | 112 | 146 | 197 | 280 | 239 | 974 | 98,2% |
| Death by the notified bill of review | 2 | 3 | 3 | 6 | 2 | 16 | 1,46% |
| Death from another cause | - | - | - | - | - | - | - |

**SOURCE:** Elaborated by the authors of the research, with data from Sistema de Informação de Agravos de Notificação - SINAN (2019).

Regarding the mode of evolution of Chagas' disease, it can be observed that the largest portion of 974 cases evolved to remission of clinical manifestations, while 101 ignored or white cases and 16 cases resulted in deaths by the reported wrongdoing.

## IV. DISCUSSION

We found that in the year 2013 to 2017 the health region with the highest number of reported cases of acute Chagas disease was the Tocantins region with 390 cases; followed by the Marajó II region with 272 cases. The Regional Health Units are 13 administrative units of the State Health Secretariat of Pará (SESPA) distributed throughout the state, aiming at decentralizing services and reducing geographical barriers to better serve the citizen (Sespa, 2019).

According to Freitas (2016), Pará is one of the states of Brazil in the northern region of the country, considered the largest portal of access to the Brazilian Amazon, whose capital is Belém. It is composed of 6 mesoregions, divided into 22 microregions, with 144 municipalities, having approximately 1,248,042 Km2 is the second largest state in Brazil.

The Marajó II Health Region has 285,389 inhabitants, distributed in 07 municipalities (Portel, Bagre, Curralinho, Anajás, Breves, Melgaço and Gurupá); about 61.61% of the population lives below the poverty line, with an economically active population of 5.35% in the 18-29 age group; and 7.88% in the 30-64 age group, with an illiteracy rate of 3.75% of the population. The regional gross domestic product (GDP) per capita R\$ 18,820.00. The region presents many social problems, including sanitary conditions: child labor, insufficient water and sewage services, and lack of selective garbage collection (Sespa, 2016).

The Metropolitan Health Region I has 2,039,298 inhabitants in 05 municipalities (Belém, Ananindeua, Marituba, Santa Bárbara do Pará and Benevides), with regional per capita GDP of R\$ 10,233.00, with 22.97% of the population having formal employment; 19.26% below the poverty line, which corresponds to 392,706 inhabitants; with an illiteracy rate of 5.3%. Regarding the urban sanitary situation of the region, 90.7% of the sanitary exhaustion is done by general or pluvial net, and in the rural area it has 9.3% of the sanitary exhaustion (Sespa, 2016).

In the Tocantins Health Region, it has 605,119 inhabitants, with 10 municipalities. It is composed by Barcarena, Abaetetuba, Igarapé-Mirim, Cametá, Moju, Oeiras do Pará, Thailand, Baião, Mocajuba and Limoeiro do Ajuru, with the economically active population in the age group of 18 to 29 years, which corresponds to 14.14% of this total; 30 to 64 years, 21.93%. However, only 0.16% of the population works in formal employment; 53.47% of the population lives below the poverty line, which corresponds to 261,450 inhabitants. The rate of child labor is 12.54%, and of illiteracy is 14.3%. Only 65.37% of the urban area is supplied with drinking water; while in the rural area, 15.41% is supplied by a general distribution network (Sespa, 2016; IBGE, 2017).

The results indicate that Chagas Acute Disease has been occurring over the years with the increase in the number of notified and confirmed cases, with the highest number of confirmed cases being 2016, with 327 cases. In the period 2000 to 2016, 16,807 (suspected cases) were notified in 130 of the 144 municipalities in the state of Pará, and 2030 confirmed cases of Chagas' Disease acute in 81 of these municipalities in the state (Santos, 2017).

In relation to the municipalities with the highest number of reported cases of acute Chagas disease, Ananindeua, Breves and Abaetetuba are the most prominent. Adding to our study, the Council of Municipal Health Departments of the State of Pará emphasizes that between 2013 and 2017, eleven of the thirteen health regions presented notifications of acute Chagas disease, with Metropolitan Regions I, Tocantins, Marajó I and II standing out with the highest number of cases, and among them the municipalities most affected: Ananindeua, Abaetetuba, Breves, Belém, Barcarena, Cametá and Igarapé- Miri (Consems-Pa, 2018).

The municipalities of Para as Abaetetuba, Igarapé-Miri, Cametá, Moju and Barcarena and Marajó archipelago (Portel, Ponta de Pedras and Anajás) stand out in the production of açaí in Pará, supplying the fruit to the metropolitan region. In Belém, the daily consumption is around 200,000 liters/day in the harvest period, being the second most consumed food in the capital. The processing of açaí in Pará is done by hand (beaters), with extraction of the pulp of the fruit with the help of a pulping machine (Santos, 2017).

According to IBGE (Brazilian Institute of Geography and Statistics), the production of açaí in the State of Pará has increased over the years, being the largest producer, with over 13,000 producers; responsible for 54% of national production, reaching around 800,000 tons per year (Tavares, Homma, 2015; IBGE, 2017).

Extractivism is an important socioeconomic role for the State of Pará, highlighting the management of açaizais. Around 25,000,000 families carry out activities related to the extraction, transportation, marketing and industrialization of the fruit, because in addition to the regional market, it meets national and international demand. Food subsistence is guaranteed by fish, açaí pulp, water flour (Brandão, 2015). Among the various plant resources, açaí is considered the staple food of riverine populations and low-income families (Mendonça, Bernardes & Del Bianchi, 2014).

In studies related to etiological agents in the processing of açaí, it was found that the fruit is very exposed during its handling. Throughout the pulp production chain, the main

problems are: contamination from technical and hygienic problems; sanitary deficiencies to which the pulp is submitted in small artisan establishments, compromising the health of consumers (Silva, Ferreira & Lacerda, 2017).

The months in which the highest number of notifications occurred are related to the period of the açaí harvest in the state of Pará. Collaborating with our study, Santos et al. (2018), Júnior et al. (2017), Souza & Povoa (2016), Brazil (2015), highlight that acute Chagas disease presents itself: in the first semester with a lower number of notifications, indicating a seasonal pattern of the disease; having an increase in the second semester between the months of August and December, coinciding with the period of higher production of Açaí in the state of Pará.

Thus, the Northern region presented in the period 2012-2016 the highest proportion of cases in the country with 97.1% between the months of August and February of the following year, considering the national average in this period which is 79% of reported cases of Chagas disease (Brazil, 2019).

Thus, Ferreira, Branquinho & Leite (2014), warns about the problem that guides the sanitary quality in pulp processing, because açaí is often involved in the oral transmission of CD, damaging the national / international marketing.

On the other hand, Guimarães et al. (2017), argue that CD is a major public health problem in the Amazon region due to its vast area of forest and associated with the common disorderly deforestation in the region, which contributes to the growth of the vectorial population, consequently contributing expressively to the emergence of endemic outbreaks in the region. Marin-Neto (2017), points out that deforestation has contributed to the contact of people with new types of hematophagous insects that start to inhabit the homes in general of the poorest with precarious housing.

We observed that the acute Chagas disease reaches more the male sex with 608 cases in relation to the female, with 483 cases. In relation to the age group, it was observed a greater involvement in people between 20 and 39 years old with 385 cases, in which the breed stood out the brown with 682 cases of disease. Reinforcing our data, the epidemiological bulletin of Acute Chagas' Disease of 2019, presents the age group between 20 and 49 years with a predominance of individuals called black and brown (Brazil, 2019).

In the same sense, Júnior et al. (2017), Santos et al. (2018), speak of the epidemiological profile of Chagas Disease in the period from 2007 to 2014: it affected more brown people, in the adult age group of 18 to 59 years,

having its main form of oral contamination associated with the ingestion of contaminated regional fruit juices, such as açaí and bacaba.

We observed that epidemiological aspects of Chagas disease in the state of Pará showed high oral transmission with 866 cases confirmed by laboratory tests. Regarding the evolution of the disease, the chronic/live form stands out, with 974 cases and 16 cases resulting in deaths by the reported wrongdoing.

Most of the cases reported in Brazil between 2000 and 2013 came from the State of Pará, with 87.5% of the Chagas disease (CD) records, and it was observed that the most frequent form of contamination was oral transmission in all years. However, 20% of the cases were closed with the form of transmission ignored or not filled in this field in the notification form (Brazil, 2015).

According to Souza & Povoa (2016), the Ministry of Health considers Chagas disease a public health problem, considering that from 2000 to 2013 there were 1,570 cases of the disease in Brazil, 1,081 people contracted it orally, 100 by the vector form, 6 vertical, 372 ignored and 11 by other forms. The northern region of the country contributed in this period with 1,430 reported cases of the disease, in the form of isolated outbreaks in family groups related to oral contamination.

Barreto et. al. (2015), argue that mortality in infected patients in Brazil occurs mainly acutely due to oral contamination, adding 8 to 35% of confirmed cases, compared to the classic form of transmission through the vector at the time of blood repast and deposition of excreta, adding 5 to 10% of cases.

Most individuals diagnosed with Chagas' disease in Brazil are chronic, although in recent years, Acute Chagas' disease has occurred in an expressive manner, generally related to the consumption of typical foods from the Amazon region contaminated by the pathogen, such as sugarcane juice, açaí and buriti (Júnior et al., 2017).

The epidemiological surveillance has records of repeated outbreaks by oral transmission in family and community groups, related to the consumption of açaí or bacaba, which are food habits of daily cultural food and subsistence of the riverside population of Pará (Santos, 2017).

The form of oral transmission of the disease is represented as the means of greater severity, because it has a marked parasite load in relation to other contamination routes, due to the characteristic of the upper digestive tract provide an area of increased absorption by the circular folds, villi and microvilli, making it much more permeable

to the parasite. As a result, the epidemiological profile takes on a new form, due to the ingestion of food contaminated with the presence of the parasite or feces such as açaí, due to the lack of adequate hygienic conditions (Simões et al, 2017).

## V.    CONCLUSION

This study made it possible to know: the clinical and epidemiological profile of acute Chagas disease within the State of Pará, identifying the health regions with the highest number of reported cases of acute Chagas disease, whose highest rates are the regions of Tocantins, Marajó II and Metropolitan I, where they lead the municipalities of Ananindeua, Breves, Abaetetuba, Belém, Cametá, Igarapé Miri.

As for the epidemiological aspects, the disease affects more the male sex, between 20 and 39 years, with greater prevalence in the brown race. Regarding the epidemiological aspects, the most frequent mode of transmission was by oral route, with the criterion of confirmation by laboratory tests, and the mode of evolution was through clinical manifestations.

We have shown that the increase in the number of cases over the years in the state of Pará may be related to the consumption of açaí, bearing in mind that the increase in cases of Chagas' disease coincides with the harvest of the fruit in the state between the months of August and November, which may be contributing to the current epidemiological situation of the disease.

The study allows identifying the areas where the greatest number of cases of the disease are occurring and where they need greater attention from epidemiological health departments. However, the elaboration of strategies is the main axis for the fight against the disease, alerting the sanitary surveillance to investigate in which part of the production chain of açaí processing presents a failure, being evidenced that the contamination by oral means is related to the ingestion of contaminated açaí, mainly in the most distant regions of the capital, where the fruit producing poles are concentrated. Preventive and educational measures have been the greatest challenge, becoming essentials for the combat, in order to reduce the chronification of the disease in the State.

It is relevant to identify the appropriate tools to ensure that the information used by managers enables the definition of public policies and action planning, so that SINAN data provide information very close to the reality experienced by the population, as a tool to support the planning of control actions. In this sense, we emphasize

that prevention campaigns should be intensified in the State of Pará.

Knowing the clinical and epidemiological profile of Chagas disease is what will allow the dissemination of the data collected for future scientific research, with the purpose of stimulating students and researchers interested in the subject to develop new research, also contributing as a source of information for health surveillance.

## REFERENCES

[1] Barreto, A. J. et al., (2018). Trypanosoma cruzi Infection through the Oral Route Promotes a Severe Infection in Mice: New Disease Form from an Old Infection? PLoS Negl Trop Dis. 2015;9(6): e 0003849. Acessado em: 02. Mar, 2018 disponível: http://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0003849

[2] Brandão, C. R. F. et al. (2015). O Açaí no Estado do Pará e seu Potencial para o Desenvolvimento Sustentável da Região. In: Congresso Técnico Científico da Engenharia e da Agronomia-CONTECC. 2015 acessado em: 02. Nov, 2018 disponível em: http://www.confea.org.br/media/Agronomia_o_acai_no_estado_do_para_e_seu_potencial_para_o_desenvolvimento_sustentavel_da_regiao.pdf

[3] Brasil, M. da S. (2015). Boletim Epidemiológico Secretaria de Vigilância em Saúde − Ministério da Saúde Volume 46 N° 21 – 2015. Acessado em: 24. Fev, 2018, disponível: http://portalarquivos2.saude.gov.br/images/pdf/2015/agosto/03/2014-020..pdf

[4] Brasil, M. da S. (2017). Guia de Vigilância em Saúde, Volume único 2a edição Brasília – DF 2017. Acessado em: 20. Out, 2018, disponível em: http://portalarquivos.saude.gov.br/images/pdf/2017/outubro/06/Volume-Unico-2017.pdf

[5] Brasil, M. da S. (2019). Secretaria de Vigilância em Saúde, Ministério da Saúde. Boletim Epidemiológico, Doença de Chagas Aguda e distribuição espacial dos triatomíneos de importância epidemiológica, Brasil 2012 a 2016, Volume 50 | Jan. 2019. Disponível em: http://portalarquivos2.saude.gov.br/images/pdf/2019/janeiro/23/2018-025.pdf, acessado em: 07. Abr, 2019.

[6] Consems-Pa, (2018). Conselho de Secretarias Municipais de Saúde do Estado do Pará (CONSEMS-PA), Desafios do SUS no Pará, setembro – 2018, disponível em: cosemspa.org.br/admin/files/conteudo/47/arquivo/livreto-cosems-final-site-print-pdf.pdf, acessado em: 02. Mar, 2019.

[7] Freitas, S. C. S. (2016). Políticas Públicas de Educação Ambiental no Estado do Pará: Trinta Anos de uma Trajetória. Revista Margens Interdisciplinar, [S.I.], v, 7, 9, p. 131-157, maio, 2016. ISSN 1982-5374 acessado em: 04. Out, 2018, disponível em: https://periodicos.ufpa.br/index.php/revistamargens/article/download/2774/2905

[8] Ferreira, R. T. B, Branquinho, M. R., Leite, P. C. (2014). Transmissão oral da Doença de Chagas pelo consumo de açaí: um desafio para a Vigilância Sanitária. Vigilância Sanitária em Debate, Rio de Janeiro, v. 2, n. 4, p. 4-11, 2014. Disponível: http://dx.doi.org/10.3395/vd.v2i4.358, acessado em: 18. Mar, 2018.

[9] Guimarães, R. J. de P. S. et al (2017). Análise espacial da Doença de Chagas no Estado do Pará no período de 2010-2014, RJ 2017 disponível em: https://www.researchgate.net/publication/318210062, acessado em: 20. Set, 2018

[10] IBGE, I. B. de G. e E., (2016). Estados@ - Pará. Disponível em: http://www.ibge.gov.br/estadosat/perfil.php?lang=&sigla=pa . Acessado em: 30. Set, 2016.

[11] Júnior, A. da S. S. et al., (2017). Spatial-temporal Analysis of Chagas Disease and its Environmental and Demographic Risk Factors in the Municipality of Barcarena, Pará, Brazil, Rev Bras Epidemiol out-dez 2017; 20(4): 742-755. Acessado em: 18. Mar, 2018, disponível: http://www.scielo.br/scielo.php?pid=S1415790X2017000400742&script=sci_abstract&tlng=pt

[12] Marin-Neto, J. A. (2017). Doença de Chagas–mais de 100 anos depois de sua cientificamente brilhante descoberta, há poucas razões para se comemorar? Revista USP, São Paulo, n. 115, p. 89-104, 2017, acessado em: 11. Ago, 2018, disponível em: https://jornal.usp.br/wp-content/uploads/7-textos-Marin-Neto.pdf

[13] Mendonça, V. C. M., Bernardes, R. H., Del Bianchi, V. L. (2014). Impacto do surto da doença de chagas na comercialização do açaí (Euterpe Oleracea mart.) no município de Pinheiro-MA. Revista SODEBRAS, p. 174-178, 2014, acessado em: 22. Set, 2018 disponível em: https://repositorio.unesp.br/handle/11449/122471

[14] Santos, V. R. C. (2017). Estudo sobre a Doença de Chagas aguda no estado Pará, Amazônia. 2017. 159 f. Tese (Doutorado em Medicina Tropical) - Fundação Oswaldo Cruz, Instituto Oswaldo Cruz, Rio de Janeiro, 2017. Acessado em 25. Dez, 2018, disponível: https://www.arca.fiocruz.br/handle/icict/25168

[15] Santos, V. R. C. et al., (2018). Acute Chagas disease in the state of Pará, Amazon Region: is it increasing?, Mem Inst Oswaldo Cruz, Rio de Janeiro, Vol. 113(5): e170298, 2018. Disponível em: http://www.scielo.br/scielo.php?pid=S007402762018000500306&script=sci_arttext, acessado em: 04. Abr, 2019.

[16] Sespa, S. E. de S. do P. (2016). Plano Estadual de Saúde 2016-2019. Belém-Pará 2016. Disponível em: www.conass.org.br/pdf/planos-estaduais-de-saude/PA_Plano-estadual-saude-2016-2019.pdf, acessado em: 04. Abr, 2019.

[17] Simões, M. V. et al. (2017). Cardiomiopatia da Doença de Chagas. Int. j. cardiovasc. sci. (Impr.), v. 31, n. 2, p. f: 173-l: 189, 2017 acessado em: 11. Dez, 2018, disponível em: http://publicacoes.cardiol.br/portal/ijcs/portugues/2018/v3102/pdf/3102011.pdf

[18] Silva, E. T. M., Ferreira, J. de S., Lacerda, L. de M. (2017). Condições Higiênicos Sanitárias da Cadeia Produtiva do Açaí na Região do Maracanã em São Luís, MA. Hig. aliment, v. 31, n. 268/269, p. 68-72, 2017. Acessado em: 10. Dez, 2018 disponível em: http://docs.bvsalud.org/biblioref/2017/07/846449/268-269-site-68-72.pdf

[19] Souza, D. do S. M., Povoa, R. M. dos S. (2016). Aspectos Epidemiológicos e Clínicos da Doença de Chagas Aguda no Brasil e na América Latina, Rev Soc Cardiol Estado de São Paulo 2016; 26(4):222-9 disponível em: http://socesp.org.br/revista/assets/upload/revista/1974977802 1534351339pdf REVISTA-SOCESP-V26-N4.pdf, acessado em 09. Nov, 2018.

[20] Tavares, G. dos S. Homma, A. K. O. (2015). Comercialização do açaí no estado do Pará: alguns comentários. Embrapa Amazônia Oriental-Artigo em periódico indexado (ALICE), 2015. Acessado em: 22. Nov, 2018 disponível em: http://www.alice.cnptia.embrapa.br/alice/handle/doc/103148 6

# An Investigation of Production Risk, Marketing Risk, and Financial Risk on Broiler Farming in Regency of Minahasa Utara-Indonesia

Erwin Wantasen[1], Jein R Leke[2], Anneke K Rintjap[1]

[1]Department of Socio economic Faculty of Animal Science, Sam Ratulangi University, Manado, Indonesia
[2]Department of Animal Production Faculty of Animal Science, Sam Ratulangi University, Manado, Indonesia

*Abstract— The purpose of this study was to investigate risks source, threat potency of risk and risk management strategy in managing risk production, marketing risk, and financial risk of broiler farm in Regency of Minahasa Utara. The research's site was selected purposively in three Villages, representing three Districts as center of broiler production in Regency of Minahasa Utara. Those three Villages were Village of Dimembe, Village of Kauditan Satu and Village of Kolongan. In detail, 59 respondents of broiler's breeders were selected by total of sampling. Data regarding on source of production risk, marketing risk, and financial risk of broiler farming was gained through in-depth interview addressed to breeders guided by a list of questions. Value of risks was then analyzed by using Failure Mode and Effect Analysis (FMEA), Results study showed sources of production risk on broiler farming on the study sites comprise of: inclination to utilize chemical medicine, disease outbreak, bad weather and utilization of conventional tools. Marketing risks dealt by broiler's breeders consist of broiler's mortality, sold broilers in lived condition, most price determined by partner and performance index target-based profit. Financial risks, then, faced by broiler's breeders are minimal capital, fearsome to lend to bank and higher input price, Based on the value of Risk Priority Number (RPN), sources of primary risk becoming inhibiting factors on success of broiler farm in Regency of Minahasa Utara, consecutively, are performance index target-based profit, disease outbreak, broiler's mortality, sold broilers in lived condition and risk of capital loan from banking sector.*

*Keywords— Risk, production, marketing, financial, risk value.*

## I. INTRODUCTION

In general, livestock sub-sector holds a significant role in Indonesian agriculture. One of types of livestock-agribusiness sufficiently cultivated is broiler. The need of chicken's meat assumedly will still increase in accordance with improvement of income and population, as depicted in 2016, 2017, and 2018. Those years were a period where Indonesian consumption pattern against chicken's meat experienced increasing as of 3,947 kg/year/capita, 4,835 kg/year/capita, and 5,668kg/year/capita respectively [1]. Therefore, productivity of chicken's meat should be necessarily improved in order to balance demand increasing against chicken's meat.

Chicken's meat has a better quality, but, in fact, there are variously complex issues dealt by broiler farming, either internal or external. Such issue can result serious risk and uncertainty for breeders [2,3]. In Indonesia, most breeders are dominated small-scale farming, non-company structure, and have highly limited opportunity to diversify their business. A consequence of existing structure, many business risks are concentrated in small-scale breeders performed individually [4,5]. This circumstance requires a better understanding from breeders concerning on business risk derived from either causing factors or mechanism to solve such risk.

Price fluctuation of chicken's meat indicates that there are risk factors in broiler farm. It shows that development of broiler business has potential risk causing loss. Hence, this condition is necessarily analyzed since it causes loss charged by breeder. For every process of broiler production, breeders should consider how much risk they have to bear on. Typically, risk suffered by broiler business farm comprises of production, marketing, and financial risk [6,7].

Specifically, Regency of Minahasa Utara is the biggest region of broiler producer in Province of North Sulawesi with

total of population of 4,806,552 heads in 2018 [8]. However, breeders sometimes experience difficulty in production, marketing and financial aspect, such as disease outbreak, fluctuate price of input and output, so that it causes instability of their income. It is common risk dealt by breeders in Regency of Minahasa Utara, urgently requiring solution. Some previous researches regarding on broiler farm have been analyzed, but they are limited on production risk; while, marketing and financial risk still demonstrate limited information. Therefore, this research aims to know risks source, threat potency of risk and risk management strategy in managing risk production, marketing risk, and financial risk of broiler farm in Regency of Minahasa Utara.

## II.    RESEARCH METHODS

### 2.1 . Site and Sampling Methods

The research's site was selected purposively in three Villages, representing three Districts as center of broiler production in Regency of Minahasa Utara along with their breeders having conducting business partnership with PT Charoen Pokphand Jaya Farm for the last five years. Those three Villages were Village of Dimembe in District of Dimembe, Village of Kauditan Satu in District of Kauditan, and Village of Kolongan in District of Kalawat. In detail, respondents were broiler's breeders and selected by total of sampling [9,10]. There were 59 breeders, comprising of 13 breeders from Village of Kolongan, 27 breeders from Village

of Dimembe, and 19 breeders in Village of Kauditan Satu. Data regarding on source of production risk, marketing risk, and financial risk of broiler farming was gained through in-depth interview addressed to breeders guided by a list of questions during March–April 2020. Further, sources of risk identified are analyzed by Failure Mode and Effect Analysis (FMEA), so the amount of respective source of risk can be known [11]

### 2.2.   Failure Mode and Effect Analysis

To calculate how much risk dealt with, each source of risks, resulted from identification obtained from breeders, was analyzed using Failure Mode and Effect Analysis (FMEA) [11]. Then, each source identified was determined its rating value of Severity, Occurrence, and Detection. Ratingis taken from some breeders acknowledged having a better analytical capacity. Therefore, in this research, respondent was selected based on some criteria, such as an experienced in broiler farm business and b) having critical thinking and better analysis. The result of each breeder's rating was averaged subsequently.

Severity is quantification on how severe condition is happened, resulted by each source of risks. It is valued from rating 1 up to 10. The more severe the effect resulted, the higher the severity value (its danger). Specifically, criteria of value determination or severity rating is shown in following Table 1.

*Table 1. Severity scale*

| Rating | Effect | Verbal Criteria |
|---|---|---|
| 10 | Dangerous | The most superior severity as potentially failure mode results on the halt of farm without notice |
| 9 | Serious | A higher severity as potentially failure mode results on the halt of business with notice |
| 8 | Extreme | Cultivation cannot operate with failure resulting cycle damage without halting broiler farm business |
| 7 | Mayor | Cultivation cannot operate without cycle damage |
| 6 | Significant | Cultivation cannot operate with small cycle damage |
| 5 | Moderate | Cultivation cannot operate without cycle damage |
| 4 | Minor | Cultivation can operate along with significantly decreasing performance |
| 3 | Easy | Cultivation can operate along with decreasing performance |
| 2 | Simple | Cultivation can operate with small obstruction |
| 1 | Not available | No impact occurred |

The possibility of risk occurring (occurrence) is displayed within 10 levels. It starts from never happen (1) up to inevitable (10). Below, possibility criteria of risk occurrence is shown in Table 2.

*Table 2. Occurrence scale*

| Rating | Effect | Verbal Criteria |
|---|---|---|
| 10 | Inevitable | Risk occurred is inevitable |
| 9 | Higher | Risk occurred is higher |
| 8 | High | Risk occurred is high |
| 7 | Quite high | Risk occurred is quite high |
| 6 | Medium | Risk occurred is medium |
| 5 | Low | Risk occurred is low |
| 4 | Small | Risk occurred is small |
| 3 | Little | Risk occurred is little |
| 2 | Seldom | Risk occurred is seldom |
| 1 | Never happen | Risk occurred is never happened |

The possibility of risk controlling (Detection) is depicted in 10 levels, where 1 shows possibly controllable or greatly controlled and 10 is possibly less controlled.

Criteria of controlling or detection is then displayed in Table 3.

*Table 3. Detection scale*

| Rating | Effect | Verbal Criteria |
|---|---|---|
| 10 | Always uncertain | No controlling toolsare able to detect causes of failure and subsequent failure mode |
| 9 | Minor | Controlling tools have minor ability to detect causes of failure and subsequent failure mode |
| 8 | Small | Controlling tools have small ability to detect causes of failure and subsequent failure mode |
| 7 | Very low | Controlling tools have very low ability to detect causes of failure and subsequent failure mode |
| 6 | Low | Controlling tools have low ability to detect causes of failure and subsequent failure mode |
| 5 | Moderate | Controlling tools have moderate ability to detect causes of failure and subsequent failure mode |
| 4 | Incline to be High | Controlling tools inclines to be high to detect causes of failure and subsequent failure mode |
| 3 | High | Controlling tools have high ability to detect causes of failure and subsequent failure mode |
| 2 | Higher | Controlling tools have higher ability to detect causes of failure and subsequent failure mode |
| 1 | Barely certain | Controlling tools have barely certain ability to detect causes of failure and subsequent failure mode |

Each scale or criteria, then, is given rating by breeders selected by researcher based on breeders' analytical ability. Based on rating obtained from each criteria or scale in Failure Mode and Effect Analysis (FMEA) then, Risk Priority Number (RPN) is calculated. It is multiplication of rating from severity, occurrence, and detection.

RPN = S X O X D

Where:

RPN     = Risk Priority Number

S        = Severity

O        = Occurrence

D        = Detection

Risk priority number (RPN) is calculated to ease risk classifying in order to determine scale of priority in its management. The result of risk priority number, then, is classified into three classes, such as low, moderate and high to know risk going to be handled promptly. Any risk including in high class is the most significant effect in business risk of broiler farm, so it becomes reference for breeders to anticipate in future to mitigate and minimize any risk possibly occurred.

2.3 Designing Risk Management Strategy

Based on the finding of the most determining risk source in broiler farm in Regency of Minahasa Utara in accordance with effect priority resulted from FMEA, it is necessary to design applicable strategy to control risk sources. Such designing is based on literature study by considering condition and ability of the research's site.

## III.     RESULTS AND DISCUSSION

3.1. Production Risk

Based on the research's findings by in-depth interview addressed to breeders as respondents, four production risks were identified, containing production input, resources, environment, and technical factor. Particularly, input factor was identified since breeders inclined to use chemical substances potentially resulting on decreasing production output. Medicine or vaccine used by breeders in the research's site had weakness, such as not having maximal productivity. It was in accordance with [12] reporting that profitability derived from small-scale broiler farm was influenced by usage of medicine input. However, even though breeders in the research's site used chemical medicine, organic medicines could press down declining number of broiler's productivity.

Resource factor identified was conventional tools. The finding of identification displays that there were no cage's temperature and automatic temperature controller. It resulted on broiler's higher mortality due to open-cage construction system used by breeders, causing cage's internal condition not suitable in accordance with rapid weather change. This condition caused broiler more susceptible infected by disease and non-maximal productivity. According to [13], environment, such as incompatible weather with broiler's growth like lower or higher rainfall, resulted on disturbed broiler's growth, so that there was a gap of broiler's weight; and, if there was no correct management, many broilers would die, producing declining harvest quantity of broiler. One of currently urgent necessity is to determine existing diseases

in broiler farm. Despite deadly contagious diseases, simply common diseases also required attention by taking into account that such diseases also provided moderately economic loss. Sanitation in broiler farm is the cheapest technique of disease prevention [14].

Lastly, technical risk was heavily influenced by imbalance medicine usage that resulted on broiler's poor immunity and non-existence of modern equipment against broiler cultivation caused non-maximal production obtained by breeders.

3.2. Marketing Risk

From the research's findings, there are 3 factors of marketing risk dealt by broiler's breeders in Regency of Minahasa Utara. It includes product, market, and partnership risk. Specifically, product risk contained broiler's mortality during cultivation, resulting on declining total of broilers. There was no supplementary of total of broilers, so the result of ready-to-sell products experienced decreasing from initial total of DOC. Moreover, product sold in the form of lived broilers was another issue of breeders, so added-value obtained by them was classified as low product. Then, its selling price was lower and it correlated with income earned. This result is similarly in line with [15], stating that causing factors dealt by breeders were lower selling price of broiler, having positive correlation with performance of broiler farm in the Southwest region of Parana, Brazil, where the lower the selling price of broilers, the more declining the broiler farm performance.

Regarding market factor, it demonstrates that product marketing performed was under partnership program, so that breeders' bargaining power was minimal in determining their product price. According to [16], agribusiness structure of Indonesian broiler farm could be classified as three dispersal, characterized by non-functional organization relationship along its business level and most price determined by main company by contract, where breeders felt that their profit was relatively low.

Partnership factor targeted or required Performance Index (PI). Such requirement made breeders, aiming to obtain greater profit, had to seize such performance index. If they did not achieve such requirement, they would get small profit. Opposingly, income earned by plasma breeders (partner) under farming contract apparently was lower that non-contractual breeders [17]. However, main company guaranteed marketing all products of its plasma breeders (partner).

3.3. Financial Risk

The finding shows that there were three factors of financial risk, including fund sources, cost and income. Sources of financial riskidentified in fund sources were that breeders always dealt with capital limitation since they heavily relied on their personal capital individually. Further, there was fearsome felt by breeders in utilizing capital loan from banking sector. These issues also created difficulty in developing their broiler farm.

Cost became one factor in determining the number of profit breeders earned. Based on the research's findings, cost expensed by breeders was relatively higher. It was due to a higher cost of production infrastructure and input price of production [18]. Also, under partnership system, there were some deficiencies. Such shortages were that over supply could be experienced by main company if broiler's harvest occurred jointly. Meanwhile, for plasma breeders, selling price of broiler by main company caused breeders could not achieve maximal profit, breeders could not sell their products to other parties since breeders were under agreement with main company, input price (DOC, feed, vitamin, medicine) was higher, and, breeders have not provided soft credit from main company to establish cages and purchase tools. The last factor of financial risk is income. There was a higher dependency of breeder's daily life fulfillment toward broiler farm. If they faced failure in their broiler business, breeders would find an issue in fulfilling their family's daily needs.

3.4. Business Risk Analysis of Broiler Farm in Regency of Minahasa Utara

The result of risk sources identification, subsequently, was analyzed using Failure Mode and Effect Analysis (FMEA). In determining its rating, a better analysis ability was highly required. Based on such criteria, of 59 respondents, eight respondents were selected to give rating related to severity, occurrence, and detection in each identified risk. Then, rating obtained from such criteria was averaged and analyzed by FMEA. As the result, Risk Priority Number (RPN), multiplication result of rating derived from severity, occurrence, and detection, was

achieved. The result of rating can be seen from following Table 4.

Based on Table 4, the value of RPN becomes indicator of risk sources, having main priority of management, so breeders did not suffer from loss or failure in their business. It, thus, requires class classification of risk comprising of low, medium, and high, based on the value of RPN-a basic calculation of each risk. It is known that the range value (the biggest value of RPN was deduced by the smallest value of RPN) was 296. Next, data of risks was classified into three classes (low, medium, and high risk). Class interval (range was divided by total of classes) was 99. Hence, low-risk class was known, consisting of utilization of chemical medicine, no modern tools applied, imbalance use of medicine, no technology applied in cultivation, and individual marketing, and minimal capital. It was due to dependency on capital. While, medium-risk class was bad weather, most price determined by main company, determination of contract price, higher input price, and higher cost of production infrastructure, and income relied on broiler farm. Lastly, high-risk class was disease outbreak, broiler's mortality causing declining productivity, products sold in lived condition, profit depending on performance index target, and capital utilization from banking sector.

According to above research's findings and details, it can be seen that all risks identified, generally, comprised of higher risk source by RPN of 392 (profit depending on Performance Index target). Respectively, then, the values of RPN were 384 (disease outbreak), 336 (broiler's mortality resulting declining productivity), 324 (broilers sold in lived condition), 288 (fearsome to lend in banking sector). Those results are in line with [19, 20, 21], arguing that disease risk, antibiotic utilization, chemical medicine and vaccine, quality of Day Old Chick (DOC), equipment utilization of out-of-dated feed processor and non-standard products resulted, were sources of risk dealt by breeders and poultry industry, including broiler farm.

*Table 4. Rating of severity (S), occurrence (O), and detection (D) on business risk of broiler farming in regency of Minahasa Utara*

| Sources of risk | | | S | O | D | RPN |
|---|---|---|---|---|---|---|
| **A. Production risk** | | | | | | |
| Production input | A | Incline to use chemical medicine | 4 | 8 | 4 | 128 |
| Environment | B1 | Disease outbreak | 8 | 6 | 8 | 384 |
| | B2 | Bad weather | 6 | 5 | 7 | 210 |
| Resources | C | No modern tools applied | 4 | 8 | 3 | 96 |

| | | | | S | O | D | RPN |
|---|---|---|---|---|---|---|---|
| Technical | D1 | Imbalance usage of medicine | | 4 | 8 | 4 | 128 |
| | D2 | No technology applied in cultivation | | 5 | 8 | 3 | 120 |
| **B.   Marketing Risk** | | | | | | | |
| Product | E1 | Broiler's mortality | | 6 | 8 | 7 | 336 |
| | E2 | Selling lived broilers | | 4 | 9 | 9 | 324 |
| Market | F1 | Individual marketing | | 4 | 9 | 4 | 144 |
| | F2 | Price fixing by main company | | 7 | 7 | 4 | 196 |
| Partnership | G1 | Performance index (PI) target-based profit | | 8 | 7 | 7 | 392 |
| | G2 | Determining of contract price | | 5 | 9 | 4 | 180 |
| **C.   Financial Risk** | | | | | | | |
| Fund sources | H1 | Minimal capital | | 4 | 8 | 4 | 128 |
| | H2 | Capital sourced from banking | | 4 | 9 | 8 | 288 |
| Cost | I1 | Higher input price | | 7 | 6 | 5 | 210 |
| | I2 | Higher production infrastructure price | | 5 | 5 | 8 | 200 |
| Income | J | Income depends on broiler farm | | 7 | 6 | 6 | 252 |

Where:

S: Severity (severity of risk effects)

O: Occurrence (occurrence frequency of risk sources)

D: Detection (controlling ability of risk sources)

RPN: Risk Priority Number, or multiplication result of S,O, and D

### 3.5. Risk Management Strategy

After determining successful sources of primary risk on broiler farm in the research's site, risk management strategy should be considered. In Regency of Minahasa Utara, breeders consciously realized that there were many risks related to broiler farm. Therefore, breeders have to have risk management strategy. Breeders, basically, in Regency of Minahasa Utara had not applied risk management strategy correctly. It was due to their limited knowledge regarding such issue. They only anticipated business risk by learning based on previous experience, without calculating the amount of business risk going to be born. In dealing with business risk in agriculture, breeders can perform following strategies to reduce loss. Some risk management strategies can be taken by 1) enterprise diversification), 2) vertical integration, 3) production contract, 4) marketing contract, 5) hedging, and 6) insurance [4, 22].

To provide risk management strategy in broiler farm located in Regency of Minahasa Utara, sustainably institutional counselling is required in the form of Village-Owned Entity (BUMDES). It (BUMDES) can be developed into several business units.

### 3.6.   Broiler Management

Mostly, breeders marketed their broiler's product in lived condition. It had not been able to improve sufficiently breeder's welfare. Thus, it requires manufacturing industry to produce added-value for broiler's product. Various manufactured products can be resulted from broiler in the form of frozen, fillet, canned, smoked, shredded and nugget. Thus, if broiler's products are well-managed, broiler's commodity along with its derivative products has highly economical value.

### 3.7.   Micro Financial Institution

Micro Financial Institution  formed in Village-Owned Enterprises (VOE) assigns and functions as financial institution to distribute capital under simple and directed credit system for villagers. Also, it avoids villagers from trapping of moneylenders operating in village. When VOE could operate, it have created equal distribution of business opportunity for low-economic class and provided service to villagers, particularly for breeders in procuring capital through credit system directed in improvement of their business activity.

### III.       CONCLUSION

Sources of production risk on broiler farm located in Regency of Minahasa Utara comprise of: inclination to

utilize chemical medicine, disease outbreak, bad weather, utilization of conventional tools, imbalance use of medicine, and no modern tools applied in cultivation.

Marketing risks dealt by broiler's breeders consist of broiler's mortality resulting declining productivity, sold in lived condition, individual marketing, most price determined by partner, performance index target-based profit, and contract pricing.

Financial risk, then, faced by broiler's breeders are minimal capital due to individual capital, fearsome to lend to bank, higher input price, higher price of production infrastructure, broiler farm-based most income.

Based on the value of Risk Priority Number (RPN), sources of primary risk becoming inhibiting factors on success of broiler farm in Regency of Minahasa Utara, consecutively, are performance index target-based profit, disease outbreak, broiler's mortality resulting declining productivity, sold in lived condition, risk of capital loan from banking sector.

As solution, some strategies that can be taken to mitigate those sources of risk in broiler farm located in Regency of Minahasa Utara are product diversification of broiler and institution strengthening by establishing Village-Owned Entity (*VOE)*.

## REFERENCES

[1] Direktorat Jederal Peternakan (2019). Konsumsi perkapita daging ayam di Indonesia, Kementerian Pertanian RI, Jakarta.

[2] Umboh, S.J.K., Hakim D.B, Sinaga B.M. Karyasa K. (2014). Impact of domestic maize price changes on the performance of small scale broiler farming in Indonesia. *Media Peternakan* 37 (3), 198-205

[3] Yemima. (2014). Analisis usaha peternakan ayam broiler pada peternakan rakyat di desa Karya Bakti Kecamatan Rungan Kabupaten Gunung Mas Provinsi Kalimantan Tengah. *Jurnal Ilmu Hewani Tropika* 3 (1), 87-94.

[4] Ishag, Kh.H.M. (2019). Broiler production systems risk management sustainability and feed subsidy policy analysis. *IOSR Journal of Agriculture and Veterinary Science* 12 (9), 33-44

[5] Setiadi D. (2015) Faktor-faktor yang mempengaruhi risiko usaha ternak ayam ras pedaging di Kecamatan Pamijahan, Kabupaten Bogor. *Jurnal Ilmu Ternak* 15 (1), 1-7

[6] Nabradi, A and Madai, H. (2007). Risk and risk management in Hungarian sheep production. *Applied Studies in Agribusiness and Commerce.* 1 (1), 61-65

[7] Hayran, S and Gül, A. (2015). Risk persecption and management strategies in diary farming: A case of Adana province Turkey. *Turkish Journal of Agriculture-Food Science and Technology* 3 (12), 952-961

[8] Badan Pusat Statistik Sulut. (2019). Minahasa utara dalam angka, Manado.

[9] Taherdoost, H. (2016). Sampling methods in research methodology; How to choose a sampling technique for research. *International Journal of Academic Research in Management, 5 (2),* 18-27

[10] Sugiono, *Metode penelitian kuantitatif kualitatif dan R&D* ( Bandung, Alfabeta, 2013).

[11] Wang, Y.M., Chin, K.S, Poon, G. K..K, Yang, J.B. (2009). Risk evaluation in failure mode and effects analysis using fuzzy weighted Geometric Mean. *Expert Systems with Applications 36*, 1195-1207.

[12] Rana, K., Rahman, M, Sattar, M. (2012). Profitability of small scale broiler production in some selected areas of Mymensingh. *Progressive Agriculture*, *23,* 101–109.

[13] Nayak, G.D., Behura, N.C, Sardar, K.K, Mishra, P.K. (2015). Effect of climatic variables on production and reproduction traits on colored broiler breeder poultry. *Veterinary Word. 8(4),* 472-477

[14] Budi, E.S., Yektiningsih, E, Priyanto, E. (2015). Profitabilitas usaha ternak itik petelur di desa Kebonsari Kecamatan Candi, Sidoarjo. *Jurnal Agraris*, 1(1), 32-37

[15] Mendes, A.S, Gudoski, D.C, Cargnelutti, A.F, Silva, E.J, Carvalho, E.H, Morello, G. (2014). Factors that impact the financial performance of broiler production in Southern State of Parana, Brazil. *Brazilian Journal of Poultry Science,* 16 (1), 113-119

[16] Nurtini, S. Mujtahidah, A.U.M, Haryadi, F.T, Hakim, A. (2017). Performance of broiler farmer in partnerships system at Surakarta, Indonesia. *Journal of Advanced Agricultural Technologies* 4(2), 196-199

[17] Yulianti, F. (2012). Kajian analisis pola usaha pengembangan ayam broiler di Kota Banjar Baru. *Jurnal Socioscientia* 4 (1*),* 65-72.

[18] Achoja, F.O. (2014). Financial risk threshold determination in broiler enterprise in Delta State, Nigeria. *Agricultura Tropica Et Subtropica*, 46 (4), 111-117

[19] Nikpay, A.A., Zaghi, D, Kohan, I.Z, Tavakol, M. (2014). Using failure mode and efdect analysis (FMEA) in the risk analysisof industrial poultry production for decreasing threats of poultry by analyzing point of failure. *International Journal of Poultry Sciece* 13 (12), 718-728

[20] Wessiani, N.A., and Sarwoko, S.O. (2015). Risk analysis of poultry feed production using fuzzy FMEA. *Procedia Manufacturing 4,* 270-281

[21] Sekarrini, R., M Harisudin, M, Riptandi, E.W. (2016) Manajemen resiko budidaya ayam broiler di Kabupaten Boyolali. *Agrisita* 4 (3), 329-340

[22] Iheke, O.R and Igbelina, C.A. (2016). Risk management in poultry production in Ikeduru local government area of Imo State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment* 12 (1), 67-74

# Effects of the binaural wave as a stimulus for student hyperattention: brain frequency records without interactive media context

Andreia Solange Bos[1], Lucília Gomes Donato[2], Marcelo Vettori[2], Milton Antônio Zaro[3]

[1]Federal Institute of Education Science and Technology of Rio Grande do Sul (IFRS), Porto Alegre RS Brazil
[2]Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, RS, Brazil
[3]University of Rio Grande do Sul, Dep. CINTED, RS, Brazil

**Abstract**— *The brain works with electrochemical, generating brain waves that represent brain activity. The basic frequencies of brain functioning are gamma (30-70 Hz), beta (13-30 Hz), alpha (8-13 Hz), theta (4-8 Hz), and delta (1-4 Hz). With these references it is possible to condition the electrical activity, inducing a specific wave pattern. The way for this to happen is through binaural waves to synchronize brain patterns. This technique is addressed in this study, in the context of interactive media and in the student's attention stimuli, so the sounds are received independently in each ear creating different effects in parts of the brain.*

**Keywords**— *Binaural wave. Media interactives. Attention.*

## I. INTRODUCTION

Every day, our society undergoes a constant transformation in which the use of information and communication technologies (ICTs) has become essential in our lifestyle. The use of ICTs contributes to a globalization process in all aspects of society, including innovation, entertainment and education. Mobile devices within the classroom are no longer a paradigm for teachers and students worldwide. For this reason, several software developers have implemented various educational applications, among which are applications, most of which are free that can be used on smartphones. Thus, its use does not present any restriction for either students or teachers.

Previously, the ability to track brain rhythms was only available using electroencephalography in large volumes, requiring medical EEG recording technique. And yet with all these difficult requirements, the quality of the EEG obtained was not always high. Currently microelectronics has taken another qualitative leap, and in recent years a large number of ready-made devices or nearly ready kits have appeared on the market, allowing the technology to be wearable, EEG data being collected with a device in real time [3]. This made it possible to provide neuroeducation feedback to track the state of the brain and mind directly connected during various types of activities, mainly in the development of attention.

To understand the influence of technology on the human brain, Hayles approaches that human beings are born with the nervous system ready to be reconfigured in response to the environment (p.123). So, the human brain is constantly reconfiguring itself to respond to the challenges posed by technology. Katherine Hayles in 2007 addresses the new technological paradigm and calls it hyperattention. The brain still works with electrical and chemical energy, and when used with electricity the brain can be considered a low-frequency machine generated by the action of the phenomena [13].

Brain waves are electrical activities that are produced by the firing of neurons in the brain. Each of these neurons comes into contact with another ten thousand neurons [20]. These electrical activities can be measured on the scalp using an electroencephalogram (EEG) device. These electrical waves emit electrochemical impulses of different frequencies that are received by an electroencephalogram [15]. The functioning of the human brain has always been a curiosity for scientists [13]. It is incredible to think that simple changes in the electrical potential of the brain can create thoughts, feelings and synchronize thousands of muscle movements and processes. Brain waves are divided

into six categories that range from the smallest to the most active. Table 1 shows brain waves and their respective frequencies [2]

*Table.1: Brain waves and their frequencies*

| Frequency Types | Frequency Range | Mental State |
|---|---|---|
| Delta | 0.1Hz to 3Hz | Deep sleep |
| Theta | 4Hz to 7Hz | Creative |
| Alpha | 8Hz to 12Hz | Imagination / Dreams |
| Low Beta | 12Hz to 15Hz | Relaxation and Focus |
| Mid-Range | 16Hz to 20Hz | Conscious |
| High Beta | 21Hz to 30Hz | Alert / agitation |

*Source: Prepared by the authors, (2020).*

The states of consciousness are the various stages that the mind can go through in a day, from very relaxed to very alert.

● Beta: The beta state is when we have 13 to 40 brain waves per second and we are most alert. It is when we are involved in activities that go through the normal day, such as talking and working.

● Alpha: The alpha state is when the brain waves decrease slightly, from 8 to 13 per second. In the alpha state, we still wake up, but we are very relaxed. This is the state that people are in during meditation.

● Theta: In the Theta state, our brain waves decrease further to 4 to 7 per second. It is in Theta that we are sleeping, or close to it.

● Delta: In the Delta state, our brain waves are 1 to 4 per second. In this state, we sleep deeply every night.

It was once approached that the bridge from brain research to education was too long a bridge (BRUER, 1993). In recent times, important progress has been improving research in the field of neuroeducation. Cognitive neuroscience is already highly relevant to education [18]. Our understanding of learning algorithms includes the importance of prediction, prediction error, consolidation of memories that is directly relevant to the efficient learning project [4]. Our understanding of the role of attention and reward, the negative effects, distraction, are important genetic discoveries that affect a lot when thinking about education [13].

As a person undergoes changes in their level of attention or mental state, small changes occur in the levels of tension and in the frequency of the signals emanating from their neocortex. The method is known as electroencephalogram (EEG) using electrodes connected through the scalp by scientists to accurately measure the signals and their fluctuations in measurement that occur [18]. These signals can be used for a variety of purposes, including diagnosing a person's attention and stress level. Some findings support the hypothesis that rhythmic stimuli trigger changes in the thalamus and the neocortex [1]. The rhythmic frequency of electrical activity within brain areas is captured by wave bands, measured in number of waves per second, or Hertz, which tend to be associated with the student's psychological state.

## II. TECHNOLOGIES

2.1 Interactive Media: During the study, videos with binaural content and sound were used with the appropriate frequencies of the study. The videos were selected because they were judged the most appropriate for the proper test and that we could use for free. Following in Figure 1 is shown image resource used during the study with the headset illustration used and binaural frequency.
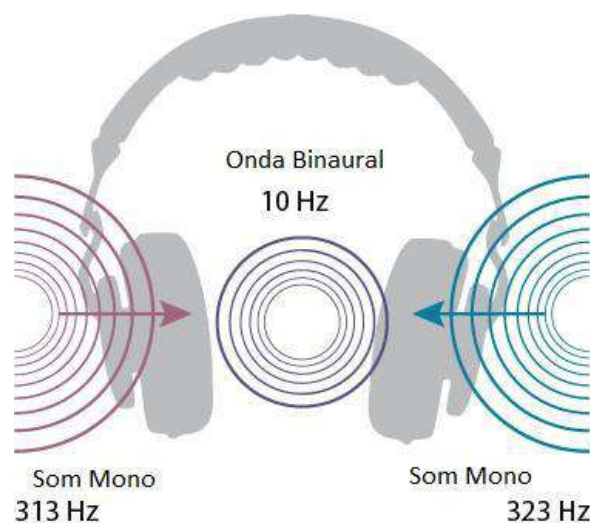


*Fig. 1: Illustrative image of the binaural sound*
*Source: Prepared by the authors, (2020).*

2.2 Biosignal sensor technology

Data collection is performed using the Neurosky Mindwave experimentation device. The mindwave has an electrode located in the subject's frontal area, and a reference electrode located near the ear that allowed to determine the students' concentration. A non-invasive alternative for acquiring signals to monitor brain activity, in particular the assessment of cognitive tasks related to the

use of attentional resources investigated in this study. The signals collected by dry electrodes are filtered and interpreted by the firmware inside the device to provide a continuous signal line. The five brain frequencies are Gamma, from 30 to 100 Hz, Beta, from 12 to 30 Hz, Alpha, from 8 to 12 Hz, Theta, from 4 to 7 Hz and Delta from 1 to 4Hz. Figure 2 shows the image of the Mindwave device.
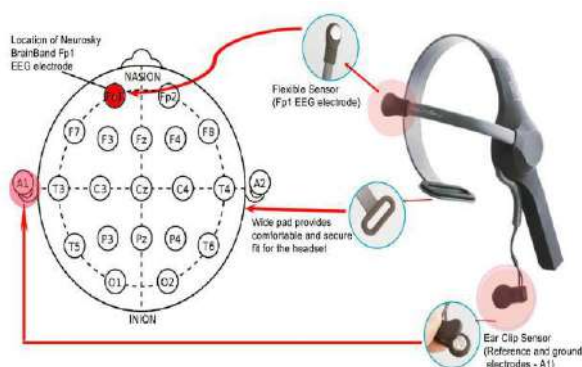


*Fig. 2: Mindwave and its sensors*

*Source: Neurosky, (2020).*

This biosensor sends brainwave signals via Bluetooth to a device and provides attention and meditation with Bluetooth paired communication. The sensor eliminates the need to use gel while using its electrode (BOS et al. 2019). Many articles have been published in research using mindwave [12].

2.3 Effective Learner Technology

For this study, the Effective Learner application was used as a brain wave recording tool. With a very simple interface, the application brings graphs of sectors and line, without limit in the measure of time, being able to store and share the data.

### III.    MATERIAL AND METHODS

To find out the degree of contribution that the brain reading system makes available, together with the biosignal sensor, we are proposing to investigate the types of students' attention during the study. To capture brain waves, we use the Neurosky mindwave that contains an EEG TGAM chip (Think Gear AM) that collects brain waves in the form of electrical pulses. Electric pulses are produced in the head whenever two neurons communicate [19].

This article presents a study on the effect of the binaural beat on the human brain during the process of reading a text. In this study we performed experiments on

two subjects and recorded their brain waves. The research subjects are students of the course of a Department of Sciences of a renowned University, aged between 20 and 28 years old, with a similar degree of knowledge. The data were acquired through a brain frequency reading system discussed above. Each sample lasted about 7 minutes with 10 Hz alpha binaural beats. These beats were played while reading the text.

The article discusses how the alpha wave dominates over the other three frequencies (beta, theta and delta). The best way to observe is through the wave that creates an illusory auditory system with lower frequency bands in the brain (below 50Hz). The brain has different experiences for different frequency bands [17]. In the alpha range, an individual tends to be more relaxed and calmer, in a state of light meditation. The graphs are also plotted for the level of care [5]. The attention measures in each of the students were made by Mindwave in units of millivolts.

### IV.    RESULTS AND DISCUSSIONS

The results of this research measured whether this type of frequency induction can stimulate students' attention. The charts for attention were plotted and the values were presented in them. The average values of attention were considered for the use of reading the text and when viewing the interactive video. Figure 3 shows the study of student A with the viewing of a video and the reading of a text. Figure 3 on the left shows the use of interactive media technology, in which the student was 27.2% with the most effective brain activity, and 12.5% very effective. Still in figure 3 of student A, on the right, which shows brain activity during the use of reading a text, however with the use of a soundtrack with sound at the binaural frequency at 10Hz, it is clear that the student was with 86 , 1% very effective in his brain activity with the stimulus caused by the interference when simultaneously hearing the binaural frequency. Figure 3 shows the results of the samples from Study A.

In study B of Figure 4, the result presented shows the graph with the use of interactive media without the use of binaural frequency. The measured results indicate that in the time of 3 minutes and 40 seconds, the student was in a state of little effectiveness in 34.1%. Followed by much effectiveness in 22.3%, fluctuating downwards in 18.6%, after decreasing in 16.8% and lastly in 8.2%. In the graph on the right, where the effectiveness of the student's brain activities is presented, the result is with the interference of the 10Hz binaural wave. In the activity with reading and listening to the binaural sound, the student presented 30.8% of brain activity oscillating positively. Followed by 25.6% fluctuating in average difference. After the recorded measurements were 12.8%, very effective for more and at the same time, 12.8% ineffective with few oscillations, these frequencies were identical in their metrics. After the student still brings fluctuations down by 10.5%, followed by 7.5% little effective.



*Fig. 3: study samples A*

*Source: Prepared by the authors, (2020).*
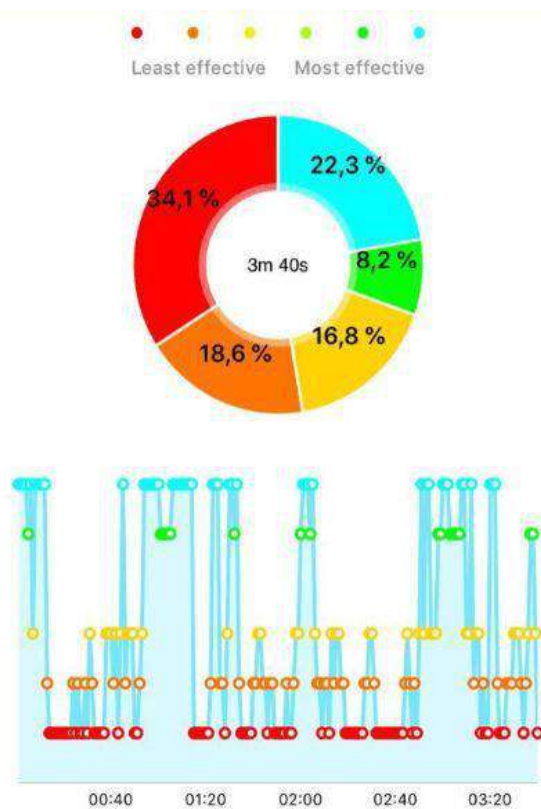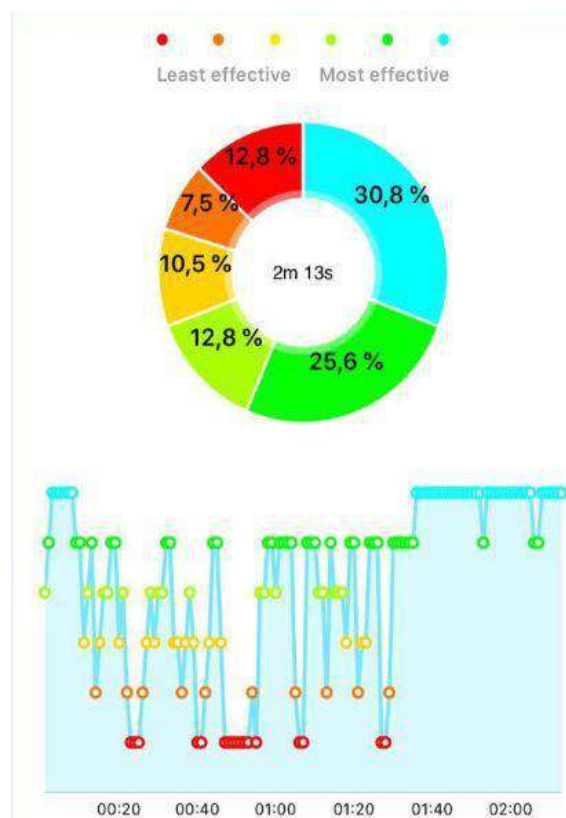
*Fig. 4 Study samples B*

*Source: Prepared by the authors, (2020).*

The experiments are based on the intensity of attention and existing neuronal stimuli. The student's attention status is investigated during data collection.

## V. CONCLUSION

The use of ICTs in teaching and learning occurs in a process in which a new tool is included to solve problems. Teachers as well as students are willing to use them, for example, educational applications, intelligent systems and accept that these applications have great potential to improve the educational process.

The results of the study data indicate that in different regions of the brain and with various types of stimulation, significant brain activities occur in the specific frequency range. This allows the use of binaural waves for application in the student's learning and focus. So, the binaural pulse is a resource that allows you to change a student's mood. By subjecting the brain to these waves, it is possible to evidence stimulation and synchronization in mental processes.

When comparing the results of the levels of attention achieved by students during the technique used, there were significant differences [7]. This is due to the fact that both studies are structured and both share the characteristics of using only two routes of attention, visual and auditory. Therefore, the link between the results is observed in the data obtained.

Finally, it must be said that the use of stimuli with binaural waves should be used in a moderate way in education to avoid saturation in its function as a distractor. The proper use of these stimuli should be prescribed as a result of further studies.

As an extension of this study, more experiments can be done by looking at other frequency ranges. Several samples of music by different artists can also be used to study the effects of music on the human mind.

## ACKNOWLEDGEMENTS

## REFERENCES

[1] Atwater, F.H. Binaural beats and the regulation of arousal levels. In Proc. of the TANS 11 Forum on New Arts and Science, 2001 Perfect, T. J., & Schwartz, B. L. (Eds.) (2002). Applied metacognition Retrieved from http://www.questia.com/read/107598848

[2] Aranha, G. (2012) Paths of Neuroeducation. / Gláucio Aranha; Alfred Sholl Franco (orgs) - 2nd ed. - Rio de Janeiro: Science and Cognition.

[3] Bos, A.S.; Pizzato, M. C; ZARO, M. Experiment to measure the level of Student Attention: the use of Interactive Media as a Stimulus Response. RENOTE-Magazine New Technologies in Education, v. 17, n. 3, 2019 a.

[4] Bos, et al. Investigation of student's attention: the use of virtual reality in the teaching of computing. TEAR -Journal of Education, Science and Technology, v.8, n.2, 2019 b.

[5] Bos, et al. Student's attention: The use of Brain Waves Sensors in Interactive Videos. International Journal of Advanced Engineering Research and Science, 6 (4), 155-157. 2019c.

[6] Bos, et al. Educational Videos: Investigation of Attention and Mapping Active Learning. In: Theoretical approaches and reflections on distance and corporate face-to-face education. Maringá: Uniedusul Editora. 2019 d.

[7] Bos, A. S., Herpich, F., Kuhn, I., Guarese, R. L. M., Tarouco, L. M. R., Zaro, M. A., Pizzato. M.C, Wives, L. (2019 e). Educational Technology and Its Contributions in Students' Focus and Attention Regarding Augmented Reality Environments and the Use of Sensors. Journal of Educational Computing Research. vol.57, n.7 https://doi.org/10.1177/0735633119854033

[8] Bruner, J. (1986). Actual minds, possible worlds. Cambridge, Massachusetts: Harvard University Press

[9] Bruer, JT (1993). Schools for thought: A science of learning in the classroom. Cambridge, MA: MIT Press.

[10] Chen, CM, & Lin, YJ (2014). Effects of different text display types on reading comprehension, sustained attention and cognitive load in mobile reading contexts. Interactive Learning Environments http://dx.doi.org/10.1080/10494820.2014.891526

[11] Effective Learner (2020). Official page. Available at: https://store.neurosky.com/ products / effective-learner. Accessed in March, 2020.

[12] Herpich, F. et al. Brain activity in the use of educational resources in augmented reality: an analysis of the learner's attention in: XXIX Brazilian Symposium on Informatics in Education (Brazilian Symposium on Computers in Education), 2018, Fortaleza. org.crossref .xschema._1.Title @ 772293c4. , 2018. p.1858.

[13] Izquierdo I., CRG Furini, JC Myskiw Fear memory Physiological Reviews, 96 (2) (2016), pp. 695-750, 10.1152 / physrev.00018.2015

[14] Ladewig, I. (2000). The importance of attention in learning motor skills. São Paulo Magazine of Physical Education, 20 (3), p. 62-71.

[15] Lent, R. (2015) Neuroplasticity. In: LENT, Roberto (Org.). Neuroscience of the mind and behavior. Rio de Janeiro: Guanabara Kogan. P. 241-252.

[16] Mindwave Mobile. (2020). Official page. Available at: http: // sto re.neurosky.com/ products / mindwave-mobile. Accessed in March, 2020.

[17] Mora, F. (2013). Neuroeducation, Solo can learn what he loves. Madrid: Alianza Editorial.

[18] Pavlov, Ivan. (1927). Conditioned reflexes: An investigation of the physiological activity of the cerebral cortex.

[19] Rebolledo-Mendez et al. (2009). Assessing NeuroSky's usability to detect attention levels in an assessment exercise. HCI, new Trends (pp. 149 and 158)

[20] Tokuhama-Espinosa, TN (2008). The scientifically substantiated art of teaching: A study in the development of standards in the new academic field of neuroeducation (mind, brain, and education science). Capella University, MN, USA.

# Normalization of Way Ruhu River in Hative Kecil, Galala and Aster Villages in Sirimau District, Ambon City

Rudi Serang

Ambon State Polytechnic, Indonesia

*Abstract*—*Way Ruhu River is one of the watersheds in Sirimau District, Ambon City. The limited handling of the city government and the awareness of the local community to expand residential areas in the Way Ruhu watershed resulted in floods and landslides that brought sedimentation and garbage, this caused shallowness that occurred on the riverbed, thereby overflowing river water into the residential area of Hative Kecil, Galala. and Aster. To overcome this problem, an intensive study and periodic handling of sedimentation and garbage on the riverbed is required by periodically backfilling the Way Ruhu river area. Therefore, the analysis of sedimentation and garbage in the Way Ruhu river needs special handlers to deal with the overflows of water that occur every rainy season in the villages of Hative Kecil, Galala and Aster. This study aims to overcome water overflow caused by the accumulation of sedimentation on the riverbed so that there is no flooding, by backfilling the riverbed. The results of the analysis of this study indicate that most of the Way Ruhu river area has been damaged by water-fed land which has been turned into residential land which has resulted in flooding and landslides in the Way Ruhu watershed area. The sedimentation rate that occurs in the Way Ruhu river watershed averages every year of: 3,599 m³ / day or 1,313,635 m³ / year. So that the sedimentation that is carried out of the river is as much:32,386m³/ dayi atau 11.954.078 m³/ year*

*Keywords*— *Watershed, Sedimentation, River Normalization.*

## I. INTRODUCTION

Climate change is a global phenomenon, experiencing an increase as a result of human activities such as the use of fossil fuels and changes in land use. One of the global climate changes is the increasing frequency and incidence of climate extremes such as storms, floods and drought.

The development of Ambon City from year to year with a sufficiently increasing population so that the problem of settlements is the main problem of the city government to overcome the existence of flooding that occurs in every river and settlement, especially the Way Ruhu river area, so that from observations in the area it must be a concern. by the local community and the city government. Observing the results of observations, most of the Way Ruhu river area has been damaged by water-fed land which has been turned into residential land which has resulted in flooding and landslides in the Way RuhuWatershedarea.

Way Ruhu is one of the watersheds in Sirimau District, Ambon City. The limited handling of the city government and the awareness of the local community to expand the residential area in the Way Ruhu watershed resulted in floods and landslides that brought sedimentation and garbage made shallowness that occurred on the riverbed, thus overflowing the Way Ruhu river water resulting in flooding in the residential area of Hative Kecil, Galala and Aster.

To overcome this problem, it is necessary to periodically study and handle intensive sedimentation and garbage and the characteristics of the river bed by periodically backfilling the Way Ruhu river area. Therefore, the analysis of sedimentation and garbage in the Way Ruhu river is felt to be done by special handlers to deal with the water overflows that occur every rainy season in the villages of Hative Kecil, Galala and Aster, from problems that occur in fact in the study area, the authors raise the title : "Normalization of Way Ruhu River in Hative Kecil, Galala and AsterVillage in Sirimau District, Ambon City".

The purpose ofThis research is to overcome water overflow so that there is no flooding in the villages of Hative Kecil, Galala and Aster by backfilling the riverbed of Way Ruhu.

## II. LITERATURE REVIEW

### 2.1. General purpose

Flood control is a relative term, because it is not economical to provide protection against the largest possible flood. Since the beginning of human civilization, flooding is a natural occurrence that is well documented after describing a series of past floods. Hoye and Langbein (1955) concluded that the concept of flood control is generally understood. Nature will let go of all the burdens it carries. Year-round floods cause immeasurable damage and terrible loss of life. Climatologists believe that the current flood rains are caused by a combination of metrological and hydrological conditions that will only occur once a million years. Reservoir,

### 2.2. Hydrology

Meteorology is part of a broader hydrological science, which includes observing the occurrence of water in the atmosphere and water on the ground and below the earth's surface. One presentation of the hydrological cycle as shown in Figure 1 which shows the formation of rain (in the form of rain, snow, drizzle or hail)

Rain usually occurs in many forms and can change shape during the process. The form of rain in the form of falling water droplets can be classified as drizzle or rain. Drizzle consists of rain with a grain size of <0.5 mm. While larger raindrops are scattered in the air, droplets> 5 mm in diameter are generally unstable. Part of the rain will evaporate partially or completely before it reaches the ground surface. Rain on the soil can be captured by vegetation, infiltrated into the soil to evaporate or become surface runoff. Evaporation can come from the soil surface, free water surface, or from plant leaves through the process of transpiration. Some of the rain will move on the ground as runoff, some of it will enter the soil used by plants, can become a deep supply of groundwater,
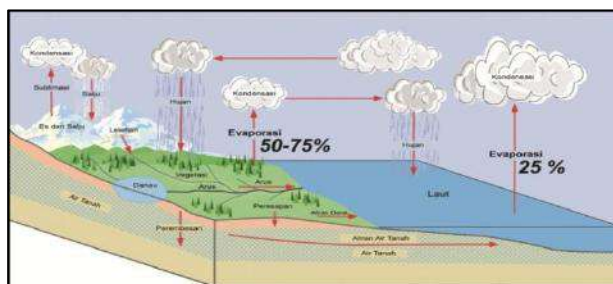


*Fig. 1: Hydrological Cycle*

### 2.3. Surface Water Runoff

Runoff is the portion of rainfall that flows towards a channel, lake, river or sea as surface or underground flow. Runoff will only occur when the rate of rain exceeds the infiltration rate into the soil. After the infiltration rate is met, water begins to fill small or large depressions on the soil surface. After the basin is filled, runoff begins. So a rain in a short time may not produce runoff, while rain with the same intensity for a long time will produce runoff, in other words, rainwater that falls to the ground will flow to the ground if the soil infiltration capacity is less than the intensity of rain. The destructive force of water flowing on the ground is greater in proportion to the steeper and longer the slope. Plants that live above the soil surface will increase the ability of the soil to absorb water and reduce the destructive force of falling raindrops, the dispersion power, and the carrying capacity of surface runoff. The rate and volume of runoff from a catchment area is influenced by the distribution of rainfall in the area, however heavy rainfall in a particular part of the catchment area can produce more runoff than moderate rainfall above the catchment. The amount of water that constitutes this layer is highly dependent on the amount of rainwater per unit time (intensity), soil conditions (especially the slope), soil type, and the presence or absence of previous rain. and surface runoff. The rate and volume of runoff from a catchment area is influenced by the distribution of rainfall in the area, however heavy rainfall in a particular part of the catchment area can produce more runoff than moderate rainfall above the catchment. The amount of water that constitutes this layer is highly dependent on the amount of rainwater per unit time (intensity), soil conditions (especially the slope), soil type, and the presence or absence of previous rain. and surface runoff. The rate and volume of runoff from a catchment area is influenced by the distribution of rainfall in the area, however heavy rainfall in a particular part of the catchment area can produce more runoff than moderate rainfall above the catchment. The amount of water that constitutes this layer is highly dependent on the amount of rainwater per unit time (intensity), soil conditions (especially the slope), soil type, and the presence or absence of previous rain.For the magnitude of the surface flow coefficient value can be seen in Table 1 as follows:

*Table .1: Flow Coefficients for the Rational Method*

| Land description / surface character | Flow coefficient, C |
|---|---|
| **Business** | |
| Urban | 0.70 - 0.95 |
| Fringe | 0.50 - 0.70 |
| Housing | 0.30 - 0.50 |
| **Single house** | |
| Multiunit, separate | 0.40 - 0.60 |
| Multiunit, incorporated | 0.60 - 0.75 |
| Village | 0.25 - 0.40 |
| Apartment | 0.50 - 0.70 |
| **Industry** | |
| Light | 0.50 - 0.80 |
| Weight | 0.60 - 0.90 |
| **Pavement** | |
| Asphalt and concrete | 0.70 - 0.95 |
| Bricks, paving | 0.50 - 0.70 |
| **Roof** | 0.75 - 0.95 |
| **Yard, sandy soil** | |
| Flat, 2% | 0.05 - 0.10 |
| Average, 2-7% | 0.10 - 0.15 |
| Steep, 7% | 0.15 - 0.20 |
| **Yard, heavy soil** | |
| Flat, 2% | 0.13 - 0.17 |
| Average, 2-7% | 0.18 - 0.22 |
| Steep, 7% | 0.25 - 0.35 |
| **Railroad yard** | 0.10 - 0.35 |
| **Playground** | 0.20 - 0.35 |
| **Garden, cemetery** | 0.10 - 0.25 |
| **Forest** | |
| Flat, 0-5% | 0.10 - 0.40 |
| Wavy, 5-10% | 0.25 - 0.50 |
| Hilly, 10-30% | 0.30 - 0.60 |

*(Source: McGuen, 1989 in Suripin, 2004)*

## 2.4. Soil Structure

Soil structure is defined as the mutually binding arrangement of soil particles, the bonding of soil particles aims as the soil aggregate that forms itself, this aggregate (Soil Survey Staff, 1975). Slopes can be grouped as shown in Table 2 below,

*Table 2: Slope Classification*

| Symbols | Slope Class | Land Shape |
|---|---|---|
| $L_O$ ` | 0 - 3 | Flat |
| $L_1$ | 3 - 8 | Slopes / waves |
| $L_2$ | 8 - 1 | Slightly sloping / wavy |
| $L_3$ | 15 - 30 | Sloping / hilly |
| $L_4$ | 30-45 | Somewhat cheating |
| $L_5$ | 45 - 60 | Steep |
| $L_6$ | > 65 | Very steep |

*(Source: Asdak, 2002)*

The effectiveness of the soil as a means of removing water depends largely on the size and resistance of the channel in the soil. The physical properties of the soil change the infiltration capacity and how large the particles can be separated and transported. Soil properties that explain how easily soil particles can be eroded are their separation and transportability. The properties that renew erosion include soil structure, texture, organic matter, and chemical and biological properties of soil.

## 2.5. Vegetation and Land Use

Vegetation is one part of the land system that provides benefits for the survival of creatures, especially humans. The existence of vegetation varies from place to place, because it is influenced by different land conditions. Vegetation plays an important role in maintaining soil sustainability because it can inhibit surface runoff and erosion, including: (1) interception of rain by plant canopy; (2) reduce surface runoff speed and water-destroying force; (3) the influence of roots and biological activities related to vegetative activities and their influence on the stability of the structure and soil porosity; and (4) transmiration which results in reduced groundwater content. Thick ground cover vegetation such as grass or jungle will eliminate the influence of rain and topography on erosion.

Land use (Land use) according to Aryad (1989; 207) can be interpreted as any form of human intervention (intervention) on land in order to meet their needs. Land use is a dynamic process. Therefore, information on land use becomes out-of-date relatively quickly when compared with geological, geomorphological and soil information.

Land use can be grouped into two major groups, namely agricultural land use and non-agricultural land use.

## 2.6. Erosion

Erosion is the event of removing or transporting material in the form of a solution or suspension from the original site by flowing water (runoff flow), erosion is the loss or erosion of soil or parts of land in one place that are transported by water and wind to another place (Arsyad, 1989).

The damage experienced to the soil where erosion occurs takes the form of a deterioration of the physical and chemical properties of the soil such as loss of nutrients and organic matter, poor infiltration, the ability of the soil to retain water, reduced stability of soil structure which ultimately leads to worsening plant growth. (Arsyad, 1989)

The classification of the level of soil damage by erosion according to (Arsyad) is presented in Table 3.

*Table 3: Classification of Soil Damage and Erosion Levels*

| Symbol | Erosion Rate | Information |
|--------|--------------|-------------|
| $E_0$ | No erosion | Fixed soil layer |
| $e_1$ | Light | Less than 25% of the top layer is lost |
| $e_2$ | Moderate | 25-27% of topsoil is lost |
| $e_3$ | It's a bit heavy | More than 75% of the topsoil up |
| $e_4$ | Weight | More than 25% of that layer is gone |
| $e_5$ | Very heavy | Same with trench erosion |

*(Source: Asyad, 1989)*

## 2.7. Land Erosion Factors

The factors that influence the amount of erosion in a watershed include:

- Rain Erosion
- Soil sensitivity to rain
- Drought and slope length and tillage factors are closely related to soil cover or vegetation
- Rain Erosion (REI)

The amount of rain erosivity can be calculated based on the maximum rainfall data for each rainy day every month (from monthly rainfall data)

- Soil Erodibility (K)

The soil erodibility factor is closely related to the condition and physical soil.

- Slope (LS)

The slope factor can be calculated based on the empirical formula developed by Wischmeies, namely:

- For the slope (S) <20%, take:

$$LS = Lo\ 0.5 \times (0.0138 + 0.00965\ S + 0.00138\ S^2)\ ...\ (1)$$

- For a slope (S)> 20%, is taken;

$$Ls^{0,61,4}\ ...................................................................\ (2)$$

Where :

     Ls = slope factor

     Lo = Length of flow over the ground

     S = Slope / slope

- Factors on Plant Types and Soil Processing (CP)

This CP factor has a huge effect on sediment production and the amount of erosion in an area. The size of the CP value can be adjusted based on soil processing activities and by planting certain types of plants on the land

- Erosion Rate

The estimated magnitude of the permissible erosion rate for a watershed is approximated by the following formula (Achlil, 1982):

$$A = 4 + 1,226\ (10\ D - K- 2)\ ....................................\ (3)$$

Where :

     A = Permissible rate of erosion (tonnes / ha)

     K = soil erodibility factor

     D = depth of soil layer, (m)

*Table 4: Classification of Erosion Hazards*

| Erosion Rate ton/ha/ year | Classification |
|---------------------------|----------------|
| 0.0 - 12.5 | Very small |
| 12.5 - 17.5 | Small |
| 17.5 - 25.0 | Medium |
| 25.0 - 30.0 | Weight |
| > 30.0 | Very Heavy |

## 2.8. Stream Erosion

In the analysis of river channel erosion, the stability of the grains on the river bed and the volume of sediment transport will be reviewed.

In a gloomy river channel, in general, sediment transport seen from the way it moves can be divided into two, namely;

- Suspended load where the sediment particles move floating in the water and carried along with the flow
- Bed load, which moves from the particles not far from the river bed and moves, shifts, rolls and jumps individually.

If there is a change in the river either artificially or naturally, the riverbed will change accordingly. Over time an adequate relationship will re-form between the hydraulic properties of the irrigation and the sediment that flows downward and eventually a stable channel will be formed.

Therefore, in making a review / planning of a river, the cross section must be selected not only based on the flood discharge but also taking into account the condition of the river repair work.

The stable condition of the channel means the conditions along the channel where there is no streak and deposition. This means that the amount of sediment flowing in each cross section of the river must be kept stable.

### 2.9. Riverbed Stability Calculations

From the results of research on riverbed stability analysis, some basic equations can be used as follows:

- Fiber force and critical shear speed according to the Two Boys:

$$To = ............................................ (4)$$

$$U * = V (Ton / fw) ........................ (5)$$

Where :

$To$ = fiber force (ton / m$^2$)

$U *$ = Sliding speed (m / sec)

$R$ = Hydraulic radius (m)

$\int w$ = Water mass density (ton / m$^3$)

$g$ = Acceleration of gravity (m / sec$^2$)

$I$ = The slope of the base of the riveri

### 2.10. Rainfall Intensity Analysis

To find out the intensity of rainfall, it is analyzed using the Gumbel method with the formula:

$$Xt = X + K. S_X ............................................ (6)$$

Where :

$Xt$ = The amount expected to occur t year (mm)

$t$ = Return period in this case t = 10 years

$X$ = Average daily rain during observation (mm)

$Yt$ = The relationship between times and the reduction factor ($Y_t$ and n)

$Sn$ = Reduced standard deposit (relationship between Yn and n)

$S_X$ = Standard deviation

The value of Sn, Yn, and YTr can be seen in Table 5; 6; 7 as follows:

*Table 5: Reduced mean (Yn)*

| N | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 0.4952 | 0.4996 | 0.5035 | 0.5070 | 0.5100 | 0.5128 | 0.5157 | 0.5181 | 0.5202 | 0.5220 |
| 20 | 0.5236 | 0.5252 | 0.5268 | 0.5283 | 0.5296 | 0.5309 | 0.5320 | 0.5332 | 0.5343 | 0.5353 |
| 30 | 0.5362 | 0.5371 | 0.5380 | 0.5388 | 0.5396 | 0.5403 | 0.5410 | 0.5418 | 0.5424 | 0.5436 |
| 40 | 0.5436 | 0.5442 | 0.5448 | 0.5453 | 0.5458 | 0.5463 | 0.5468 | 0.5473 | 0.5477 | 0.5481 |
| 50 | 0.5485 | 0.5489 | 0.5493 | 0.5497 | 0.5501 | 0.5504 | 0.5508 | 0.5511 | 0.5515 | 0.5518 |
| 60 | 0.5521 | 0.5524 | 0.5527 | 0.5530 | 0.5533 | 0.5535 | 0.5538 | 0.5540 | 0.5543 | 0.5545 |
| 70 | 0.5548 | 0.5550 | 0.5552 | 0.5555 | 0.5557 | 0.5559 | 0.5561 | 0.5563 | 0.5565 | 0.5567 |
| 80 | 0.5569 | 0.5570 | 0.5572 | 0.5574 | 0.5576 | 0.5578 | 0.5580 | 0.5581 | 0.5583 | 0.5585 |
| 90 | 0.5586 | 0.5587 | 0.5589 | 0.5591 | 0.5592 | 0.5593 | 0.5595 | 0.5596 | 0.5598 | 0.5599 |
| 100 | 0.5600 | 0.5602 | 0.5603 | 0.5604 | 0.5606 | 0.5607 | 0.5608 | 0.5609 | 0.5610 | 0.5611 |

*(source, Suripin, 2004)*

*Table 6: Reduced standard deviation (Sn)*

| N | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 0.9496 | 0.9676 | 0.9833 | 0.9971 | 10,095 | 10,206 | 10,316 | 10,411 | 10,493 | 10,565 |
| 20 | 10,628 | 10,696 | 10,754 | 10,811 | 10,864 | 10,915 | 10,961 | 11,004 | 11,047 | 11,080 |
| 30 | 11,124 | 11,159 | 11,193 | 11,226 | 11,255 | 11,285 | 11,313 | 11,339 | 11,363 | 11,388 |
| 40 | 11,413 | 11,436 | 11,458 | 11,480 | 11,499 | 11,519 | 11,538 | 11,557 | 11,574 | 11,590 |
| 50 | 11,607 | 11,623 | 11,638 | 11,658 | 11,667 | 11,681 | 11,696 | 11,708 | 11,721 | 11,734 |
| 60 | 11,747 | 11,759 | 11,770 | 11,782 | 11,793 | 11,803 | 11,814 | 11,824 | 11,834 | 11,844 |
| 70 | 11,854 | 11,863 | 11,873 | 11,881 | 11,890 | 11,898 | 11,906 | 11,915 | 11,923 | 11,930 |
| 80 | 11,938 | 11,945 | 11,953 | 11,959 | 11,967 | 11,973 | 11,980 | 11,987 | 11,994 | 12,001 |
| 90 | 12,007 | 12,013 | 12,020 | 12,026 | 12,032 | 12,038 | 12,044 | 12,049 | 12,055 | 12,060 |
| 100 | 12,065 | 12,069 | 12,073 | 12,077 | 12,081 | 12,084 | 12,087 | 12,090 | 12,093 | 12,096 |

*(Source: Suripin, 2004)*

*Table 7: Reduced Variate (YTr)*

| Reset Period Tr (year) | Reduced Variate YTr | Reset Period Tr(year) | Reduced Variate YTr |
|---|---|---|---|
| 2 | 0.3668 | 100 | 46,012 |
| 5 | 15,004 | 200 | 52,969 |
| 10 | 22,510 | 250 | 55,206 |
| 20 | 29,709 | 500 | 62,149 |
| 25 | 31,993 | 1000 | 69,087 |
| 50 | 39,028 | 5000 | 85,188 |
| 75 | 43,117 | 10000 | 92,121 |

*(Source, Suripin, 2004)*

## 2.11. Calculation of Flood Plan

Design flood is a large annual flow rate caused by rain with a certain return period.

Calculation of the flood discharge plan using the Der Weduwen Method:

Formula: Q = α .β .qn. A ............................................. (7)

Where :

$Q$ = Discharge (m³ / sec)
$\alpha$ = Flow coefficient (run off coefficient)
$\beta$ = Reduction coefficient
$qn$ = Maximum rain (mm)
$A$ = Area of flow

1. The run off coefficient is the ratio between run off and rain: α = 1 - 4.1 / (β.qn + 7) ......................... (8)

2. Concentration Time (t)
   t = 0.25. L .A -0,126.I-0,26 ................................. (9)
   Where :

   t   = Concentration time (hours)
   L   = Length of river (km)
   I   = Slope of 0.001
   A   = Area of watershed (km²)

3. Redux Coefficient (β)
   This figure is used to get the average rainfall from the maximum rainfall.

   $$\beta = \frac{120 + \frac{t+1}{t+9} A}{120 + A}$$ ................................................. (10)
   Where :

   $\beta$ = Reduction coefficient
   $t$ = Concentration time(hours)
   $A$ = Area of the watershed(km²)

4. The relationship between q and R
   $$q_n = \frac{Rn}{240} + \frac{67,65}{t+1,45}$$ .........................................(11)

## 2.12. Analysis River Discharge

This analysis was carried out to determine the river discharge that occurred in the Way Ruhu river using the following formula:

River Water Flow Discharge (DLAS) uses the general equation DLSA (Chow), namely;

$$Q = V \cdot A \quad\text{.....................................................} (12)$$

Where :

    Q  = River flow rate ($m^3$ / sec)

    V  = River water layer velocity (m / sec)

    A  = Wet cross-sectional area of river water layer ($m^3$)

## 2.13. Analysis Average Sediment Discharge

To calculate the annual average sediment discharge, the planned annual return time discharge using the DER WIDUWEN method is used as follows:

$$Q = a * \beta * g * A \quad\text{.......................................................} (13)$$

Where :

    Q    = Return flood discharge ($m^3$ / sec)

    A    = Area of flow area ($Km^2$)

    S    = slope of the river bed

    t    = Kosenttimeconstellation (hour)

    $\beta$    = Reduction coefficient

    g    = Intensity of rain yang is calculated ($m^3$ / $km^2$ / sec)

## 2.14. Sedimentation Rate

Sedimentation rate prediction is done using the equation:

$$Qs = Q \cdot S \quad\text{....................................................} (14)$$

Where :

    $Q_S$  = River water sediment discharge (gram / second)

    Q  = River flow rate ($m^3$ / sec)

    Cs  = Weight of filter paper (mg)

    V  = Sediment concentration (mg / liter)

## 2.15. Sedimentation Transport

Many methods for estimating the capacity for sediment transport have been developed based on the hydraulic shear rate, flow velocity and sediment properties.

$$V = P * Q \quad\text{..................................................} (15)$$

Where :

    V  = volume of sedimentation ($m^3$)

    P  = length of river (m)

    Q  = amount of sedimentation ($m^2$)

The process of erosion between grooves is used in several computer models to estimate erosion, including CREAMS (Kniel, 1980).

## III. METHODOLOGY

### 3.1. Analysis Technique

In general, the sedimentation rate analysis of this study can be seen in the following diagram:
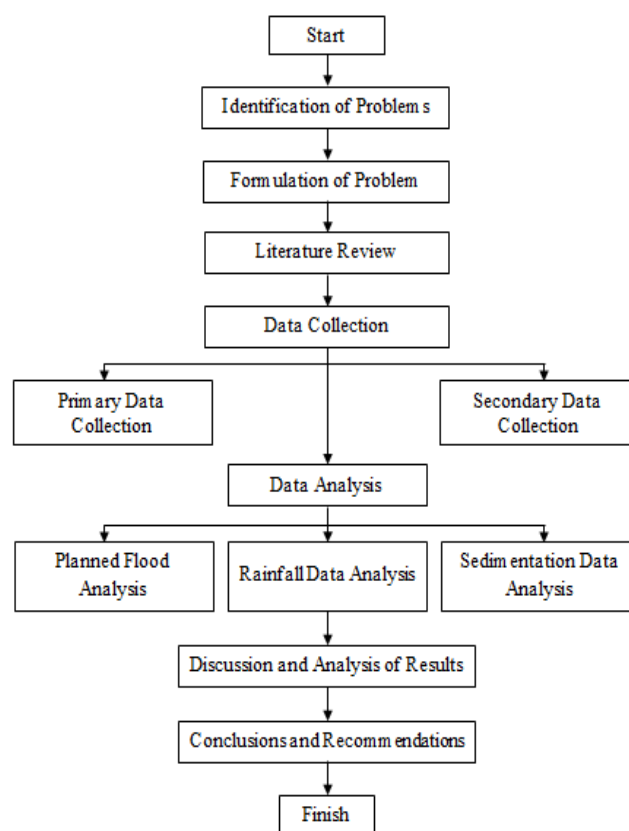


*Fig.4: Research Flowchart*

### 3.2. Location and Time

The location or object of the analysis was taken based on the sediment transport plan that occurred in the Way Ruhu River (NegeriGalala), in the last 10 years the rainfall data at the Ambon Pattimura Airport Meteorological Station.

*Fig.3: Map of Research Location*

### 3.3. Materials and Analysis Tools

The materials needed in conducting this analysis are a permit and data, both in the form of analysis data and planning data from the object being analyzed, and so on. Meanwhile, the tools used are digital cameras, heavy equipment to support the implementation, meters and other supporting tools.

### 3.4. Analysis Variable

The analysis variables required in the analysis of sedimentation transport on the Way Ruhu River are specified based on the following problem formulations:

    1) Map of the Way Ruhu River

    2) Research Location Map

### 3.5. Data Collection Technique

The data collection stages from the sedimentation transport analysis are as follows:

1) Preparation phase

2) Data Collection Stage

3) Problem Formulation Stage

4) Problem Analysis Stage

5) Implementation of Activities

## IV. ANALYSIS AND DISCUSSION

### 4.1. The Mechanism of Erosion

So erosion can occur at least in one step, namely dispersion by granules or runoff. The erosion stages include:

1. Raindrops collide with the ground;
2. Splash the ground by raindrops with soil.
3. Destruction of a lump of soil by raindrops;
4. Transport of splashed particles / soil mass dispersed by runoff during rain.

To find out the relationship between erosion and hydrology, we must study the effects of land and vegetation management in the upper watershed areas, including its effects on erosion, water quality, flooding and climate in the upstream and downstream areas. And the influencing factors in this calculation are rain erosivity, slope slope, soil sensitivity to erosion, and river length. And soil management factors are closely related to land cover or vegetation.

### 4.2. Hydrological Data Analysis

To find out how much erosion has occurred in the Way Ruhu watershed, it is necessary to know the planned flood discharge which will be used to calculate the amount of erosion rate that occurs in the Way RuhuWatershed.

Rainfall data required is maximum daily rainfall data with a minimum number of observations of 10 years. Rainfall data for this analysis were taken from the Pattimura - Ambon Meteorological Station

### 4.3. Rainfall Calculation

Rainfall calculation analysis, selected the Pattimura Airport Meteorological Station Observation Post - Ambon.

*Table 8: Data of Way Ruhu River Maximum Daily Rainfall 2003 - 2012*

| No. | Observation Year | Rainfall (mm) |
|-----|------------------|---------------|
| 1 | 2003 | 94.47 |
| 2 | 2004 | 135.65 |
| 3 | 2005 | 237.82 |
| 4 | 2006 | 262.05 |
| 5 | 2007 | 284.66 |
| 6 | 2008 | 476.31 |
| 7 | 2009 | 167.32 |
| 8 | 2010 | 325.68 |
| 9 | 2011 | 384.17 |
| 10 | 2012 | 420.09 |

*(Source: Pattimura-Ambon Airport Meteorological Station)*

a) Calculation of Algebraic Average Rainfall

$R = \frac{1}{n} (R^1 + R^2 + R \dots R^n)$ ............................ (16)

b) Calculation of Standard Deviation, Coefficient of Variation and Coefficient of Skewness

    1. Σ Year (n) = 10

    2. On average, Rr

$$Rr = \sum \frac{Ri}{n}$$
$$= \frac{2788,29}{10}$$
$$= 278,82$$

3. Standard Deviation, Std

$$\mathbf{Std} = \sqrt{\sum_{i-1}^{n} \frac{(R-Rr)^2}{n-1}}$$
$$= \sqrt{\frac{3411,03}{9}}$$
$$= 19,46$$

4. Coefficient of Variation, Cv

$$\mathbf{Cv} = \frac{\mathbf{Std}}{\mathbf{Rr}}$$
$$= \frac{19,46}{278,82}$$
$$= 0,06$$

5. Skewness Coefficient, Cs

$$\mathbf{Cs} = \frac{\mathbf{n} \sum(\mathbf{R-r})^3}{(\mathbf{n-1})(\mathbf{n-2})(\mathbf{Std})^3}$$
$$= \frac{10 \, x \, 7047794,66}{(9)(8)(19,46)^3}$$
$$= 132.82$$

*Table 9: Rainfall Recapitulation*

| Year | R | R - Rr | $(R - Rr)^2$ | $(R - Rr)^3$ |
|------|------|---------|---------|---------|
| 2003 | 94.47 | -184.35 | -33984.92 | -6265.12 |
| 2004 | 135.65 | -143.17 | -20497.64 | -2934648.34 |
| 2005 | 237.82 | -41 | -1681 | -68921 |
| 2006 | 262.05 | -16.77 | -281.23 | -4716.27 |
| 2007 | 284.66 | 5.84 | 34.10 | 199.17 |
| 2008 | 476.31 | 197.49 | 39002.3 | 7356848.77 |
| 2009 | 167.32 | -111.5 | -12432.25 | -1386195.87 |
| 2010 | 325.68 | 46.86 | 2195.84 | 102897.98 |
| 2011 | 384.17 | 105.35 | 11098.62 | 1169239.88 |
| 2012 | 420.09 | 141.27 | 19957,21 | 2819355.46 |
| Σ | 2788.29 | | 3411.03 | 7047794.66 |

*(Source: Analysis Results)*

**4.4. Calculation of Flood Plan**

Design flood is a large annual flow rate caused by rain with a certain return period.

To calculate the planned flood discharge, the Der Weduwen method can be used:

- Calculation of flood discharge plans using the Haspers Method:

The formula $Q = \alpha \cdot \beta \cdot qn \cdot A$

Where :

    Q    = Debit

    α    = Flow coefficient (run off coefficient)

    β    = Reduction coefficient

    qn = Maximum rain (mm)

    A    = Area of flow = 0.0216 km$^2$

1) Calculation of the length of rain (hours)

    t = 0.25. L .A -0,126.I-0,26

Where :

    t    = Concentration time (hours)

    L    = Length of river (km)

    I    = Slope of 0.01

    A    = Area of watershed (km$^2$)

    t = 0.25. L .A -0,126.I-0,26

    = 0.25. 9.10. 0.0216-0.126. 0.01-0.26

    = 12 hours

2) $\beta = \frac{120 + \frac{t+1}{t+9} A}{120 + A}$

Where :

    β    = Reduction coefficient

    t    = Concentration time (hours)

    A    = Area of watershed (km$^2$)

$$\beta = \frac{120 + \frac{12+1}{12+9} 0,0216}{120 + 0,0216} = 1.02$$

3) Calculation of rainfall area (m$^3$ / sec. km$^2$) with a return period

    $qn = \frac{Rn}{240} + \frac{67,65}{t+1,45}$

Where :

    Rn   = Maximum daily rainfall (mm / day) with return period (n) years. = 278.8 mm / day

    t    = Time (hour)

    $qn = \frac{278,8}{240} + \frac{67,65}{12+1,45}$

    $= 6.2$ m$^3$ / sec.km$^2$

4) The run off coefficient is the ratio between run off and rain:

    α = 1 - 4,1 / (β qn + 7)

Where :

β       = Reduction coefficient

qn      = area of rainfall ($m^3$ / sec.$km^2$)

$\alpha$ = 1 - 4,1 / (1,02 6,2+ 7)

= 0.7

5)  Flood discharge calculation

Q = α .β .qn. A

Where :

Q   = Discharge ($m^3$ / s)

α   = Flow coefficient = 0.7

β   = Reduction coefficient = 1.02

qn  = Maximum rain (mm) = 6.2 $m^3$ / sec.km

A   = Area of flow = 0.0216 $km^2$

Q   = α .β .qn. A

= 0.7. 1.02. 6.2. 0.0216 = 0.0956 $m^2$ / sec

## 4.5. Slope (Ls)

As an example of calculating the slope, the Way Ruhu Watershed was chosen

Known :

River length, L        = 9.10 km

Watershed area        = 0.0216 $km^2$

Drainage Density, d  = 9.10 / 0.0216 = 421.29 $km^2$

## 4.6. Calculation of potential and actual land erosion on the Way Ruhu river

From the data it is known:

1.  For land slopes of 0 - 3%,      value of K = 0.120
2.  For land slopes of 3 - 8%,      value of K = 0.120
3.  For land slopes of 8 - 15%,     value of K = 0.260
4.  For land slopes of 15 - 40%,   value of K = 0.230
5.  For land slopes> 40%,          value of K = 0.210

## 4.7. Calculation of Average Slope

(for average slope S = 4%)

D  = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0, 26. 4 + 2. 80

= 572,581

Lo = $\frac{1}{2 . D}$

= $\frac{1}{2 . 572,581}$

= 285.79 m

Ls = $Lo^{0.5}$ (0.0138 + 0.00965. S + 0.00138. S2)

= 285,790.5 (0.0138 + 0.00965.4 + 0.00138.42)

= 1,259

(for the average slope S = 11.50%)

D  = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0, 26. 11.50 + 2.80

= 574,531

Lo = $\frac{1}{2 . D}$

= $\frac{1}{2 . 574,531}$287,265 m

Ls = $Lo^{0.5}$ (0.0138 + 0.00965. S + 0.00138. S2)

= 287.2650.5 (0.0138 + 0.00965.11.50 + 0.00138.11.502)

= 5,211

(for average slope S = 20%)

D  = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29+ 0, 26. 20 + 2.80 = 576,741

Lo = $\frac{1}{2 . D}$

= $\frac{1}{2 .576,741}$288,370 m

Ls =. = $14,283\left(\frac{Lo}{22,1}\right)^{0,6}\left(\frac{20}{9}\right)^{1,4}$

(for average slope S = 35%)

D  = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0, 26. 30 + 2.80 = 579,341

Lo = $\frac{1}{2 . D}$

= $\frac{1}{2 .579,341}$289,670 m

Ls = $\left(\frac{Lo}{22,1}\right)^{0,6}$. = $31,351\left(\frac{35}{9}\right)^{1,4}$

(for average slope S = 40%)

D  = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0.26 .40 + 2.80 = 581,941

Lo = $\frac{1}{2 . D}$

= $\frac{1}{2 . 581,941}$290,970 m

Ls =. = $37,898\left(\frac{Lo}{22,1}\right)^{0,6}\left(\frac{40}{9}\right)^{1,4}$

*Table 10: Calculation of Slope Slope (Ls)*

| No. | Long River | Large Watershed | Drainage Density (d) | Slope Land% | Slope is average | D | Lo (m) | Ls |
|---|---|---|---|---|---|---|---|---|
| | Way RuhuWatershed | | | | | | | |
| | 9,10 | 0.0216 | 421.29 | 0 - 3 | 4.00 | 572,581 | 285.79 | 1,259 |
| | 9,10 | 0.0216 | 421.29 | 3 - 8 | 11.50 | 574,531 | 287,265 | 5,211 |
| | 9,10 | 0.0216 | 421.29 | 8 - 15 | 20.00 | 576,741 | 288,370 | 14,283 |
| | 9,10 | 0.0216 | 421.29 | 15 - 40 | 35.00 | 579,341 | 289,670 | 31,351 |
| | 9,10 | 0.0216 | 421.29 | > 40 | 40.00 | 581,941 | 290,970 | 37,898 |

*(Source: Analysis Results)*

Thus:

1. For land slope 0 - 30%
   Formula: A = 4 + 1.226 (10 D - K- 2)
   A = 4 + 1.266 (10. 572,581 - 0.120 - 2)
   = 7250,191 ton / ha / year

2. For land slope 3 - 8%
   A = 4 + 1.266 (10. 574,531 - 0.120 - 2)
   = 7274,878 ton / ha / year

3. For land slope 8 - 15%
   A = 4 + 1.266 (10. 576,541 - 0.260 - 2)
   = 7300,147ton / ha / year

4. For land slope 15 - 40%
   A = 4 + 1,266 (10,579,341 - 0,230 - 2)
   = 7335,633 ton / ha / year

5. For slopes> 40%
   A = 4 + 1.266 (10.581,941 - 0.210 - 2)
   = 7368,575 ton / ha / year

The average allowable rate of erosion rates for the Way Ruhu river basin are:

So the formula that I derive is:

$$\overline{Ar} = \frac{1A + 2A + 3A + 4A + 5A}{5}$$

$$\overline{Ar} = \frac{7250{,}191 + 7274{,}878 + 7300{,}147 + 7335{,}633 + 7368{,}575}{5}$$

$$= 7305{,}884 \text{ ton/ha/year}$$

*Table 11: Calculation of Erosion Rate*

| Watershed Name | Slope Land (%) | ThicknessHumus (D)(M) | Erodibility(K) | Erosion Rate(A) ton / ha / year | A Average (ton / ha / hr) |
|---|---|---|---|---|---|
| Way Ruhu | 0 - 3 | 3.00 | 0.120 | 7250,191 | 7,305,884 |
| | 3 - 8 | 3.00 | 0.120 | 7274,878 | |
| | 8 - 15 | 3.00 | 0.260 | 7300,147 | |
| | 15 - 40 | 3.00 | 0.230 | 7335,633 | |
| | > 40 | 3.00 | 0.210 | 7368,575 | |

*(Source: Analysis Results)*

The calculation of erosion can be seen in Table 11. Based on the calculation results, it can be seen that the rate of erosion in the Way Ruhu watershed is classified as very heavy, so it needs immediate treatment.

**4.8. Annual Average Sediment Discharge Calculation**

To calculate the annual average sediment discharge, the annual discharge plan for the return period using the Der Widuwen method is used as follows

$$Q = \alpha * \beta * q * A$$

Where :

A = Flow area ($km^2$) = 0.0216 $km^2$

t = Concentration time (hours) = 4.65 hours

β = The reduction coefficient = 1.26

q = The calculated rainfall intensity (m3 / $km^2$ / sec) = 314,130 $m^3$ / $km^2$ / second

α    = Flow coefficient = 0.421

Thus, the annual average sediment discharge can be calculated as follows:

Q   = 0.421 * 1.26 * 314,130 * 0.0216

   = 3,559 m3 / day

Q year = 365 * 3,599 = 1,313,635 $m^3$ / year

## 4.9. Sedimentation Transport

River length         : 9100 m

Lots of sedimentation : 3,599 m³ / day

: 1,313,635 m³ / year

Sedimentation Transport (V)    = P * Q

Sedimentation Transport / day  = 9100 m * 3,559 m³ / day

= 32,386m³ / day

Sedimentation Transport / yr    = 9100 m * 1,313,635 m³ / yr

= 11,954,078 m³ / year

## V.    CONCLUSIONS AND SUGGESTION

### 5.1. Conclusion

Based on the results of calculations and analysis, the following conclusions can be drawn:

The sedimentation rate that occurs in the Way Ruhu river basin annually is: 3,599 $m^3$ / day or 1,313,635 $m^3$ / year.

So that the sedimentation that is carried out of the river is as much: 32,386m³ / day or 11,954,078 m³ / year

### 5.2. Suggestion

In this study, several suggestions are presented as follows:

1. For the Government of Galala Village and Hative Kecil Village and the communities of the two villages to be able to participate and work together to maintain environmental sustainability by replanting shade trees, providing formative counseling so that the people around the Watershed area realize their responsibility to keep maintaining and protecting existing forests from damage.

2. For people who live around the watershed, they should maintain and preserve a clean culture by not throwing garbage into the river.

## REFERENCES

[1] Arsyad, 1989. S Soil and Water Conservation. Faculty of Agriculture, Institute of Agriculture: Bogor

[2] Bennet, HH, 1939. Soil Conservation, Mc.Graw-Hill, New York.

[3] Choy Asdak, MSc, PhD, 2002. Hydrology and Watershed Management, Gajah Mada.

[4] Ministry of Public Works Standard SK SMI – 18–1989 – F, 1989. Flood Discharge Calculation Method. LPMB Foundation: Bandung.

[5] Ministry of Public Works, Directorate of Irrigation I, 1986. Handbook of Irrigation Planning, Bandung: cv. Galang Persada.

[6] Rahim.SE 2002. Soil Erosion Control in the Context of Environmental Conservation, Bandung: Earth Literacy.

[7] Vanoni, V, A. 1975. Sedimentatioan Engineering, New York.

# Use of Aerial Images as Support for Cost Analysis of Sewage Collection Networks

Dênis Cardoso Parente[1], Caio Sá Honorato[2], Rafael Alves Amorim[3], Larissa Moreira Cardoso[4], Marcelo Brandão Monteiro dos Santos[5], Jucilene da Costa Pereira[6], Daniel Iglesias de Carvalho[7], Edivaldo Alves dos Santos[8], Kaio Vilela Santos[9], Aurélio Pessoas Picanço[10]

[1,2,7,8,9]Centro Universitário de Luterano de Palmas, CEULP/ULBRA, Brasil
[4]Instituto Brasília Ambiental, IBRAM, Brasil
[5,10]Instituto Federal de Educação, Ciência e Tecnologia Goiano, IFGO, Brasil
[3,6]Universidade federal do Tocantins, UFT, Brasil

*Abstract*— *The present work aims to analyze the applicability of aerial images obtained with Unmanned Aerial Vehicle (UAV) in decision making regarding the choice of sewage collection network in a sector of the city of Palmas - TO. In order to arrive at a cost comparison between simple and double network that meets the necessity of sewerage of the sector studied. Through orthorectified images, it was specifically pointed the types of coverings, quantitative, for the items of demolition, removal and restoration of pavements and sidewalks. The usage of these images aimed to assess the accuracy in the budget of projects of these networks, since the practice used for the preparation of the budgets is made through visual inspection in loco or by estimation, being an expensive, slow and imprecise practice. The studied tool proved to be efficient, as it is possible to verify, with the resolution adopted for the images, the types of coating, precision in the quantitative survey through the orthomosaic.*

*Keywords*— *Unmanned aerial vehicle (UAV), budget, sewage collection network, sewer.*

## I. INTRODUCTION

Among the existing alternatives for the operation of sewage collection network, the destructive method is the traditional and the most used alternative. This method consists of excavating trenches along the entire length of the projected network, where the piping system is installed directly in the trench over a cradle with suitable materials [1].

The conditions for the operation of these networks are established by [2]. The standard establishes guidelines for removing the pavement, opening the trench, sewering, shoring, laying, filling the trench and recomposing the pavements and sidewalks.

Besides the choice regarding the practice of operation of networks, using the destructive or non-destructive method, it should also choose simple network or double network. According to [2] the pipes of simple network must be located in the third most favorable to the connections, while the double nets must be elaborated as close as possible to the curb, with space available, preferably on the sidewalk.

According to [3], the characteristics of each existing covering, be it asphalt, sidewalks, interlocked pavers, etc., dictate the removal and recomposition practices, which consequently reflect on the cost of the works. The identification and the quantitative of paved sections and sidewalks where the projected network will intersect, precedes the preparation of budgets and is done through visual inspection in loco, an expensive and slow practice.

Considering that construction budgets consist of transforming the details of the project into costs, it must be prepared before the execution of the work, since through it there is a forecast of the cost of the work, thus providing the basis for viability of the object in question [4].

Included in this scenario, the use of technologies, the survey of geographical information and aerial imaging, have emerged as an auxiliary tool for civil and scientific purposes. According to [5], unmanned aerial vehicles (UAVs) present themselves as a potential alternative in the process of obtaining images that assist in the identification and characterization of surfaces, coverage and land use.

Initially, UAVs were used for military purposes, however, their use is becoming increasingly attractive for commercial and governmental applications due to the enormous potential for property monitoring and inspection [6].

In recent years, the use of UAVs for civilian purposes has started to increase thanks to technological advances, cost reduction and the size of sensors related to the Global Positioning System (GPS), pre-programmed flights, IMUs (inertial motion units) and auto-pilots. In this way, technology can fill some knowledge gaps, improving the spatial and temporal resolution of the most common current remote sensing systems [7].

[8] relates that the cost-effectiveness, ease of use, flexibility of flight planning and deployment, the availability of a range of high resolution sensors and post-processing software give this tool the superior potential over images satellite images and images of manned planes.

In a work developed by [3] using aerial images for the budgeting of network, the author finds that the refinement of the resolution used in the process of obtaining the images brought richness of details that allowed in some cases, in addition to the specification of the material, the distinction of the shapes of the pieces used in interlocked pavers and even their state of conservation.

As a sample unit for the development of this research, it was considered a sector in the southern region of the city of Palmas - TO, not yet contemplated with projects of water supply and sewer sytem. On the aerial image of the area overflown, two network routing models were created, one with a simple network arrangement and the other with a double network arrangement, all serving the same sub-basins.

Dimensions and identifications of the types of coating of the sidewalks and roads obtained by the images orthomosaic were compared with the field data, aiming to evaluate the reliability of the referred quantitative and specifications extracted by the sensor attached to the Unmanned Aerial Vehicle (UAV).

## II. METHODOLOGY

In order to achieve the proposed objectives, the applied experimental methodology compared costs of sewage collection networks, budgeted based on quantitative and specifications obtained by aerial image.

### 2.1 Field of study

For the development of this research, it was considered a sector in the southern region of the city of Palmas - TO

which hasn't yet been contemplated with sewage collection network projects. Even without a previously elaborated project, two hydraulic collection network arrangements were elaborated on the same area, one simple, serving both sides of the roads, and the other, double arrangement serving both sides of each road.

In order to isolate the design variables, the same direction of flow was adopted, the same internal neighborhoods to be served, a standard distance of 50m between manholes, a minimum diameter of 150mm and an average depth of 1.60m for the network.

Bertaville sector, an area defined as the object of this research, has an area of approximately 60 ha and is located in the southern region of the city of Palmas - TO. The choice is justified by the fact that it is an area in the initial occupation process and with infrastructure services, such as asphalt and pavement already executed, thus subsidizing the achievement of the proposed objectives.

### 2.2 eBee UAV and softwares for flight and image processing

To collect the images, eBee model aerial vehicle, was used, with registration certificate Nº PP-220920032 (Figure 1), of Swiss manufacture, 96 cm (38 in) wingspan and flight range of around 30 min. It has a propeller at the rear and its foam construction allows flexibility and lightness (700 grams -1.5 lbs), resulting in reduced energy consumption. The aircraft contains a platform with specific sensors attached, which allow photographic images and videos obtention. The aircraft has built-in sensors that enable the stability of the equipment on mission, as well as the transmission of data that guarantee the direct monitoring of the flight opetarion.



*Fig.1: Unmanned aerial vehicle eBee.*

Flight planning is carried out by the base station, developed by the same aircraft manufacturer (senseFlay),

with the following set: eMotion 2 software, responsible for the flight preparation and operation of the aircraft's path, and a transmission antenna, which allows the real-time monitoring of the overflight, as well as the sending of landing commands, changes of direction or obtention of images. The program interface shows important information about the battery level, ambient temperature, altitude, position, duration and speed of the flight, wind speed, resolution and longitudinal and latitudinal overlap of the area to be overflown, altitude and radio link.

For image processing and creation of orthorectified mosaics, the aircraft also has a specific software, Pixel4D (senseFlay). In this process, the points captured by the aircraft's GPS are related with the correspondent image.

## 2.3 Image capture device (camera)

The camera used to capture images, model Canon RGB S110, brought together suitable features compatible with the eBee system and the orthomosaic assembly application. It has a 12.3 megapixel Live MOS sensor, with an ISSO range of 100 to 6400, with capacity to record images in RAW (12-bit lossless compression), JPEG, JPEG + RAW, image stabilizer and a maximum speed of shutter of 1/4000s, being able to shoot 3 frames per second.

## 2.4 Flight planning and image obtention

The plan established for this research aimed the obtention of images that would guarantee better distinction of objects on the surface and greater accuracy in the survey of sidewalk and pavemented areas. For this purpose, a single overflight was carried out at a height of 120 m with overlapping of images on the order of 60% in the longitudinal, 75% on the side and a resolution of 3.4 cm/pixel, resulting in an overflight with a duration of 30 min approximately.

The method seeks to ensure that the stripes may be "tied" by the connection points determined in the common area and form a block.

## 2.5 Orthomosaic assembly

The georeferenced mosaic was obtained after a series of steps, which involved the removal of errors and distortions caused by the image acquisition process, and aimed to guide the images in relation to each other and in relation to the complete scene.

This image processing was done using the UAV GPS information and its own algorithms, capable of automatically finding the linking points between the photos, generating orthomosaics in tif format, DEM (Digital Elevation Model), triangular model 3D and georeferenced point cloud.

Its obtention allows the survey of measurable data, such as area and volume, making easier the identification of imagined points.

## 2.6 Survey of data in the field and by way of the mosaic

Considering that the wastewater collection network can be located both under the sidewalk and under the street, in order to obtain the data collected in the field and via the mosaic, 10 points were randomly chosen in the recorded area, with 5 sections on streets and avenues and 5 sections on sidewalks, so that the sample unit brought different types of coating, thus subsidizing the assessment of the tool reliability in the proposed survey.

## III. RESULTS AND DISCUSSIONS

## 3.1 Photointerpretation of images

The result of the image processing resulted in a mosaic with good resolution quality, which facilitated the identification of the types of coatings and precision in the measurements. With the mosaic it was possible to obtain details of the material specification and even the distinction of the shapes of the pieces used, as it can be observed in Figure 2.



*Fig.2: Detail, in mosaic, of interlocking pavers.*

In another section extracted from the mosaic, it is possible to observe the presence of painted concrete sidewalks (Figure 3).

*Fig.3: Painted concrete sidewalk.*

## 3.2 Measurement of sections of road and sidewalk

The lengths of roads and sidewalks adopted as sample units to verify the accuracy of the survey are shown in table 1.

*Table 1. Variations in dimensions adopted as sampling*

| Nº | COATING | DIMENSION (m) (field) | DIMENSION (m) (image) | VARIATION (m) | DIFFERENCE (%) |
|---|---|---|---|---|---|
| 1 | Asphalt | 6.80 | 6.84 | -0.04 | -0.59% |
| 2 | Asphalt | 6.00 | 5.95 | 0.05 | 0.83% |
| 3 | Asphalt | 6.60 | 6.58 | 0.02 | 0.30% |
| 4 | Unpaved | 4.85 | 4.87 | -0.02 | -0.41% |
| 5 | Unpaved | 6.62 | 6.59 | 0.03 | 0.45% |
| 6 | Unpaved | 6.53 | 6.57 | -0.04 | -0.61% |
| 7 | Concrete | 6.82 | 6.86 | -0.04 | -0.59% |
| 8 | Concrete | 7.65 | 7.68 | -003 | -0.39% |
| 9 | Interlocked | 6.34 | 6.38 | -0.04 | -0.63% |
| 10 | Interlocked | 6.39 | 6.35 | 0.04 | 0.63% |

When comparing the data on asphalt crossings and sidewalks, it is noticed that the maximum variation between

the values of sidewalks and crossings on the pavement was of the order of 4.0 cm, which may be caused by the projection of the shadow of obstacles, making difficult the survey of measurements at some points in the mosaic.

In some situations, the aforementioned aspect can interfere and become the limiting factor in the accuracy of the obtention of measurements, that is, the position of the sun in the flight schedule is responsible for the projection of the shadows, whatever be the surface. As a way to restrain such interference, it is possible to plan flights with greater overlap of the route and at schedule between 10 am and 11 am.

Even with the difficulties found, it can be observed that the individual percentage variation did not exceed 1.0%, which attests to the degree of reliability of the use of images obtained by UAV in the survey of the quantitative of services, for works of wastewater collection network.

## 3.3 Network costs

Taking as a cost base the composition tables of the local sanitation concessionaire and the numbers of cut and recomposition of sidewalks and pavement, the budgets for the two network models were obtained. In their conceptions the simple and double networks have lengths of 8,132m and 12,575m respectively.

The neighborhood studied is all paved and with 80% of its sidewalks in natural terrain with the remaining 20% of pavements in: concrete, interlocked paver and grass. Such quantitative were obtained in the mosaic generated by the images.

The global cost of the network to be implanted varies considerably in cost. The double network is more expensive, with a percentage of 14% above the cost of the simple network, covering the same area. Table 2 shows the synthetic budget of services for the execution of the work.

*Table 2. Synthetic budget of network elaborated in the mosaic.*

| ITEM | R$ DOUBLE NETWORK | R$ SIMPLE NETWORK |
|---|---|---|
| PRELIMINARY SERVICES | R$ 21,063.29 | R$ 21,063.29 |
| TECHNICAL SERVICES | R$ 84,507.00 | R$ 71,558.96 |
| SIGNALING / WARNING | R$ 14,580.11 | R$ 9,294.53 |
| EARTHMOVING | R$ 697,081.16 | R$ 512,486.46 |

| | | |
|---|---|---|
| PAVEMENT REMOVAL / REPAIR IN STREETS AND AVENUES | R$ 37,916.88 | R$ 693,524.63 |
| SOIL REPLACEMENT FOR RECOMPOSITION OF PAVEMENT | R$ 8,490.45 | R$ 174,374.22 |
| REMOVAL / REPAIR OF SIDEWALK | R$ 647,582.56 | R$ - |
| DITCHING SHORING | R$ 275,599.43 | R$ 173,802.52 |
| MAINTENANCE HOLES | R$ 577,271.04 | R$ 369,814.26 |
| LOADING, TRANSPORT AND UNLOADING (L.T.U) | R$ 11,465.70 | R$ 35,535.53 |
| INSTALLATION | R$ 55,743.72 | R$ 35,535.53 |
| HYDRAULIC PART | R$ 34,320.10 | R$ 21,873.73 |
| TOTAL | R$ 2,465,621.44 | R$ 2,118,863.66 |

Even though there is a difference in cost between the networks, it's necessary to think about the extensions of connections that interconnect the network itself with the home to be served.

Simple network extensions are longer, considering that a single line of piping installed in the street should serve both sides of the road. Starting from the network, located on the asphalt, following up to the limit of the land lot, the installation of the branches generates cutting and recomposition on both asphalt and coated sidewalks, which does not occur in the double network installed on the sidewalks. Figure 4 shows the difference in length between the two situations.



*Fig.4: Connections outflowed in simple (a) and double network (b), showing the variation in the length of extensions*

Both concepts were elaborated to serve 1,100 potential connections, that is, with buildings generating domestic effluent. The lengths of branches for each network design were 6.0 m for simple network connections and 2.0 m for double network connections, variation caused by the distance between the network and the points to be outflowing.

Budgeted home connections with their respective branch lengths, cut-off numbers and pavement restoration, it was arrived at the values per connection unit presented in table 3.

*Table 3. Total cost of home connections.*

| | QUANTITY OF CONNECTIONS | R$ / CONNECTIONS | TOTAL |
|---|---|---|---|
| SIMPLE NETWORK CONNECTION | 1,100.00 | R$ 990.71 | R$ 1,089,781.00 |
| DOUBLE NETWORK CONNECTION | 1,100.00 | R$ 439.04 | 482,944.00 |

Home connections are installed in a associated way with the networks, that is, their values are incorporated into the total value of the sewer system of the inhabited sectors.

The total values of each of the network budgeted here with their respective connections can be observed in table 4.

*Table 4. Total cost with network and connections.*

|  | R$ TOTAL CONNECTIONS | R$ TOTAL NETWORK | TOTAL |
|---|---|---|---|
| SIMPLE NETWORK | 1,089,781.00 | R$ 2,118,863.66 | R$ 3,208,644.66 |
| DOUBLE NETWORK | 482,944.00 | R$ 2,465,621.44 | R$ 2,948,565.44 |

The double network in its complete design, including connections, is approximately 8.1% cheaper than the simple network.

## IV.    CONCLUSION

The usage of aerial image for the purposes proposed in this research added agility and accuracy in the quantification of services for the operation of sewerage network, maximizing the information through georeferenced images, which can be consulted at the appropriate time, enabling the clarification of uncertainties present in the budgeting of works stage.

For the situation described, considering the same depth of trenches, hydraulic material, diameter of piping, conditions of coating roads and sidewalks, the double network proved to be a more economical and viable solution.

It is important, therefore, to point out that situations of unpaved roads and more expensive sidewalks, with ceramic coating, tiles and ornamental stones, can interfere with the cost of the network and must be analyzed in a specific way.

The methodology proved to be promising, presenting fast and accurate results, which can be used as a subsidy in the practice of decision making for projects and work budgetings of sewage collection networks.

## REFERENCES

[1] DEZOTTI, M. C. Análise da utilização de métodos-não destrutivos como alternativa para redução dos custos sociais gerados pela instalação, manutenção e substituição de infraestruturas urbanas subterrâneas. 2008. 231 f. Dissertação (Mestrado em Engenharia Civil), Universidade de São Paulo, São Carlos, 2008. Disponível em: <www.teses.usp.br/teses/disponiveis/18/18143/tde-03102008-000200/.../diss_mcd.pdf>. Acesso em: 25 mar. 2016.

[2] ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 12266: Projeto e execução de valas para assentamento de tubulação de água, esgoto ou drenagem urbana. Rio de Janeiro, 1992.

[3] PARENTE, D. C.; LIMA, S. N.; PICANÇO, A. P. Utilização de veículo aéreo não tripulado no levantamento de serviços para orçamentação de redes coletoras de esgoto e de abastecimento de água Revista DAE, v. 66, n. 213, p. 76-84, 2017.

[4] SEVERO, R. D. Orçamento em obras de saneamento. Porto Alegre: Technique Engenharia, 2014. 47 slides, color. Disponível em: <http://docplayer.com.br/4453617-Orcamento-em-obras-de--saneamento-como-garan4r-um-bom-etalhamento-de-custos.html>. Acesso em: 20 mar. 2016.

[5] SILVA, J. S.; ASSIS, H. Y. E. G.; BRITO, A. V.; ALMEIDA, N. V. VANT como ferramenta auxiliar na análise da cobertura e uso da terra. In: X Congresso Brasileiro de Agroinformática, 2015.

[6] GIUFFRIDA, F. Property Drone Consortium. Potential Uses and Considerations Regarding the Use of UAS Technology in Assessment. 2015.Disponívelem:<http://propertydrone.org/wp-ontent/uploads/2017/01/Potential-Uses-and Considerations-Regarding-the-use-of-UAS-Technology-in-Assessment-c.pdf>. Acesso em: 06 ago. 2019.

[7] Nishar, A., Richards, S., Breen, D., Robertson, J., Breen, B. (2016), "Thermal infrared imaging of geothermal environments and by an unmanned aerial vehicle (UAV): A case study of the Wairakei - Tauhara geothermal field, Taupo, New Zealand", Renewable Energy 86 (2016) 1256 - 1264.

[8] BREEN, B.; BROOKS, J. D.; JONES, M. L. R.; ROBERTSONS, J.; BETSCHART, S.; KUNG, O.; CARY, S. C.; LEE, C. K.; POINTING, S. B. Application of an unmanned aerial vehicle in spatial mapping of terrestrial biology and human disturbance in the McMurdo Dry Valleys, East Antarctica. Polar Biol, (2015) 38:573–578.

# The Relevance of the inclusion of fish in the Human Food and Nutritional Diet

Henrique Pereira de Aquino[1], René Geraldo Cordeiro Silva Junior[2]

[1]Universidade Federal do Vale do São Francisco, Rua Mario Borges, 146. Bairro João XXIII. CEP 48.900-200/ Juazeiro - Bahia

[2]Universidade Federal do Vale do São Francisco, Rua Anizio Moura Leal, 67. Apartamento 204. Bairro Maria Auxiliadora, CEP 56.328-010 / Petrolina - Pernambuco

*Abstract— This article is an excerpt from the research entitled "Potentialities and Weaknesses of Artisanal Fisheries and Pisciculture in Tanque Rede in the Municipality of Sobradinho-Bahia", whose objective was to get to know the current reality of family fish farming and business fishing in the Sobradinho lake, specifically in the city of Sobradinho where this practice excels in the sub-middle São Francisco region. It is a quantitative and qualitative research, involving documentary analysis in the fishermen's colony, interviews recorded with the use of forms, both with artisanal fishermen and with businessmen, in order to diagnose their ways of life, work and future expectations. The sample consisted of twenty fishermen and family fishermen and six entrepreneurs who raise tilapia in a net tank, chosen at random. The data were processed by the software SAS - Statiscal Analysis Sistem, where the variables were registered in the columns and the observations in the lines, pointing out that extractive fishing is decreasing, due to the reduction of species in the São Francisco River, while fish farming net tank is on the rise in the municipality, given the favorable environmental conditions, with a positive impact on the food security of the riverside population.*

*Keywords— fishing; food security; network tank; environment; water resource.*

## I. INTRODUCTION

### 1.1 Historical Framework

With the increase of the world population, the great challenge for the nations is to produce food in quantity, quality and regularity in a sustainable way, respecting the environment and the culture of the peoples, which is not an easy task, considering that the portion urban in the last ten years has grown at a rate of 1.83%, while the number of family farmers who produce food has remained stable (SILVA et al, 2009). According to data from FAO - Food and Agriculture Organization of the United Nations (2018), the projection is that in the year 2030, the world population will reach 8.6 billion people, demanding from governments effective actions of social and economic inclusion, with public policies aimed at increasing income and consumption.

With the increase in the world population, the great challenge for nations is to produce food in quantity, quality and regularity in a sustainable manner, respecting the environment and the culture of the people, which is not an easy task. which is believed to be viable for Brazil and, more specifically for the northeast and semi-arid region, is investment in fishing, an activity that throughout history has been used by women and men for their survival, because the Brazil has a maritime coast with 8,500 km and an Exclusive Economic Zone (EEZ) totaling 4.3 million km²; 12% of the fresh water available on the planet; large volume of water held in reservoirs and groundwater; 5 million hectares of flooded land; 2.5 million hectares of estuarine area; 1 million hectares suitable for marine shrimp farming; favorable climatic conditions; availability of labor; strategic location for the flow of production to the Southern Cone, Europe and the USA, and; among others, a large domestic market of different economic classes (XIMENES, Luciano J.F and VIDAL, Maria de Fátima, 2018).

In Latin America, Brazil is the country with the largest area available for mariculture, around 150 thousand km², wind speed and ideal depths for installing cages and longlines, although the high cost of the feed can discourage (XIMENES, Luciano JF and VIDAL, Maria de Fátima, 2018). In the São Francisco River, in almost all its extension, the creation of fish in a net tank has alreadyit is a reality, although much of the fish consumed is the result of artisanal fishing, which consists of an individual or

family activity, whose vessels are precarious and operated by the owner, with the main purpose of maintaining the family's food and supplying free markets and small businesses (FAO, 2012).

The importance of stimulating the consumption of fish in the diet of Brazilians, especially the population of the semiarid region bathed by the São Francisco River, are its excellent health properties. According to Stansby (2012), fish are low-fat and high-protein foods, in addition to being sources of vitamins A, B and B1 and minerals such as calcium, phosphorus, iron, copper, selenium and polyunsaturated fatty acids. Its digestibility is high, above 95%, much higher than that of red meat and milk. Omega-3 fatty acids are related to heart disease. Kris-Etherton et al (2002), gathered epidemiological studies and clinical tests and concluded that EPA + DHA supplementation between 0.5 and 1.8 g per day (both as fish fat and as a dietary supplement), significantly reduced the risk of death from these diseases. According to those authors, clinical tests have demonstrated the relationship between omega-3 fatty acids and the reduction of non-fatal cardiac events, stroke and myocardial infarction and the delay in the progress of atherosclerosis in cardiac patients.

The regular intake of fish contributes to the food and nutritional security of children and adults, and this procedure is thus conceptualized by Law 11.345 / 2006.

"Everyone's right to regular and permanent access to quality food, in sufficient quantity, without compromising access to other essential needs, based on health-promoting food practices that respect cultural diversity and are socially, economically and environmentally sustainable . " (Organic Law on Food and Nutritional Security, art. 3, 2006).

The concern with the food of the population is not recent, even though the terminology "Food and Nutritional Security" was not yet used. In the 18th century, the English demographer Thomas Robert Malthus (1798), already defended the theory that demographic growth would surpass the productive capacity of the land, generating hunger and misery, serving as the basis for the Conservative Modernization of the Green Revolution that in the 20th century , between the 1930s and 1980s, transformedthe productive system in the world. However, the timeline points to the end of the two great world wars as important moments to think about the countries' autonomy in food production; to face wars; the weather of nature; the unfavorable climate for crops in certain seasons; international conflicts for political, religious or military reasons. Such a discussion came to the fore, as European countries were torn apart by wars, without material and human conditions to immediately redo their productive structures (OLIVEIRA et al, 2010). There were many ideas that emerged to solve this problem, ranging from the creation of an international body with the specific purpose of taking care of the matter, to the establishment of other useful institutions, capable of supporting the reconstruction of their economies, but with regulation. After a wide debate, FAO - Food and Agriculture Organization of the United Nations was created in 1945, with the objective of combating hunger and poverty, promoting agricultural development, improving nutrition, seeking food security and access of all people, at all times, to the food necessary for an active and healthy life, as well as the IMF - International Monetary Fund, with the purpose of helping local economies, with interest rates below those practiced in the market (BELIK, 2003) .

In the semiarid, the techniques suggested by the modernization of agriculture brought many possibilities in the generation of work and income; in salaried employment with the implantation of crops irrigated by the waters of the São Francisco River, but leaving a liability liability for the environment: erosion and salinization of soils by improper water management; excessive use of fresh water from the São Francisco River for agriculture, to the detriment of other uses for human and animal consumption; contamination of water and workers by pesticides; destruction of riparian forests, with negative impacts for native species of São Francisco (OLIVEIRA et al, 2018).

## II. THE SÃO FRANCISCO RIVER AND FISH PRODUCTION

The São Francisco River, also called the National Integration River, denomination attributed by the pioneers who in the 17th and 18th centuries penetrated theinterior of the country through its waters. It is also known as Rio do Currais,because it was through him that the cattle of the

sertão were transported to other regions of Brazil. It is born in Serra da Canastra - MG, in Chapada da Zagaia, in the municipality of São Roque de Minas, about a thousand meters high. From Canastra, it plummets 200 meters at the waterfall of Casca d'Antas, covering 2,700 kilometers, through the states of Bahia, Sergipe, Alagoas and Pernambuco, receiving 36 tributaries. Around 13 million inhabitants live in the entire region of the basin, which corresponds to 10% of the Brazilian population (MINISTRY OF INTEGRATION, NATIONAL, 2018). Its benefits reach 503 municipalities, which fall into four categories: Alto São Francisco, which extends from the source to the mining town of São Francisco. Middle São Francisco, comprising the stretch between the city of São Francisco to the Bahian city of Remanso. Sub-Middle São Francisco, covering the city of Remanso to Paulo Afonso in Bahia and Baixo São Francisco, which integrates areas from the states of Bahia, Pernambuco, Sergipe and Alagoas, extending from Paulo Afonso to the mouth (MINISTRY OF NATIONAL INTEGRATION, 2018 ).

Throughout the river, professional artisanal fishing is practiced, involving thousands of families. Currently, however, the situation of fishermen and fisherwomen who live from this activity has been facing difficulties in catching fish, due to the degradation conditions of the river (OLIVEIRA et al, 2010). All the actions implemented on its banks and within it and its tributaries, contribute to the disappearance of native species, which were already more than 150 (ALMEIDA, 1971). Surubim (Pseudoplatyatoma coruscans), a species highly appreciated for the flavor of its meat and due to its size, sometimes reaching more than 100 k, it has not been found for many years, except when it is brought from the states of Tocantins and Mato Grosso. The Golden (Salminus maxillosus) is still rare; Pacú (Piaractus mesopotamicus); Curimatâ (Prochilodus scrofa); Traira (Hoplias malabaricus) and the exogenous Tucunaré (Cichla spp), Tambaqui (Colossoma macropomum) and Tambacu (Colossoma macropomum), brought from other basins by CODEVASF - Development Company of the São Francisco and Parnaiba Valleys, as a strategy for the settlement of the river (OLIVEIRA et al. 2010).

The speeches of the interviewees in this research, reveal the desolation of those who practice extractive fishing as a survival activity. Fisherman 1: "(...) I've been in this business for over thirty years. I started again, accompanying my father, who was also a fisherman. At that time we lived well. My father built a masonry house with many rooms, a yard that looked like a farm, with plants, fruit trees and where my mother raised pig and chicken. The house fit all the children and more the

grandchildren. Furnished with the furniture of that time. Every son had his own bed and our food was plentiful. I still managed to educate my children and give them a more or less condition. My house is my own and I owe nothing to anyone. I have my own boat,bought with what I got from the river. At that time, the river had a lot of fish. I would go on a journey of three, four days and bring the boat full of surubim, dorado, pirá, curimatâ, only good and big fish. I had part of the fish because there was no trade for everything. It was a good time. Today I don't live only on fishing. I have a winery that earns me some money. But the river is a cachaça. We don't forget and I still fish. But it is a sadness. The fish is gone. I bring home five kilos, if anything. And only medium and small fish. Just to eat a fresh fish ..'.

Younger, fisherman 2, does not have the same memories. He entered fishing for lack of opportunity in another area. Poor, without a family, he saw fishing as an opportunity to at least feed himself. Never studied. He started out as an assistant to an acquaintance, but has been in the business for more than ten years. He didn't get plenty of water in the river, but he notes that the situation is getting worse every day. He says: "I've never been able to do anything in my life. I don't have a home and I live in favor. I have four children and they all studied at government schools. Some dropped out of school, wanted nothing to do with school, but I have one who took the agricultural technician course. This one got a job on a farm. He even helps me sometimes. I only managed to buy a small boat. It's all my wealth. But I can't live on fishing anymore. There's no more fish. What we get, we can barely eat. But I can't quit because I don't know how to read and I wouldn't get a job anywhere. "

A very different situation was that of fisherwoman 3, one of the most successful in this male-dominated activity. Divide your time between fishing and agriculture. It has a small area by the river, where it plants onion, guava, acerola and banana. He still wants to plant mangoes and grapes, but for now he doesn't have the money to invest in these crops. He never despaired of the decrease in fish, because he knows that when development arrives, "one side improves and the other gets worse". Your speech is of hope on better days. "(...) I started dealing with fish, just cleaning, treating and salting, and also selling at the fair. It didn't make much money, but it helped withhousehold expenses. But it was too little for me. I wanted more. Then I decided to get my feet wet and go to play the hammock that I bought to provide an acquaintance. Two friends and I rented a boat because none of us had a boat. On the first trip, when we shared the result of the sale of fish, there was a small profit for each

one. But we had to continue if we wanted to be someone. As time went by we learned to know the address of the fish, and things got better, until I got the money to buy my boat. This river is a blessing. He gave me everything I have. My home, my land, my trade. I never wanted my kids involved in fishing, because I wanted a less painful life for them. And I did it. They all study in college. Very true, it was not just fishing that gave me everything, but it was where I started. Today I go fishing every now and then, because my family is already on my way and I have a farm. But I would do it again. For those who are not afraid of work, life always rewards ".

The fisherwoman's simplistic reasoning is an indisputable truth. With the construction of the Sobradinho dam here in the Middle São Francisco, work of great importance for the region, both for the generation of energy and for the control of water, the increase in urbanization, the expansion of commerce and industry, the crops irrigated areas that today are determinants of the increase in the GDP of the cities Juazeiro, Petrolina, Casa Nova, Sobradinho and others, studies carried out by Projeto Áridas (1995), indicate that in the late 90s of the 20th century, 66% of the riparian forests of the São Francisco had already disappeared and fishing production was reduced by 90%. It is also worth considering predatory fishing, carried out by many fishermen in the region, who, when using inappropriate or illegal equipment, disrespect the rules, producing negative impacts on the formation of fish stocks. Even in the closed season, inspection is common to find people fishing with a fine mesh net, not only for their consumption, but also for commercialization (COSTA and COLESANTI, 2011).

As the retired fisherman said 9: "He has a partner who never respects the spawning period of the fish. He lives off that, but he doesn't think that if the fish don't breed, he will be without the goose that lays the golden eggs. Something for those who do not think about the future ". For the solution of the low stock of fish in the river, CODEVASF and other institutions have been fishing with species from other basins adapted to the climatic conditions of the region, but there are risks of diseases brought by these animals, in addition to being predators of native species. .

Even with these problems, artisanal fishing practiced on the São Francisco River remains an activity of socioeconomic and environmental importance, generating work and income for thousands of people and ensuring food for families that have no other alternative for survival. As Diegues (2004) believes, even with rivers and lakes currently compromised by the contamination of their waters and reduction of native species, coastal and riverside communities make this profession their way of surviving in a capitalist and unequal society, promoting cultural diversity and the economy local, being fundamental in the northeast region.

## III. FISH BREEDING IN REDE TANK - AN EXPANDING ALTERNATIVE IN THE SÃO FRANCISCO SUB-MEDIUM

Law 11,959 / 2009, which institutes the National Policy for the Sustainable Development of Aquaculture and Fisheries, defines this activity as "cultivation of organisms whose life cycle under natural conditions occurs totally or partially in aquatic environment, implying the ownership of the stock under cultivation, equated with agricultural activity and classified under the terms of article 20 of this law ". However, it is in Article 19 of the same law that aquaculture modalities are classified as: commercial, scientific or demonstrative, environmental, family and ornamental recovery (BRASIL, 2009).

In Brazil, the standardization of the use of public waters for fish farming occurred by Decree Law 1,965 / 95, which establishes the rules for the activity, which are:

• Prior authorization

• Environmental impact studies

• Licensing modality

• Inspection

• Monitoring

The aforementioned Decree also provides for technical standards such as location, wind, depth, compatibility with other uses of the area, such as tourism, leisure, irrigation, navigation, not belonging to an environmental preservation area, biological reserve, etc.

Legal order condition for implantation of fish farming in net tanks

Based on Decree Law nº 1,965 / 95, Normative Instruction nº 5, of January 18, 2001, the installation of a farm for raising fish in a net tank, requires:

• Obtaining the Aquaculture Registration at the Ministry of Agriculture.

• Licensing at the State Environment Department (Sema).

• Authorization for the use of water by the Regional Management of Patrimony

of the Union (GRPU).

• Mark the cages and inform the Captaincy of the Ports, if the location is

navigable.

The extractive production of fish in Brazil has been decreasing for the reasons already exposed, while the aquaculture segment in a net tank is on the rise, mainly due to the need for income for the breeder and the investments that are not so high initially, since this cultivation system dispenses the contribution ofresources with initial physical works, which can be implemented in flooded areas formed by hydroelectric reservoirs, rivers, mining areas, weirs and other small dams of different use (MEDEIROS; CHAGAS, 2002). A study by FAO FISHERIES AND AQUACULTURE DEPARTMENT (2016), informs that the production of aquaculture grew on average 12.40% a.a., between 2016 and 2018, while the production of fisheries (extractive capture) was 2.50% a.a. There are other segments to be considered here in the productive chain of cultivated fish, since 70% of the fish farming production costs are allocated to feed, which requires the entrepreneur to have a financial reserve consistent with the size of his business (FAO, 2018).

Net tanks are structures of varying sizes, whose purpose is the confinement of fish chosen according to their adaptability to the environment, consisting of a net or mesh that facilitates the free circulation of water, providing them with ideal growth conditions through adequate food and water of good quality. It is an intensive cultivation system that requires the breeder to master the technology involving density, food handling and nutritional needs of the cultivated species. As it is semi-mobile, it can be moved to other locations, when this strategy is recommended for environmental, economic or legal reasons. An important advantage of this system is its uninterrupted production, starting with the first harvest, ensuring permanent income for the entrepreneur. However, it is not a 100% safe crop, free from damage, and some disadvantageous situations may occur, such as:

- Possibility of partial or total loss of cultivated species as a result of leakage, accidents and theft. In the Sobradinho region, interviewed breeders showed concern about thefts, which are recurrent, demanding an additional expense with hiring night surveillance to avoid such an occurrence.
- Total dependence on good quality feed, adapted to the nutritional requirements of cultivated species.
- Potential impact on the environment, which may change the water quality, due to the excess of food not assimilated by the fish.

- Possibility of causing genetic problems to native populations, in case there is an eventual escape of the cultivated animals.
- Lack of uniformity in the size of the fish in the same net tank (KUBTISA, 2004).
- Failure to comply with legal requirements with environmental agencies.
- Inadequate choice of the species to be cultivated (EMBRAPA, 2009).

The choice of the appropriate species to the climatic and environmental conditions is fundamental for the success of the enterprise. Knowing beforehand, that regardless of the species, the feed cost corresponds to 70% of the total breeding expenses, the chosen species must have a good feed conversion rate. For this, it is recommended the use of balanced diets, adequate to the nutritional requirements of the cultivated species, as well as the adoption of good practices of food management. It is also very relevant to choose species that enjoy preference in the market for their flavor and, to add value to the product, take care of its presentation, with a view to facilitating its commercialization.

There are three categories of network tanks:

• Fixed - When they are attached to the bottom of the reservoir by means of stakes and / or anchors.

• Floating - When supported by a floating necklace or frame. They are the most used types, having a wide variety of shapes. Some units are rotating, which helps in cleaning the containment structure (nets or screens).

• Submerged - They are net tanks fixed at the bottom of the aquatic environment. Widely used in the cultivation of salmon. With the exception of submerged ones, the others must be positioned at a distance of at least 50 cm from the bottom, in order to allow the free circulation of water, this is because the water at the bottom of the water bodies is of the worst quality, where accumulate crop residues (feed scraps and waste) and the oxygen concentration is lower (EMBRAPA TECNOLOGICAL INFORMATION, 2009).

As for the shape, they can be square, rectangular or round and the size must be proportional to the number of fish that will be placed in it, understanding that producing the maximum amount of fish in a net tank does not mean maximum profit. The Economic Biomass - BE point (maximum accumulated profit) is well before the carrying capacity is reached. This is because, when the production in a net tank approaches support capacity, the performance indices deteriorate sharply, especially the feed conversion and the daily weight gain. Studies suggest that, in a small volume and high density network tank, the support capacity varies between 500 kg / m³ and 700 kg / m³. In

high volume, low density network tanks, between 80 kg / m³ and 120 kg / m³. In Brazil, there are reports of the production of tilapia in net tanks from 4 m³ to 5 m³, where the best economic return on production was obtained with biomass in a net tank of 150 kg / m³ at 250 kg / m³. The variations in BE depend on the sales value and the cost of production, related to efficiency and scale of production; thus, it is important to evaluate it at each production cycle, in order to allow the maximization of accumulated profits. (EMBRAPA TECNOLOGICAL INFORMATION, 2009).

The fish should be fed slowly. Scholars such as, (CRESCÊNCIO et al., 2005; RONDÁN et al., 2004; VAN DER MEER et al., 1997) suggest that when feeding tilapia, one should "provide at each meal what fish are able to consume in operation, about 15 minutes ", because fish that eat a lot, convert food less efficiently into meat. Many technicians and researchers recommend fixed amounts of food depending on the weight of the fish. However, the quality of the water must be monitored twice a day, in order to ensure the well-being of the fish, considering that the concentration of oxygen dissolved in the water is what maintains their vital functions. For most species, dissolved oxygen must exceed 5 mg / L. For that, the water must be renewed when necessary; control the temperature; maintain aeration; control water turbidity; repair networks; perform periodic biometrics to adjust the feeding; use feed on the expiration date; avoid stress due to aggression to the fish's way of life (MEYER et al, 2004). The greater the abundance of water, the lower the incidence of problems with intensive fish farming, up to the time of harvesting, which is the partial or total removal of fish from tanks for sale, in street markets, supermarkets, markets. from neighborhoods and at the producer's own establishment to neighbors, friends and the population of the neighborhood, preferably alive, in polystyrene boxes from 500L to 1000L, with water renewal to keep the fish in good condition, until the purchase by customers.

The United Nations Food and Agriculture Organization (FAO) estimates for fish consumption in 2020 in Brazil is 8.3 kg / person / year, which is still little, considering the quality of fish meat for human health and food and nutritional security (FAO, 2018).

## IV.     MATERIAL AND METHODS

### 4.1 Ethical Aspects

This study was APPROVED by the Ethics and Research Committee - CEP of the Ethics and Deontology Committee in Studies and Research - CEDEP of the Federal University of Vale do São Francisco (UNIVASF), under protocol No. 3,533,696 CEP / CEDEP / UNIVASF

and respected the ethical principles present in Resolution No. 466December 12, 2012, of the National Health Council / Ministry of Health, which regulates research involving human beings (BRASIL, 2013); as well as Resolution no. 510/16, which provides for the rules applicable to research in Human and Social Sciences whose methodological procedures involve the use of data directly obtained from the participants or of identifiable information or which may entail greater risks than those existing in everyday life (BRASIL, 2016).

All research volunteers were informed about the project's purpose, methodological character and were invited to participate spontaneously in the study; after acceptance, they read and signed the Free and Informed Consent Form (ICF).

### 4.2 Description of the Study Area

The study was carried out in the municipality of Sobradinho, territory of identity Sertão do São Francisco, northern region of the state of Bahia, in the fishing colony Z 026 and in the fish farming project Lago de Sobradinho, managed by CHESF (Companhia Hidroelétrica do São Francisco).

### 4.2.1 Profile of the Municipality of Sobradinho

Located on the right bank of the São Francisco River, Sobradinho occupies an area of 1238.923 km², having its population in 2019 estimated at 23,191 inhabitants. It is part of the Integrated Administrative Region for the Development of Polo Petrolina and Juazeiro, having the highest GDP per capita of RIDE, as it houses the Sobradinho Hydroelectric Plant. It is assumed that this name originated due to a small townhouse located near the waterfall, for the operation of the locking system which was called Sobrado waterfall or Sobradinho waterfall. Time passed and, in the twentieth century, the 1970s, the site, at the time a district of the municipality of Juazeiro, underwent major changes, due to the dispossession by CHESF, for the construction of the Sobradinho Dam by the Ministry of Mines and Energy. The purpose of this building was to change the course of the São Francisco River to a flow of 2,060 m³ / s, to support the operation of the plants built downstream from Rio, in particular Paulo Afonso. The dispossessed people were relocated, resulting in an episode of impact and social conflicts, due to the inability or non-acceptance of new homes, or the loss of cultural identity suffered particularly by small producers and fishermen. Expropriation is still felt today. This change affected more than 70 thousand people (XIMENES & VIDAL, 2018).

## V. DISCUSSION

To answer the research questions, documentary analyzes were carried out at the fishermen's colony in the municipality of Sobradinho to identify the associated fishermen, the annual reports, the contracts with CONAB and other government agencies and the public policies accessed by the associated fishermen. Subsequently, in the second stage of the research, 20 artisanal fishermen were selected at random, for semi-structured interviews, with the support of a form, in order to learn about their way of life, work and their future expectations. The same procedure was used with fish farmers in fish breeding in a net tank, with 6 interviewed entrepreneurs.

Previously observed by Gandra et al (2007), in this research it was also found that the majority of artisanal fishermen have a low level of education and insufficient resources potential, being observed by large businessmen and fish farmers as a form of productive collectivity unfit to face the dispute in the globalized world. They have ages ranging from 18 to 65 years, with greater representation between 40 and 60 years for artisanal fishermen and 50 and 60 for fish farmers. More than half of the participants (80%) are beneficiaries of the Bolsa Família Program and declared to live with an average income of less than half the minimum wage. There is no infrastructure and basic sanitation in all houses and, therefore, many fishermen 77% still live in mud houses and not masonry. 100% of fishermen follow their parents' profession, although not always at will. Economic difficulties make parents want other professions for their children, however, the lack of education and preparation for other activities, determine for them the continuity of the activity with which they have always been involved. Other disadvantages are added to the questions, such as: market integration; family management; productive inefficiency; diversified small-scale production with high costs; intensive work exposure; backward practices; low productivity and weak economic movement; all of this in contrast to the capitalist model that is shown to be integrated into the market and capable of reproduction; responsible management; international incorporation; high-scale production; inexpensive costs; modern technologies, with high productivity and great economic movement.

On the other hand, studies in different parts of the world show that artisanal fishing has a great capacity to generate jobs and distribute income,contributing to the diversification of the use of rural space. Favorable to artisanal fishing, there are several positive externalities resulting from its development, such as: greater distributive efficiency - better income distribution and greater job generation; improvement in food security; reduced

migration from the countryside to the city; small property and food production for the domestic market, among others (GANDRA et al, 2007).

In relation to the surveyed entrepreneurs, there was weakness in the domain of fish handling, fattening and reproduction, fish transport and storage, as this activity is still very recent in the region and there is a lack of technical training for entrepreneurs.

Producing food for the world population, without a doubt, is a general concern. Food security and environmental sustainability issues are among the priorities that international organizations have placed so that countries can incorporate in their programs in the coming years. According to SOFIA (2018), by 2050, it is estimated that the world population will exceed 9 billion people and, to supply this growing demand, the annual meat production will need to expand by 200 million tons. In this scenario, Brazil is expected to be in the international fish market alongside China, the United States and the European Union.

In September 2015, realizing that the economic, social and environmental indicators of recent years were pessimistic about the future of the next generations, the United Nations (UN), proposed that its 193 member countries sign the 2030 Agenda, a global plan composed of 17 sustainable development objectives (SDGs) and 169 goals, in order to achieve sustainable development by 2030. Among these objectives, the second and the fourteenth deal directly with the contribution of fishing to the pre-established goals.

Objective two (2), specifically refers to 'Zero Hunger and Sustainable Agriculture' and aims to end hunger, achieve food security and improve nutrition and promote sustainable agriculture. In this perspective, by 2030, signatory countries must develop programs and policies that can double the productivity of small farmers, including women and indigenous peoples, in order to increase the income of their families. Objective fourteenth (14), which refers to 'Life in the Waters', aims to conserve and sustainably use the oceans, seas and marine resources for sustainable development, and that in 2030 all harmful practices are eliminated and / or illegal fishing activities that damage the marine ecosystem.

Fishing activity is often based on extractivism and the use of own and natural resources without any planning. This type of work lasted for a long time, while the fishing stock met the expectations of fishermen, however, with the reduction of species due to various reasons, aquaculture is an alternative for the continuation of fish farming for sustainable development.

Following World Bank prospects (2013), more than 60% of the fish used for consumption will be from aquaculture (captive production) by 2030. In this space, the FAO (Food and Agriculture Organization of the United Nations) encourages production, as it believes that Brazil will have a major role in the fishing sector, reaching 20 million tons per year (aa). By 2016, world production exceeded seven hundred million tons (FAO, 2018), while China, which is currently the largest fish producer in the world, reaches over 45 million tons a.a. In South America, only analyzing aquaculture, Brazil is the second largest producer, second only to Chile, which is an important salmon producer.

In Brazil, the best scenario for aquaculture production occurred when the Ministry of Fisheries and Aquaculture was created, an organ that granted various incentives at the time of its existence while it lasted. According to Kubitza (2015), Brazil has been on the world meat scene, except fish, since 2004, reaching its peak in 2014; period in which the aquaculture sector displaced all meats with growth above all other proteins, with an average expansion greater than 8%, against 5.1% of beef; 4.1 chicken and 2.9 pork. The biggest highlight was the raising of tilapia. While the increase in fish production was 10%, tilapiculture alone reached more than 14%.

This expansion in the tilapia aquaculture sector in Brazil is far from other protein production chains, however, it indicates the fishing capacity and investment of the agricultural sector. The development of national fish farming has been exploring a variety of species, but with an emphasis on tilapia, tambaqui (their hybrids), carp and pirarucu. National fish farming is a growing field with wide potential due to the country's water resources, continental dimensions, favorable climate and entrepreneurship by producers (PEIXE BR, 2019).

Sustainable territorial development works from the perspective of generating jobs and income, valuing small and medium-sized businesses, fighting poverty, reducing inequalities, providing quality public policy, generally unexpected conditions for communities that passively wait (INSTITUTO CIDADANIA, 2016) . Campagnola et. al (2007), proposes that, to be part ofeconomic, social and environmental variables it is essential that the management of the rural-urban space is placed in order to overcome the recent administrative design, with modern planning and implementation at the territorial level. Thus, the rural environment is characterized as a social development, based on social actors and economic agents, in accordance with the interests, objectives, projects and the implementation of strategies that will enable dynamics in the exploitation of resources or organization of civil society.

Santos (1996), points out that circumstances in the ways of life need, in their measure, how and where they are inserted, and infers that "The citizen is the individual in a place". Therefore, working on special practices in different regions of a different society, is subject to the risk of exclusion or inclusion of your rights.

The Sub-Middle São Francisco, a portion that extends from Remanso to the city of Paulo Afonso (BA), represents an enormous aquatic potential, as it has a high and uniform temperature throughout the year (SOARES et al., 2007). However, the stocks of rivers and reservoirs are declining for several reasons, some of which are the fact that: 1) many native species are migratory and most dams in Brazil alter their habitat, interfering with their life cycle. An example of this are the surubim (Pseudoplatystoma corruscans), the curimatã (Prochilodus argenteus) and the dorado (Salminus franciscanus), which practically disappeared after the construction of the dam. 2) that agriculture dumps tons of agrochemicals on the São Francisco River, contaminating its waters and killing the life there; that 3) domestic and industrial pollution throws its waste directly into the river without treatment, even contaminated with heavy metals; that the 4) closing of the connections between lakes and the river by the great farmers and entrepreneurs, has been contributing for the destruction and pollution of these places; that the 5) settlements of rivers and reservoirs, with exotic species, predators of native species have contributed to the decrease of native species; that the 6) absence of riparian forest has contributed strongly to the silting up of the river; as well as the 7) use of irregular mesh (STANSBY, 2012).

This reality gave way to the emergence of fish farming in net tanks in Lago de Sobradinho, in the confrontation with artisanal fishing, a secular activity in the region, among riverside dwellers. According to Bueno et al. (2011), fish farming is the main growth activity in Brazil, in reservoirs with an intensive system, using network tanks. The prospect of growth of this activity for Brazil is often superior to any other type of animal production, having seen the relation area per kilo produced and also to the misuse of the spaces indicated for aquaculture production in a country that has the largest reserve of fresh water on the planet.

In Sobradinho, fish farming was developed with the help of agencies such as Bahia Pesca, a company linked to the Bahia Department of Agriculture, Irrigation and Agrarian Reform - SEAGRI, and the São Francisco and Parnaíba Valleys Development Company - CODEVASF,

linked to the Ministry of National Integration. However, production capacity is still far below its full potential. The Sobradinho reservoir, according to Suassuna (2008), has a storage capacity of 34.1 billion cubic meters in its nominal quota of 392.50 m, constituting a large artificial lake, one of the largest in the world. However, the large fluctuation in the level of the dam, depending on the rainfall regime, the seasons and the need for electricity generation, can be a major complicating factor for regular activity. Currently linked to Bahia Pesca, the Sobradinho Fishing Terminal has already operated, in the 1980s, with about 50,000 kg / fish per month, but with the construction of the Sobradinho Dam there was a considerable drop in the region's fishing production. Allied to this, the lack of inspection was not able to restrain predatory fishing that contributed to the extinction of several species of fish in the São Francisco River (BAHIA PESCA, 2008).

The state of Bahia already contributes 7% of the Brazilian continental aquaculture production, focused on the cultivation of tilapia and tambaquis (BOSCARDIN, 2008). And there is, according to CODEVASF (2005; 2011), a great potential for expansion of this activity in the area of Lago de Sobradinho, reaching up to 779 thousand tons / year with the use of only 0.1% of the lake area; besides being able to generate more than 3 thousand direct jobs. The quality of the waters of the São Francisco River is a prominent factor, enhancing production in the region (CODEVASF, 2006).

In Brazil, the per capita consumption of fish is on average 9.7 kg / inhab. / Year. This average consumption is below 12 kg / inhab. / Year recommended by the World Health Organization (WHO). However, the consumption of fish by the population studied is at least three times a week, and for most, consumption is daily in more than one meal, exceeding the WHO recommendation by more than three times. Despite the considerable consumption of fish, the studied population presents inadequacies regarding protein needs, due to the absence in the diet of other components necessary for nutritional balance.

## VI.    CONCUSIONS

The concept of Food and Nutritional Security is a concept in permanent construction, as society's expectations and the power relations of the segments that make it up are constantly evolving. Since the beginning of the 90s, a strong movement towards the reaffirmation of the Human Right to Adequate Food has been consolidated in the world, as provided for in the Universal Declaration of Human Rights.

Human Rights (1948) and the International Covenant on Economic, Social and Cultural Rights - PIDESC (ABRANDH, 2010). More recently, other dimensions have been associated with the term, such as the sovereignty of peoples, in the perspective that each nation defines policies that guarantee the food and nutritional security of its people, including the right to preserve traditional food production practices for each culture. (VIA CAMPESINA, 2003).

The FAO report (2018) removes Brazil from the hunger map, due to the social policies of income transfer that are being implemented in the country, as well as the fact that Brazil produces food in quantity, quality and regularity to meet the demand of its population. However, due to lack of income, many families become part of the nutritional risk framework, due to the absolute financial condition of acquiring them, which is why Food and Nutritional Security policies must address the need to provide access to food for the poor. insecure groups, meeting the needs of food consumption as citizens. The artisanal fishing activity, in addition to being a source of income and family subsistence, is an important cultural tradition for local commerce, in addition to the traditional knowledge of fishermen being a source of information for management projects related to environmental preservation. With regard to fish farming, stimulating the increase in domestic production is essential to increase the food and nutritional quality of its population, in addition to expanding external marketing, considering the favorable environmental conditions and the technology available for increasing productivity.

The nutritional superiority of fish compared to other products of animal origin, especially because it is a source of proteins of high biological value, of the considerable amounts of fat-soluble vitamins, phosphorus, iron, copper, selenium, iodine, as well as omega-polyunsaturated fatty acids -3, constitutes a strong reason for this food to become part of the diet of Brazilians in greater quantity, especially those residing on the margins of water resources, to obtain them at a lower price, thus ensuring health. Although artisanal fishing is declining on the São Francisco River, for reasons that accumulate leaving an irrecoverable liability, aquaculture, which includes the cultivation of aquatic organisms, is considered one of the most efficient ways to reduce the deficit between demand and demand. offer of fish in the market (CAVALLI; FERREIRA, 2010). For using natural, manufactured resourcesand human, this activity according to Valenti (2002), can be sustainable, without harming the environment and promoting social development.

From the research findings, it can be concluded that Brazil lacks effective public policies to leverage artisanal fishing, a relevant segment for the food security of vulnerable populations, as well as greater contributions to fish farmers, in the perspective of opening external fish-consuming markets, expanding their profits and making them competitive nationally and internationally with the largest producers in the industry.

## REFERENCES

[1] ABRANDH/MDS. **Fortalecimento da Implementação do Sistema Nacional de Segurança Alimentar e Nutricional nos Níveis Estaduais, Distrital e Municipais**. Brasília – DF, 2010.

[2] ALMEIDA, Manuel José de. **O drama do São Francisco**. Gráfica do SenadoFederal: Brasília,1971.

[3] ANUÁRIO PEIXE BR DE PISCICULTURA.Associação Brasileira de Piscicultura. **Texto Comunicação**, 2019.

[4] BOSCARDIN, N.R. A produção aquícola brasileira. In: OSTRENSKY, A.; BORGHETTI, A. J. R.; SOTO, D. (Eds.). **Aquicultura no Brasil: o desafio é crescer**.Brasília: Organização das Nações Unidas para Agricultura e Alimentação, 2008, p 27- 72.

[5] BUENO, J. M. et al. **Educação alimentar na obesidade: adesão e resultados antropométricos.** Revista de Nutrição, v. 24, n. 4, p. 575-584, ago. 2011.

[6] BAHIA PESCA. **Relatório de atividades do terminal pesqueiro**. Sobradinho, BA: 2008. 16 p.

[7] BELIK, Walter. **Perspectivas para Segurança Alimentar e Nutricional no Brasil**. Saúde e Sociedade, V.12, n. 1, p. 12-20, jan-jun 2003.

[8] BRASIL, Companhia de Desenvolvimento do Vale do Rio São Francisco e do Parnaíba. **Estudo macrodiagnóstico da região nordeste do Vale do São Francisco**. Estados da Bahia, Sergipe, Alagoas e Pernambuco. Brasília: 2005.

[9] BRASIL. Companhia de Desenvolvimento do Vale do Rio São Francisco e do Parnaíba. **Estudo macrodiagnóstico da região nordeste do Vale do São Francisco**. Estados da Bahia, Sergipe, Alagoas e Pernambuco.Brasília: 2006.

[10] BRASIL. Companhia de Desenvolvimento do Vale do Rio São Francisco e do Parnaíba. **Estudo macrodiagnóstico da região nordeste do Vale do São Francisco**. Brasília: 2011.

[11] CAMPAGNOLO R, Nuñer APO. **Sobrevivência e crescimento de larvas de surubim.** Pseudoplatystoma corruscans (Pisces, Pimelodidae), em diferentes densidades de estocagem. *Acta Sci Anim Sci*, v.28, p.231-237, 2007.

[12] CAVALLI, R; FERREIRA, J. **O Futuro da Pesca e da Aquicultura Marinha no Brasil: a maricultura** . Revista da Sociedade Brasileira para o Progresso da Ciência. Ano 62, n.3, 2010.

[13] CHAGAS, E. C.; GOMES, L. C.; MARTINS JÚNIOR, H..; ROUBACH, R.. **Produtividade de tambaqui criado em tanque-rede com diferentes taxas de alimentação.** Ciência Rural, Santa. Maria, v. 37,n. 4, p. 1109-1115, 2007.

[14] COSTA, R.G.S. e COLESANTI, M.M. A contribuição da percepção ambiental nos estudos de áreas verdes. *RA'E GA-O* **Espaço Geográfico em Análise**, 22: 238-251, 2011

[15] CRESCÊNCIO, R.; ITUASSÚ, D. R.; ROUBACH, R.; PEREIRA FILHO, M.; CAVERO, B. A. S.; GANDRA, A. .L. Influência do período de alimentação no consumo e ganho de peso do pirarucu. **Pesquisa Agropecuária Brasileira.** Brasília - DF, v. 40, n. 12, p. 1217-1222, 2005.

[16] DIEGUES, A. C. S. O **Mito Moderno da Natureza Intocada**. São Paulo, Hucitec, 2004.

[17] EMBRAPA INFORMAÇÕES TECNOLÓGICAS. **Piscicultura em Tanque Rede**. Brasília – DF, 2009.

[18] FAO - FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATION. *State of World Fisheries and Aquaculture* – *2012*. Disponível em: <http://www.fao.org/docrep/016/i2727e/i2727e.pdf>. Acesso em: 25/08/2020..

[19] **The state of world fisheries and aquaculture**: opportunities and challenges. Rome:FAO, 2016. 243 p. [27] **FAO, IFAD, UNICEF, PMA e OMS** . 2017**.** *O Estado da Segurança Alimentar e Nutricional no Mundo.*Construindo resiliência para a paz e a segurança alimentar . Roma, FAO, 2017.

[20] FAO – FOOD AND AGRICULTURE ORGANIZATION. **El estado mundial de la pesca y la acuicultura**.Departamento de pesca y acuicultura de la FAO. Roma, 2018. 233p.

[21] GANDRA, A.; ITUASSÚ, D. R.; PEREIRA FILHO, M.; ROUBACH, R.; CRESCÊNCIO, R.; CAVERO, B. A. S. Pirarucu growth under different feeding regimes. **AquacultureInternational**, Amsterdam, v. 15, n. 1, p. 91-96, 2007.

[22] INSTITUTO CIDADANIA. *Projeto Fome Zero – Uma Proposta de Política de Segurança Alimentar para o Brasil*.São Paulo: Instituto Cidadania, 2016.

[23] Kris-Etherton PM, Harris WS, Appel LJ, American Heart Association. **Fish consumption, fish oil, omega-3 fatty acids**, and cardiovascular disease. Circulation, 2002.

[24] KUBITZA, F. A . Aquicultura no Brasil: principais espécies, áreas de cultivo, rações, fatores limitantes edesafios. **Panorama da Aquicultura**, Rio de Janeiro, v. 25, n. 150, jul./ago. 2015.

[25] Lei nº 11.346, de 15 de setembro de 2006. **Cria o Sistema Nacional de Segurança Alimentar e Nutricional - Sisan** com vistas em assegurar o direito humano à alimentação adequada e dá outras providências. *Diário Oficial da União,* setembro de 2006.

[26] Lei no 11.959/2009 - Dispõe sobre a política nacional de desenvolvimento sustentável da aquicultura e da pesca, regula as atividades pesqueiras e dá outras providências.

[27] SANTOS, M.C.C.L & ARAUJO, Marilene. **Declaração Universal dos Direitos Humanos.** Juruá Editora, São Paulo, 2018.

[28] MEDEIROS, F. das C. **Tanque-rede**: mais tecnologia e lucro na piscicultura. Cuiabá: Editora da UFMT, 2002. 110 p.

[29] MEYER, G.; FRACALOSSI, D. M.; BORBA, M. R. Importância da quantidade de energia da ração de peixes. **Panorama da Aqüicultura**, Rio de Janeiro,v. 83. p. 53-57, 2004.

[30] MINISTÉRIO DA INTEGRAÇÃO NACIONAL**. São Francisco, 2018**. Disponível em: <http: www.integracao.gov.br/saofrancisco/> Acesso em: 20/08/2020.

[31] OLIVEIRA JM, Luzia LA, Rondó PHC. **Ácidos Graxos Poli-insaturados Ômega-3: saúde cardiovascular e sustentabilidade ambiental.** Segurança Alimentar e Nutricional. 2012;19:89-96.

[32] **Organização das Nações Unidas para a Agricultura e Alimentação (FAO/ONU). State of The World Fisheries and Aquaculture (Sofia)**, 2018.

[33] RONDÁN, M.; HERNÁNDEZ, M. D.; EGEA, M.A.; GARCIA, B.; RUEDA, F. M.; MARTINEZ, F. J. Effect of feeding rate on the fatty acid composition of sharpsnout seabream (*Diploduspuntazzo*). **Aquaculture Nutrition**, Weymouth, v. 10, p. 301-307, 2004.

[34] RESOLUÇÃO CNS 466/12 - Aprova as diretrizes e normas regulamentadoras de pesquisas envolvendo seres humanos e revoga as Resoluções CNS nos. 196/96, 303/2000 e 404/2008.

[35] RESOLUÇÃO CFN 510/2012 - RESOLUÇÃO CFN Nº 510/2012 Dispõe sobre o registro, nos Conselhos Regionais de Nutricionistas, de atestados para comprovação de aptidão para desempenho de atividades nas áreas de alimentação e nutrição e dá outras providências.

[36] SANTOS, José Luiz dos**. *O Que é Cultura***. 16ª. ed. São Paulo: Brasiliense, 1996.

[37] SANTOS, M.C.C.L & ARAUJO, Marilene. **Declaração Universal dos Direitos Humanos.** Juruá Editora, São Paulo, 2018.

[38] SILVA, M.E.P.A.; CASTRO, P.M.G.; MARUYAMA, L.S.; PAIVA, P.**Levantament da pesca e perfil socioeconômico dos pescadores artesanais profissionais  no reservatório Billings**. *Boletim do Instituto de Pesca*, *35*(4): 531-543, 2009.

[39] SOARES;Maria Teresa Costa;LIMA,Gilson Brito Alves;BRADÃO,André Augusto Pereira.**Impactos econômicosda degradação ambiental:a crise da atividade pesqueira**em Jurujuba-Niterói/Rio de Janeiro, 2007.

[40] Represa de Sobradinho: um reservatório estratégico e desconhecido. In: **Repórter Brasil**. Disponível em: <http://www.reporterbrasil.org.br/exibe.php?id=1341&name=Represa-de-Sobradinho:-um-reservat%F3rio-estrat%E9gico-e-desconhecido>Acesso em: 20/08/2020

[41] STANSBY ME. **Polyunsaturates and fat in fish flesh**. J Am Diet Assoc.;63:625-630, 2012.

[42] VAN DER MEER, M. B.; HERWAARDEN, H.; VERDEGEM, M. C. J. Effect of number of meals and frequency of feeding on voluntary feed intake of *Colossoma macropomum*(Cuvier). **AquacultureResearch**, Oxford, v. 28, p. 419-432, 1997.

[43] VALENTI, W.C. Introdução. In: VALENTI, W.C. et al. **Aqüicultura no Brasil**: bases para o desenvolvimento sustentável. Brasília: CNPq/Ministério da Ciência e Tecnologia, 2000. p. 25-32.

[44] VIA CAMPESINA. NGO **Forum Declaration in the World Food Summit of FAO(Rome+5).** Roma, junho de 2003.

[45] XIMENES, Luciano J.F & VIDAL, Maria de Fátima**. Pescado no Brasil: Produzir Bem e Vender Melhor**. Banco do Nordeste. Caderno Setorial, ano 3, n.49, nov 2018.

# Experimental Review on "Evaluation of Antimicrobial activity of Metabolites from the fruit coat of *Cucumis Sativus*"

Arjun Kumar[1], Manisha Sahani[2], Srinath Pandey[3], Vinay Dwivedi[4], Prashant Ankur Jain[5], Ved Kumar Mishra[6]

[1,2,3&4]Department of Biotechnology, Naraina Vidya Peeth Engineering and Management Institute, Gangaganj, Panki, Kanpur, Uttar Pradesh, India-208020

[5]Department of Computational Biology and Bioinformatics (CBBI), Jacob Institute of Biotechnology and Bioengineering (JIBB), Sam Higginbottom University of Agriculture Technology and Sciences (SHUATS), Allahabad, Uttar Pradesh, India-211007

[6]Vidhyashram Educational and Development Hub (VED Hub), 204, Dih-Ganjari, Gangapur, Varanasi, Uttar Pradesh, India-221302

Corresponding Author: ved.m45@gmail.com

***Abstract***— *Skin inflammation vulgaris is the most broad skin illness and a persevering incendiary issue influencing 90-95% of young people. Irritation is because of the over multiplication of Propionibacterium acnes, Staphylococcus aureus and Staphylococcus epidermidis. Numerous manufactured makeup have been created for the treatment of skin break out. Be that as it may, they are known to have many reactions and are found to get safe after some time. In this manner, the current work was embraced to explore a characteristic restorative plant, Cucumis sativus separates, for their enemy of oxidant, antimicrobial potential and its corrective incentive in treatment of skin break out. Results demonstrated the nearness of all out phenolic content (19.25 μg and 6.23 μg GAE) and flavonoid content (1.82 μg and 6.24 μg catechin in new and dried concentrates individually. New concentrate of Cucumis sativus showed promising antibacterial potential and was blended in with tea tree (Melaleuca alternifolia) oil and linseed (Linum usitatissimum) oil to get ready polyherbal cream (O/W) details . Details were additionally assessed for pH, consistency and different physical boundaries. F5 cream definition indicated pH in scope of 5-6.*

***Keywords***— ***Staphylococus, Flavonoid, Inflammation, Phenolic.***

## I. INTRODUCTION

Cucumis sativus Linn. (Family: Cucurbitaceae) is a yearly, rather coarse, plump, prostrate or climbing vine generally disseminated everywhere throughout the world especially in Asia, Africa and South America1. Customarily, this plant is utilized for cerebral pains; the seeds utilized as cooling and diuretic, the organic product juice is utilized as a nutritive and as a demulcent in hostile to skin inflammation salves; Juice of leaves utilized as an emetic in intense acid reflux in children5.Several examinations uncovered antidiabetic2, antiulcer3, moisturizing4, cancer prevention agent and pain relieving property5 of the natural product separates. The seed extricates were discovered productive on controlling weight reduction of diabetic rats1 and against tapeworms6. Leaves

and stems separate have been accounted for cytotoxic, antifungal11 and antibacterial activity7. Recognized phytoceuticals from its leaves and seeds were acylated flavone C-glycosides, for example, isovitexin 2"- O-(6"'- (E)-p-coumaroyl) glucoside, isovitexin 2"- O-(6"'- (E)-pcoumaroyl) glucoside-4'- O-glucoside, isovitexin 2"- O-(6"'- (E)- feruloyl) glucoside-4'- O-glucoside and isoscoparin 2"- O-(6"'- (E)- pcoumaroyl) glucoside10 ,cucurbitasides B , C and ferredoxin8,9 and _-and _-amyrin, sitosterols and cucurbitasides10. The point of the current examination was to investigate antibacterial, antifungal and cytotoxic possibility of various dissolvable concentrate of leaves of Cucumis sativus. The broad study of writing uncovered that Cucumis sativus, is a significant restorative plant with

different pharmacological range. Cucumis sativus is broadly utilized in Ayurveda, Siddha, Chinese medication and so forth. The huge examination done on the plant demonstrated that the plant has numerous significant phytoconstituents like Glycosides, flavones, terpinoids, phytosterol, saponins and anolignan B, Tannins, ellargic corrosive, glucose, fructose. These mixes were seen as liable for a significant number of the pharmacological exercises, for example, antibacterial, antifungal, antidiabetic, Cytotoxic , Antacid and Carminative action , Hepatoprotective movement, Wound mending exercises. Further the plant is utilized in the treatment of gastric ulcer, obstruction, general debility, heaps. Henceforth, this plant gives a noteworthy job in the avoidance and treatment of an infection. Further assessment should be done so as to investigate the hid zones and their down to earth clinical applications, which can be utilized for the government assistance of the humankind.

The expanded shopper interest for high caliber, long time span of usability, and prepared to-eat nourishments has started the improvement of just somewhat safeguarded items that keep their common and new appearance beyond what many would consider possible. Microbiological development ordinarily initiates bothersome organoleptic and appearance change during the capacity of food items. In the event that bacterial development in food items could be deferred, or ended, enormous gainsin items timeframe of realistic usability would be conceivable. Evasion of pathogenic and decay microorganisms in food is typically accomplished by utilizing synthetic additives. These synthetic concoctions go about as antimicrobial mixes which repress the development of unwanted microorganisms. While various conventional or administrative endorsed antimicrobials, they have numerous confinements. There is an as of now solid discussion about the wellbeing parts of substance additives since they are viewed as answerable for some, cancer-causing agent characteristics just as leftover poisonousness. For these circumstances, shoppers have an affinity to be dubious of substance added substances and in this way the investigation of normally happening antimicrobials for food conservations gets expanding consideration because of purchaser consciousness of common food items and a developing worry of microbial opposition towards regular additives (Skandamis et al., 2001; Schuenzel and Harrison, 2002). That has prompted scan for novel antimicrobial mixes from characteristic sources. Normally inferred mixes and other common items may have applications in controlling microscopic organisms in nourishments (Deloguis and

Mazza, 1995, Bowles and Juneja, 1998). The essential motivating force for indentifying powerful antimicrobials among normally happening mixes is to grow the range of antimicrobial action over that of the administrative endorsed substances. Conventional antimicrobials are commonly constrained to high corrosive, low fat food items in view of communications with pH and food parts. Enthusiasm for common antimicrobials is additionally determined by the way that universal administrative organizations are commonly exceptionally exacting as to necessities for toxicological assessment of novel direct food antimicrobial. One gathering of normally determined antimicrobial mixes is restorative plants and their fundamental oils. These mixes have been sheltered, have been appeared to have shifting level of antimicrobial action, and could give another obstacle to development of foodborne pathogens and deterioration microbes, subsequently improving the timeframe of realistic usability of food items. Various investigations have detailed that restorative plants produce countless optional metabolites with antimicrobial impacts on pathogens (Mari et al., 2003; Obagwu and Korsten, 2003). Restorative plant removes, along these lines, for the control of the development of foodborne pathogens and food waste microorganisms are rising as options in contrast to regular normal additives as they are commonly protected to people, and naturally agreeable (Thangavelu et al., 2004). Be that as it may, characteristic antimicrobial movement of therapeutic plants and their fundamental oils is frequently factor. Most examination on therapeutic plants as common antimicrobial has been led in Vitro in microbiological media. Uses of these substances to food are constrained and the movement in food is altogether different in light of the microenvironment in food. There exists a need to improve the movement of these antimicrobial mixes in nourishments. Antimicrobial bundling is a promising type of dynamic food bundling, and come to be the one of the ways to deal with forestall sullying of microorganisms on the outside of food items and postpone decay. A perfect answer for the food business to conquer the sanitation and condition issues is to fuse antimicrobial substances in to eatable movies (Padgett et al., 1998). A few antimicrobial operators were consolidated into consumable movies and were appeared to restrain the food waste microorganisms. Soy protein can be utilized to create consumable antimicrobial film to apply antimicrobial specialists on the outside of food items. The expansion of the interest for new, advantageous, and long time span of usability items augurs a brilliant future for antimicrobial bundling. The adequacy of normal plant separates is should

have been assessed to indicate their antimicrobial movement and likely reactions in bundle food. In this manner, the investigation of the antimicrobial movement of some Thai customary restorative plants and the application in eatable film has become a significant examination premium and a major test. Either the entire plant or plant items having therapeutic properties are usually known as restorative plants. These therapeutic plants are known to have different phytochemicals, which display more bioactivities, for example, antibacterial, antifungal, anticancer action, and so on. In this examination, Aegle marmelos was gathered from Chennai, unrefined concentrate of products of the soil of the picked plant was oppressed for antimicrobial movement. Subjective examination for the phytochemicals of the plants was investigated. Negligible inhibitory centralization of the rough concentrates was identified.Crude extricate was exposed to TLC bioautography for antibacterial action. The division which indicated antibacterial action was exposed to GC-MS examination. Cucumber (Cucumis sativus L.) has a place with the family cucurbitaceae . There are 30 Cucumis species found in Asia and Africa. Cucumber is a local to the tropics and is one of the most established developed vegetable harvests. It is known in the history for more than 3,000 years (Yawalkar, 1985). Cucumis sativus (CS) is developing generally all through the India (Varanasi area), Indian subcontinent, Sri Lanka. Obviously cucumbers have begun in the lower regions of the Himalayan Mountains, only north of the Bay of Bengal, the region which is currently basically involved by Bangladesh. While there doesn't appear to be any wild cucumbers present in the region today, researchers have recognized a little unpleasant product of the squash family, which is thought to have delivered the cucumber. Late examinations prompted the presumption that cucumbers may have begun on the African landmass, anyway fossils, which could prove such cases have not yet been found. Reality is that cucumbers have just been generally developed before, which is clear from put down accounts in a wide range of societies. Records show that cucumbers were at that point developed as far East as China as right on time as 2,000 years before the Christian Era. The current article endeavors to give thorough data on pharmacological properties of Cucumis sativus for additional exploration. All the data was gather from the distributed exploration paper on Cucumis sativus concerning the purpose of future examination on it. Plants are fit for blending a different cluster of optional metabolites. These might be created constitutively (preformed antimicrobial mixes, or phytoanticipins) or because of pathogen or

herbivore assault or stress (phytoalexins) (Yawalkar K.S, 1985). There has been recharged enthusiasm in the course of the most recent 20 years in the disengagement of antimicrobial mixes from plants due to their basic decent variety, one of a kind bioactivity and ecological similarity, which are more positive than those of manufactured synthetic concoctions (Ankita S. et al, 2012)

## II. METHODOLOGY

### Test assortment

Around 4 kg test was required. The plant Cucumis sativus was gathered in the period of February. The organic products were cut into pieces, conceal dried at room temperature and powdered. The dried organic product powder (500 gm) was progressively separated utilizing methanol, chloroform, ethanol and water by utilizing Soxhlet mechanical assembly. The last hint of dissolvable was evacuated under decreased tension refining and afterward vacuum dried. The dried rough concentrates were utilized.

### Glass wares

- Test tubes,
- Beaker,
- Petri plates,
- cone shaped carafe
- Instruments
- Soxhlet Apparatus,
- Incubator,
- Drier,
- smasher,
- Knife,
- Autoclave,
- Pestle and mortar,
- Spectrophotometer (to check O.D of strain)

## III. TECHNIQUE

1.Take cucumber and expel its spread methods its buildup which isn't utilized for eating however it's tossed as waste. Take roughly 4kgs of cucumber

2. Dry it on placing it in daylight with the goal that al dampness substance get expelled from it after that when it got dried in daylight on the other hand put it in drier at 30

level of tem so it tends to be warmed at the level that it could be granulated and make in controlled structure.

3 .After getting dried of buildup smash it in fine structure like powder.



*Fig.1: Powder form of sample*

4. Then after this utilization that example for gauging and for one time of soxhlet took 10-12gm of test tied it in bit of cotton material and afterward set it in Chloroform arrangement in soxhlet with the goal that we could get pass on of cucumber and it very well may be additionally utilized of following stage to be performed. Soxhlet system needs time of in any event 24hrs.



*Fig.2: Soxhletion process of sample*

5. At that point when we get cucumber arrangement in soxhletits expelled and afterward it's dried in container to vanish the fluid.

6. With the assistance of the spatula dried buildup is taken out from the recepticle.

7. Then that is in semi-strong structure. At that point to make it in fluid for performing sequential weakening its broke up in peptone water.

8. Then 5 effendrof is taken and afterward sequential weakening is done up to multiple times as it were. at that point in that little circle made of watmann channel paper is placed in each cylinder.

9. Then its saved for one day (24 hrs)

10. NAM (supplement agar plate) is made and work plate gets dried effendrof isn't upset.

11. After drying of media on plate from rear numbers is written as per sequential weakening.

12. Strain is taken and with the assistance of cotton strain is scattered everywhere throughout the media.

13. After scattering of type (strain of E.coli) circles are taken out as indicated by their number and put at the number composed on the plates like in case weakens is initial one and that is kept at the first position composed on the plate.

14. Then after this plate is kept in hatchery at 37 degree for 24hrs to get result.

15. Next day plate is takes out to see result.

## IV.     RESULT AND DISCUSSION

These outcomes proposed that the arrangements consolidating new concentrate of Cucumis sativus The antibacterial action in the plant extractives could be because of the flavonoid and phenolic substance of these plants as they are fit for shaping a complex with extracellular and solvent proteins and with bacterial cell dividers. They are hypothesized to include film disturbance likewise by the lipophilic mixes. We have seen antimicrobial movement of cucumber in numbers 1,4,5 we have seen antimicrobial action of cucumber.

*Fig.3: Antimicrobial movement of sample*

## V.    CONCLUSSION

Home grown arrangements showing restraint agreeable are progressively satisfactory in the conviction that they are more secure with less reactions than the engineered drugs. Subsequently the current work surveys the antimicrobial and cancer prevention agent capability of Cucumis sativus which is a safe and restoratively compelling hotspot for natural enemy of skin break out creams. Be that as it may, the dynamic flavonoids and phenolic Components Cucumis sativus which are of intrigue should be investigate further for improvement of hostile to skin inflammation items to upgrade the medical advantages.

## ACKNOWLEDGEMENT

## REFERENCES

[1]  A'lam H. 1993. Cucumber. In Yarshater E. ed. Encyclopedia Iranica, Vol. 6. Costa Mesa: Mazda Publishers, 450–452.

[2]  Adams F. 1834. The Medical Works of Paulus Aegineta. London: Welsh, 43, 103.

[3]  Aetius Amidenus. 1804. Biblion Yatrikon, vol. A. Venice.

[4]  Alvarez de Morales C, Giron Irueste F. 1992. Ibn Habib (m. 238/853) Mujtasar fi l-Tibb (Compendio de Medicina). Madrid: Consejo Superior de Investigaciones Cientificas, 94, 103–139.

[5]  Amar Z, Lev E, Serry Y. (in press). On Ibn Juljul and the meaning and importance of the list of medicinal substances not mentioned by Dioscorides. Journal of the Royal Asiatic Society, 3rd series.

[6]  Amar Z, Lev E. 2011. Watermelon, chate melon, and cucumber: new light on traditional and innovative field crops in the Middle Ages. Journal Asiatique 299: 193–204.

[7]  Amar Z. 2000. Giddule Erez-Yisra'el Bime Habenayim. [Agricultural Produce of the Land of Israel in the Middle Ages.] Jerusalem: Yad Ben-Zvi (Hebrew), 288.

[8]  Ankita S., Kaur P., and Gupta R. Phytochemical screening and antimicrobial assay of various seeds extracts of Cucurbitaceae Family. International Journal of Applied Biology & Pharmaceutical Technology. Volume 3, Issue 3(2012): 401-409

[9]  Ankita S., Kaur P., and Gupta R. Phytochemical screening and antimicrobial assay of various seeds extracts of Cucurbitaceae Family. International Journal of Applied Biology & Pharmaceutical Technology. Volume 3, Issue 3(2012): 401-409

[10]  Anqori Z. 1966. Adderet Eliyyahu. Ramla: HaMo'aza ha'Arzit shel 'Adat haYehudim haQara'im beYisra'el (Hebrew), 395.

[11]  Ar-Razi M. 1982. Manafi 'al-Aghdhiya wa-Daf' Madarriha [Book of Foods and Correctives]. Beirut: Dar Ihya al-'Ulum (Arabic), 229–230.

[12]  Ascherson P, Schweinfurth G. 1887. Illustration de la Flore d'Egypte. Cairo: Memoires de l'Institut Egyptien, 76–78.

[13]  Barbaro E. 1529. Historia Mundi. Basel: Frobenium, 270–271.

[14]  Barney SA, Lewis WJ, Beach JA, Berghof O. 2006. The Etymologies of Isidore of Seville. Cambridge: Cambridge University Press, 356.

[15] Bates DM, Robinson RW. 1995. Cucumbers, melons and water-melons. In: Smartt J, Simmonds NW. eds. Evolution of crop plants, 2nd edn. Harlow: Longman, 89–96.

[16] Baumann FA. 1974. Das Erbario Carrarese. Berne: Benteli Verlag, 52.

[17] Beck LY. 2005. Pedanius Dioscorides of Anazarbus: De Materia Medica. Hildesheim: Olms-Weidmann.

[18] Bertelli C, Lilla S, Orofino G. 1992. Dioscurides Neapolitanus. Rome: Salerno Editrice.

[19] Bisht IS, Bhat KV, Tanwar SPS, Bhandari DC, Joshi K, Sharma AK. 2004. Distribution and genetic diversity of Cucumis sativus var. hardwickii (Royle) Alef. in India. Journal of Horticultural Science and Biotechnology 79: 783–791.

[20] Brunet MEPL. 1939. Sime´on Seth Me´decin de l'Empereur Michel Doucas, Sa Vie, Son Œuvre. Bordeaux: Delmas, 44, 107–108.

[21] Budge EAW. 1976. The Syriac Book of Medicines. Amsterdam: Philo Press, English 332, 357, 372; Syriac 296, 314, 324.

[22] Cabaret-Dupati M. 1844. L'E´ conomie Rurale de Palladius. Paris: C. L. F. Panckoucke, 204–205.

[23] Chakravarty HL. 1966. Monograph of the Cucurbitaceae of Iraq. Baghdad: Ministry of Agriculture Technical Bulletin 133.

[24] Chakravarty HL. 1982. Fascicles of Flora of India: Fascicle 2, Cucurbitaceae. Howrah: Botanical Survey of India, Botanic Garden, 36.

[25] Civitavecchia B di, Paglia A. 1546. Antidotarium Joannis Filii Mesuae. Leiden: Frellonios, 459.

[26] Cle´ment-Mullet JJ. 1866. Le Livre de l'Agriculture d'Ibn-Al-Awam. Paris: Franck, 205–226.

[27] Collins BA, Al-Tai MH. 1994. Al-Muqaddasi: The Best Divisions for Knowledge of the Regions, a Translation of Ahsan al-Taqasim fi Ma'rifat al-Aqalim. Reading: Garnet Publishing, 390.

[28] Collins M, Raphael S. 2004. A Medieval Herbal: A Facsimile of British Library Egerton ms. 747. London: British Library.

[29] Collins M. 2000. Medieval Herbals: The Illustrative Traditions. London: British Library.

[30] Condorelli S. 1978. Gargilii Martialis Quae Exstant, vol. 1. Rome: Bretschneider, 9–10.

[31] Conrad LI, Neve M, Nutton V, Porter R, Wear A. 2003. The Western Medical Tradition 800 BC to AD 1800. Cambridge: Cambridge University Press, 230.

[32] Cornarius J. 1542. Aetii Medici Graeci. Basel.

[33] Cowan, M.M. Plant products as antimicrobial agents. *Clin. Microbiol. Rev*. **1999**, *12*, 564-582.

[34] Crescenzi P. de'. 1495. Opus Ruralium Commodorum. Speyer: Drach, 79.

[35] Crescenzi P. de'. 1504. De Agricultura, 2nd Italian edn, chapter 21. Venice.

[36] Dalby A. 2003a. Flavours of Byzantium. Totnes: Prospect. Dalby A. 2003b. Food in the Ancient World from A to Z. London: Routledge.

[37] Daunay MC, Laterrot H, Janick J. 2008. Iconography and history of Solanaceae: antiquity to the XVIIth century. Horticultural Reviews 34: 1–111, 8 pl.

[38] De Candolle A. 1886. Origin of cultivated plants. New York: Appleton, 264–266. De Capella M. 1523. Liber Totius Medicine Necessaria Continens. Lyons: Jacobi Myt, 60.

[39] De Goeje MJ. 1991. Ahsan al-Taqasim fi Ma'rifat al-Aqalim, al-Muqaddasi, 2nd edn. Cairo: Maktabat Madbuli, (Arabic), 443.

[40] De Sacy S. 1810. Relation de l'E´ gypte par Abd-Allatif, Me´decin Arabe de Bagdad. Paris: Imprimerie Impe´riale, 34.

[41] Dietrich A. 1993. Die Erga¨nzung Ibn Ğ ulğul's zur Materia Medica des Dioskurides. Go¨ttingen: Vandenhoeck & Ruprecht, 57.

[42] Drexl F. 1925. Achmetis Oneirocriticon. Leipzig: Teubner, 196–198.

[43] Du Cange C du Fresne. 1688. Glossarium ad Scriptores Mediae & Infimae Graecitatis. Leiden: Anissonios, Poseul, & Rigaud, col. 9.

[44] Editorial Commission of Institute of Botany, Chinese Academy of Sciences. *Flora Reipublicae Popularis Sinicae*; Science Press: Beijing, China, 1986.

[45] Eisendrath ER. 1961. Portraits of plants. A limited study of the 'icones'. Annals of the Missouri Botanical Garden 48: 291–327.

[46] Elisha, E.E., Twaij, H.A.A., Ali, N.M., Tarish, J.H., Al-Omari, M.M. and Karim, S. The anthelmintic activity of some Iraqi plants of the Cucurbitaceae. Pharma. Biology, 1987; 25: 153-157.

[47] Elkhadem H. 1990. Le Taqwim al Sihha (Tacuini Sanitatis) d'Ibn Butlan: Un Traite´ Me´dical du XIe Sie`cle. Louvain: Peeters, 83, 168–171.

[48] Ermerins FZ. 1840. Anecdota Medica Graeca e Codicibus. Leiden: Luchtman, Leiden, 224–275.

[49] Feliks J. 1967. Kil'e Zera'im weHarkava [Seed Crossing and Grafting]. Tel Aviv: Devir (Hebrew), 44–52.

[50] Fleischmann W. 1919. Capitulare de Villis vel Curtis Imperatorii Caroli Magni [No locality or publisher], 60.

[51] Flower B, Rosenbaum E. 1974. The Roman Cookery Book, a Critical Translation of the Art of Cooking by Apicius. London: Harrap, 9–22, 74–79.

[52] Forbes D. 1857. A Dictionary, Hindustani & English, 2nd edn. London: W. H. Allen.

[53] Forster ES, Heffner EH. 1955. Lucius Junius Moderatus Columella: On Agriculture 10–12. Cambridge, MA: Harvard University Press, 26–27, 40–43, 159–163.

[54] Friedenwald H. 1944. Manuscript copies of the medical works of Isaac Israeli. The Jews and Medicine, Essays, vol. 1, 185–192, 2 pl.

[55] Frye RN. 1972. Byzantine and Sasanian trade relations with northeastern Russia. Dumbarton Oaks Papers 26: 263–269.

[56] Fuchs L. 1549. De Historia Stirpium. Leiden: B. Arnollet, 662.

[57] Gaisford T, Bernhardy G. 1853. Suidae Lexicon Graece et Latine. Halis: Sumptibus Schwetschkiorum, 750.

[58] Givens JA. 2006. Reading and writing the illustrated Tractatus de Herbis, 1280–1526. In: Givens JA, Reeds KM, Touwaide A. eds. Visualizing medieval medicine and natural history, 1200–1550. Aldershot, UK: Ashgate, 115–145.

[59] Grant M. 1997. Dieting for an Emperor: a translation of Books 1 and 4 of Oribasius' Medical Compilations. Leiden: Brill. Grant M. 2000. Galen on food and diet. London: Routledge.

[60] Grant M. 2007. Anthimus: on the observance of foods. Totnes: Prospect Books, 70–71.

[61] Gyulai G, Humphreys M, Lagler R, et al. 2006. Seed remains of common millet from the 4th (Mongolia) and 15th (Hungary) centuries: AFLP, SSR and mtDNA sequence recoveries. Seed Science Research 16: 179–191.

[62] Ha¨meen-Anttila J. 2006. The last pagans of Iraq, Ibn Wahshiyya and his Nabatean Agriculture. Leiden: Brill, 233.

[63] Hamidullah M. 1993. The book of plants by Abu Hanifa al-Dinawari. Karachi: Bait al-Hikmat, 528.

[64] Haverman AM. 1970. Mishna 'im Perush haRambam, Defus Rishon, Napoli 5202 [Mishna with Commentary of Maimonides, First Printing, Naples, Jewish Year 5202]. Jerusalem: Sifriyyat Meqorot (Hebrew), Kil'ayim 1: 2.

[65] Heidari H., Kamalinejad M., Eskandari M. Hepatoprotective activity of Cucumis sativus against cumene hydroperoxide induced-oxidative stress. Research in Pharmaceutical Sciences, 2012; 7(5): S936-S939.

[66] Hesseling DC, Pernot H. 1910. Poe`mes Prodromiques en Grec Vulgaire. Amsterdam: Johannes Mu¨ller, 44. Hispani P. 1515. Omnia Opera Ysaac. Lyons: Barthelemy Trot, 124.

[67] Hisahiro Kai1, Masaki Baba1, Toru Okuyama Inhibitory Effect of Cucumis sativus on melanin production in melanoma B16 Cells by down regulation of tyrosinase expression; Planta Med 2008; 74(15): 1785-1788.

[68] Hort A. 1976. Theophrastus, enquiry into plants, vol. 1. London: William Heinemann, 92–93.

[69] Ideler JL. 1842. De Alimentis, vol. 2. In Physici et Medici Graeci Minores. Berlin: Reimer, 257–281.

[70] Itoh, T.; Kikuchi, Y.; Shimizu, N.; Tamura, T.; Matsumoto, T. 24β-Ethyl-31-norlanosta-8,25(27)-dien-3β-ol and 24β-ethyl-25(27)-dehydrolophenol in seeds of three cucurbitaceae species. *Phytochemistry* **1981**, *20*, 1929-1933.

[71] Janick J, Paris HS, Parrish DC. 2007. The cucurbits of Mediterranean antiquity: identification of taxa from ancient images and descriptions. Annals of Botany 100: 1441–1457.

[72] Janick J, Paris HS. 2006. The cucurbit images (1515–1518) of the Villa Farnesina, Rome. Annals of Botany 97: 165–176.

[73] Jessen C. 1867. Alberti Magni: De Vegetabilibus Libri vii, Historiae Naturalis pars xviii. Berlin: Reimer, 500–502.

[74] Jiangsu Institute of Botany. *Xinhua Compendium of Material Medica*; Shanghai Science &

[75] Johann Wolfgang Goethe University, Frankfurt-am-Main. Millas Vallicrosa JM, Aziman M. 1955. Ibn Bassal: Libro de Agricultura. Tetuan: Instituto Muley el-Hasan, Arabic 127–139, Spanish 165–180.

[76] Jones WHS. 1951. Pliny Natural History, vol. VI. Cambridge, MA: Harvard University Press, 4–11.

[77] Jones WHS. 1967. Hippocrates, vol. 4. London: Heinemann.

[78] Joshi SG. Medicinal Plants, Oxford and IBH Publishing Co. Pvt. Ltd; New Delhi, 2003,157–8.

[79] Joysree D**,** Anusua C**,** Subrata KB**,** Utpal KK**,** Syeda RS**,** Sheikh ZR, Md AM, Cytotoxicity and Antifungal Activities of Ethanolic and Chloroform Extracts of Cucumis sativus Linn (Cucurbitaceae) Leaves and Stems. Reserch Journal of Phytochemistry, 6,2012,25-30.

[80] Kahl O. 2003. Sabur ibn Sahl: The small dispensatory. Leiden: Brill.

[81] Karthiyayini T, Rajesh K, Senthil KLK, Sahu RK, Roy A, Evaluation of antidiabetic and hypolipidemic effect of Cucumis sativus fruit in streptozotocin-induced-diabetic rats. Biomedical & Pharmacology Journal, 2, 2009, 351-355.

[82] Keng H. 1974. Economic plants of ancient north China as mentioned in Shih Ching (Book of Poetry). Economic Botany 28: 391–410.

[83] Kirsten P. 1609. Kitab al-Thani min Qanun al-Qanun al Ibn Sina. Liber Secundus de Canone Canonis a Filio Sina. Wroclaw: Kirsten.

[84] Kumar D, Kumar S, Singh J, Narender, Rashmi, Vashistha BD, Singh N, Free radical scavenging and analgesic activities of Cucumis sativus L. fruit extract. Journal of Young Pharmacist, 2, 2010, 365-368.

[85] Kykkotis I. 1942. English–Greek and Greek–English dictionary. London: Lund Humphries.

[86] Langkavel B. 1866. Botanik der Spaeteren Griechen. Verlag von F. Berggold, 25.

[87] Langkavel B. 1868. Simeonis Sethi: Syntagma de Alimentorum Facultatibus. Leipzig: Teubner, 21–22, 108.

[88] Leclerc L. 1883. Traite´ des Simples par Ibn El-Beithar. Paris: Imprimerie Nationale, vol. 1, 363; vol. 2, 63–64; vol. 3, 62.

[89] Li H-L. 1969. The vegetables of ancient China. Economic Botany 23: 253–260.

[90] Lindsay WM. 1966. Isidori Hispalensis Episcopi Etymologiarum sive Originum, vol. 2. Oxford: Oxford University Press [not paginated].

[91] Maire B. 2007. Se Soigner par les Plantes: Les 'Reme`des' de Gargile Martial. Lausanne: E´ditions BHMS, 20.

[92] Mallik J., Akhter R., Phytochemical Screening and In-vitro Evaluation of Reducing Power, Cytotoxicity and Anti-Fungal Activities of Ethanol Extracts of Cucumis sativus.

International Journal of Pharmaceutical &Biological Archives 2012; 3(3): 555-560.

[93] Manfredi H. 1500. Rhaza, et Varior Opera Medica. Venice: Johann Bentmol, 14.

[94] Manniche L. 1989. An ancient Egyptian herbal. Austin: University of Texas Press, 95–96.

[95] Martius J. 1568. Noni Medici Clarissimi: De Omnium Particularum Morborum Curatione. Strasbourg: Rihel.

[96] Mazzini I. 1984. De Observantia Ciborum. Rome: Giorgio Bretschneider, 55.

[97] McNally, D.J.; Labbe, C.; Quideau, S.; Belanger, R.R. Complex C-glycosyl flavonoid Phytoalexins from *Cucumis sativus*. *J. Nat. Prod*. **2003**, *66*, 1280-1283.

[98] Meyerhof M. 1931. 'Ali at-Tabari's 'Paradise of Wisdom', one of the oldest Arabic compendiums of medicine. Isis (Brugges) 16: 6–54.

[99] Minaiyan, M., Zolfaghari, B. and Kamal, A. Effect of hydroalcoholic and buthanolic extract of Cucumis sativus seeds on blood glucose level of normal and streptozotocin-induced diabetic rats. Iran Journal of Basic Medical Science, 2011 ;14: 436-442.

[100] Moravec J, Lebeda A, Krˇistkova E. 2004. History of growing and breeding cucurbitaceous crops in Czech lands. In: Lebeda A, Paris HS. eds. Progress in cucurbit genetics and breeding research, Proceedings of Cucurbitaceae 2004, the 8th EUCARPIA Meeting on Cucurbit Genetics and Breeding. Olomouc: Palacky University, 21–38.

[101] Nadkarni AK, Nadkarni KM, Indian Materia Medica, Popular Prakashan, Bombay, 2005, 403–04.

[102] Nasrallah N. 2007. Annals of the Caliph's kitchens, Ibn Sayyar Al-Warraq's Tenth-century Baghdadi cookbook. Leiden: Brill, 168.

[103] Nicolosi E, La Malfa S, El-Otmani M, Negbi M, Goldschmidt EE. 2005. The search for the authentic citron (Citrus medica L.): historic and genetic analysis. HortScience 40: 1963–1968.

[104] O'Leary D. 1964. How Greek science passed to the Arabs. London: Kegan Paul, 96–119.

[105] Oberhelman SM. 1991. The Oneirocriticon of Achmet. Lubbock: Texas Tech University Press, 215–216.

[106] Olson SD. 2006. The learned banqueters: Athenaeus. Cambridge, MA: Harvard University Press, 330–331.

[107] Opravil E. 1979. Die Gurke in der Burgwallzeit. In: Rapports du 3e Congre`s International d'Arche´ologie Slave, Tome 1. Bratislava: Veda, 597–598.

[108] Osbaldeston TA, Wood RPA. 2000. Dioscorides: De Materia Mediapprox. Johannesburg: Ibidis Press. Owen T. 1806. Geoponica, vol. 2. London: Young, 113–116.

[109] Pa¨cht O. 1950. Early Italian nature studies and the early calendar landscape. Journal of the Warburg and Courtauld Institute 13: 13–47. Republished, 1965, Vaduz (Liechtenstein): Kraus Reprint.

[110] Pandey S, Dhillon NPS, Sureja AK, Singh D, Malik AA. 2010. Hybridization for increased yield and nutritional content of snake melon (Cucumis melo L. var. flexuosus). Plant Genetic Resources 8: 127–131.

[111] Paper HH. 1972. HaTora beFarsit-Yehudit: Tirgum haTora He'atiq Beyoter leFarsit-Yehudit [A Judeo-Persian Pentateuch]. Jerusalem: Ben-Zvi Institute (Hebrew), 91.

[112] Paris HS, Daunay MC, Janick J. 2009. The Cucurbitaceae and Solanaceae illustrated in medieval manuscripts known as the Tacuinum Sanitatis. Annals of Botany 103: 1187–1205.

[113] Paris HS, Daunay MC, Pitrat M, Janick J. 2006. First known image of Cucurbita in Europe, 1503–1508. Annals of Botany 98: 41–47.

[114] Paris HS, Janick J, Daunay MC. 2011. Medieval herbal iconography and lexicography of Cucumis (cucumber and melon, Cucurbitaceae) in the Occident, 1300–1458. Annals of Botany 108: 471–484.

[115] Paris HS, Janick J. 2008. Reflections on linguistics as an aid to taxonomical identification of ancient Mediterranean cucurbits: The piqqus of the faqqous. In Pitrat M. ed. Cucurbitaceae 2008. Avignon: INRA, 43–51.

[116] Paris HS. 2000. Paintings (1769–1774) by A. N. Duchesne and the history of Cucurbita pepo. Annals of Botany 85: 815–830.

# Utilization of pequi Residual Biomass from the Brazilian cerrado for obtaining raw and activated biochars and bio-oil

Mateus Rodrigues Brito[1*], Cláudio Carneiro Santana Junior[1], Magale Karine Diel Rambo[1], Elisandra Scapin[1], Marcelo Mendes Pedroza[2], Michele Cristiane Diel Rambo[2], Lorena Nascimento Barbosa[3]

[1]Graduate Program in Environmental Science, Federal University of Tocantins (UFT), Tocantins, Brazil.
[2]Federal Institute of Education, Science and Technology (IFTO), Tocantins, Brazil.
[3]Graduation in Environmental Engineering, Federal University of Tocantins (UFT), Tocantins, Brazil.
Email: rodriguesmr21@gmail.com  (Corresponding author*)

*Abstract*— *The pequi (Caryocar brasiliense Camb) is a fruit native to the Cerrado, with a production of 765 tons per year. However, their peels (76% of the fruit) are generally discarded. In this study, the physical-chemical characterization of the biomass of the pequi was carried out and physical activation processes were developed through slow pyrolysis and physical chemical activation with zinc chloride (ZnCl$_2$) to produce bio-based products, including bio-oil (30.5%) and biochar (34%). Analytical techniques, such as mid-infrared spectroscopy, gas chromatography coupled with mass spectrometry, surface area, pore size, approximate and elementary analysis, helped to elucidate, identify and quantify such compounds. The biochars produced showed a low surface area of 30,30 m²/g (BET) and 39.11 m²/g (Langmuir), however the superior calorific power of activated carbon (29.59 kJ.g$^{-1}$) and raw coal (26,92 kJ.g$^{-1}$) highlight the potential of biochar for use as a solid fuel. Bio-oil, on the other hand, presented valuable chemicals in its fraction, such as vaccenic acid (21.23%), palmitic acid (19.73%) and furfural acid (7.04%).*

*Keywords*— *Bioproducts, Peel of pequi, pyrolysis, residue.*

## I. INTRODUCTION

The cerrado is the second largest biome in Brazil, concentrated mainly in the central-west region and occupies two million square kilometers, corresponding to 24% of the country's territorial extension. It stands out as a global hotspot, with a wide ecological diversity, about 11,627 species, and its hydrological function highlights the importance that the biome plays in the environment and society [1,2].

The pequi (*Caryocar brasiliense* Camb) is a fruit native to the Cerrado. Fruit production in Brazil in 2018 was 765 tons (core), of which 441 tons were in the northern region alone[3]. Despite all production, in general, only pyrenes (21.6%) are used, making the rest of the fruit (76% of peel) waste from the process[4]. That said, it is important to understand the use of these residues and their alternative use for the production of biochar and bio-oil [5].

Pyrolysis is a physical-chemical process, which can be performed slowly or quickly, to produce such compounds. Slow pyrolysis enhances the yield of biochar, while rapid pyrolysis benefits the yield of bio-oil [6]. The composition of bio-oil consists of a complex mixture of different substances such as: ketones, phenols, aldehydes and hydrocarbons, which provide the production of chemicals and applications in biofuels [7]. Among the applications of bio-oil we can highlight: heating furnaces, boilers, diesel engines and turbines. It can be incorporated into other chemicals to produce adhesives and resins. Due to the diversity of chemical compounds, they can be characterized and used in the pharmaceutical and chemical industries [8-9].

The biochar, considered an organic residue, basically composed of carbon and ash, has chemical and physical characteristics that contribute to: removal of pollutants in the soil, improvement of photosynthesis, increase of carbon sequestration, decrease of Greenhouse Gases - GHG, and containment of soil erosion [10-13]. The biochar can be activated chemically or physically and serve as a powerful adsorbent for the removal of pollutants, drugs, and purification processes [14].

In this context, the objective of this research was to perform the slow pyrolysis of the residues of the raw pequi (peel), in order to verify the potentials of bio-oils, biochars and activated biochars, as alternative sources of bioproducts.

## II. MATERIALS AND METHODS

### 2.1 Sample preparation

The pequi mesocarp (*Caryocar brasiliense* Camb) was collected in the indigenous village of the Xerente tribe, in the city of Tocantínia, in the state of Tocantins, which is part of the Legal Amazon of Brazil. The collected material was processed at the Chemistry Laboratory of the Federal University of Tocantins, where the fractions were separated manually, the shells were dried in an oven at 60ºC for 24 hours, ground in a Willye knife mill (model Star FT 50, Fortenox) and deposited in hermetically sealed glass bottles. All analyzes were performed in duplicates.

### 2.2 Pyrolysis Process

The raw samples were inserted into the Pyrex tubular fixed bed reactor to be subjected to the pyrolysis process. Thus, 30g of biomass at 500 °C was used for 30 min [15] For the transfer of vapors and aerosols from pyrolysis, chloroform was used in the helium flow (20 mL min$^{-1}$) and two chloroform traps (50 mL) kept in ice/salt baths. After the pyrolysis process, the liquid residue (bio-oil) and the solid residue (biochar) were stored for further analysis. The solids separator was used to recover all the solid material resulting from pyrolysis. The biochar yield (%) was calculated according to equation 1, and the bio-oil yield was calculated according to equation 2.

$$Biochar\ yield\ (\%) = mfc/mic\ X\ 100 \qquad (1)$$

Where: *mfC*: Final mass of Charcoal; *miC*: Initial mass of Charcoal.

$$Bio-oil\ yield\ (\%) = mfb/mibX100 \qquad (2)$$

Where: *mfB*: Final mass of Bio-oil; *miB*: Initial mass of Bio-oil.

### 2.3 Activation of coal

The activation of the coal was carried out with a solution of zinc chloride - $ZnCl_2$ (Merck) with a concentration of 10% m/v in the proportion of 1: 5 (coal: solution, mass: volume) was added to the biomass sample. Then, the sample container was covered with film paper for 24 hours. Subsequently, the sample was washed with distilled water and kiln-dried at $110 \pm 5$ °C [16].

The washed biomass was placed in a cordierite crucible, closed with rock wool and cordierite plate, and once again it was pyrolyzed in a vertical oven (Jung 815), at $600 \pm 5$ °C, for 2 hours. A 2 mol solution of hydrochloric acid - HCl (Merck). L$^{-1}$ was used to wash the activated carbon, removing and unclogging the pores. The process was concluded with drying the charcoal in an oven at $110 \pm 5$ °C for 24 h, resulting in the pequi peel activated carbon.

### 2.4 Biochar analysis

#### 2.4.1 Approximate chemical analysis

The approximate chemical analysis was carried out following the procedures of the American Society for Tests and Materials (ASTM). The biomass was taken to the greenhouse, remaining for 12h at 105 °C to determine the humidity [17]. Then, this material was kept for 3 hours at a temperature of 600 °C to determine the ash content [18]. The volatile matter was measured with the aid of the muffle at $800 \pm 10$ ºC for 7 min, based on a dry sample of 1.0 g [19]. Through the difference between the ash content and volatile matter, the percentage of FC was determined.

#### 2.4.2 Elementary analysis

The elementary analyzer (vario macro Cube - Hanau, Germany) was used to determine the elementary compositions (C, H, N and O). The Oxygen (O) content was obtained according to ASTM-D3176-15 [20].

#### 2.4.3 Superior Heat Power (HHV)

To estimate the HHV content, the content of carbon (C), nitrogen (N), hydrogen (H), sulfur (E), oxygen (O) and ash (A) was previously measured. The determination of HHV values followed the standard of ASTM-D3176-15 [20] according to equation 3.

$$HHV\left(\frac{kj}{g}\right) = 0.3491 * C + 1.1783 * H + 0.1005 * S - 0.1034 * O - 0.0151 * N - 0.0211 * A \ (3)$$

#### 2.4.4 Surface Area Brunauer, Emmett and Teller - BET

The biochar samples (0.5 g) were taken to the Surface Area System and Porosimetry equipment (ASAP 2010 micro-merit model) to establish the N$_2$-BET surface

area and the pore size arrangement. The diameter range used as standard was 0.35 to 300 nm for the pores and 0.01 to 3,000 m²/g in the surface area range, the treatment temperature was 30 to 350 °C.

### 2.4.5    Infrared Spectroscopy (FTIR)

Changes in functional groups were identified through FTIR analysis. Using a single beam Agilent Technologies spectrometer (Cary 630 FTIR), the samples were analyzed using a range from 500 to 4000 cm $^{-1}$ with 0.5 nm increments. The samples were made in triplicates and the medium spectrum was used.

### 2.4.6    Determination of pH

The pH of raw biomass and biochars was determined with a pH meter (TECNAL, model 3MP, according to the NREL/TP-433-7965 method) [21] 1:20 (w/w) distilled water was added to the samples in order to form a homogeneous suspension and after 1.5 h the pH was determined.

## 2.5  Bio-oil Analysis

### 2.5.1    Determination of Bio-Oil Density

The bio-oil density was analyzed using a 10 mL glass pycnometer in a thermostatic bath at 20 °C.

### 2.5.2    Determination of Bio-Oil pH

For pH determination, 10 mL of bio-oil was inserted into the digital pH meter (TECNAL, Model 3MP).

### 2.5.3    Analysis by Gas Chromatography Mass Spectrometry (GC-MS)

With the aid of GC-MS QP2010 Plus equipment equipped with a capillary column Rtx-5MS WCOT (30 m × 0.25 mm x 0.25 μm), the organic and aqueous bio-oil fraction were separated. For the chromatographic separation, the planning for the use of temperatures was followed: for 1 min (isothermal), raised to 7 ℃ min$^{-1}$ at 100 ℃ and then at 4 ℃ min$^{-1}$ at 320 ℃ followed by 10 min at 320 ℃. The carrier gas used was helium at 1.90 mL/min. To obtain the mass spectra, the IEI mode (with ionization energy of 70 eV) was used.

## III.    RESULTS AND DISCUSSION

## 3.1  Physico – chemical characterization of pequi biomass

A previous study by the authors shows the results of the chemical analysis (Table 1) of the pequi (Caryocar brasiliensis Camb.) [22] residues, and were used as the basis for this work.

*Table 1. Chemical analysis of the raw dry biomass*

| Component | Concentration ± SD/ (%) |
|---|---|
| AIL | 20.44 ± 0.30 |
| ASL | 5.48 ± 0.40 |
| TL | 25.71 ± 0.75 |
| Humidity | 7.00 ± 0.20 |
| Ashes | 2.82 ± 0.20 |
| CF | 25.27 ± 0.80 |
| Cellulose | 36.3 ± 0.08 |
| Hemicellulose | 5.35 ± 0.06 |
| Extractives | 34.47 ± 0.08 |

SD: standard deviation; AIL: acid insoluble lignin; ASL: acid soluble lignin; TL: total lignin; CF: fixed carbon.

Source: Scapin et al [22].

When charcoal is to be produced, the ratio of lignin, extracts and hemicellulose is inversely proportional. Lignin and Extractives are important in the conversion of biomass to coal, as high levels of these substances affect thermal stability and a higher value of energy released in the combustion process, thus contributing to better quality of coal [23]. The results of the total value of lignin (25.71%) and extractives (34.475) in this study are satisfactory. High rates of hemicellulose are undesirable to produce charcoal, as it causes greater thermal instability [24]. In this study, a low hemicellulose value of 5.35% was obtained.

### 3.2  Phrolysis

The yield of the pyrolysis process ranges from 30 to 70% for bio-oil and 15 to 50% for solid coal and depends on the type of reactor, the raw material and the operating conditions. Under the conditions of this study (30 minutes at 500 °C) the bio-oil yield is 20 to 40% and the biochar from 25 to 50% [25].

In this study, the pyrolysis process presented a yield of 30.5% bio-oil, of 34% biochar (Figure 1). The yield of bio-oil and biochar resulting from pyrolysis are related to fraction size, temperature and time [26]. When characterizing the seed pyrolysis products of pequi Miranda et al., [27], they obtained 40% charcoal and 43% bio-oil. The authors point out that the good results of bioproducts come from the degradation of lignin and extracts and emphasize that biomass is promising for the generation of heat and energy in the industry.
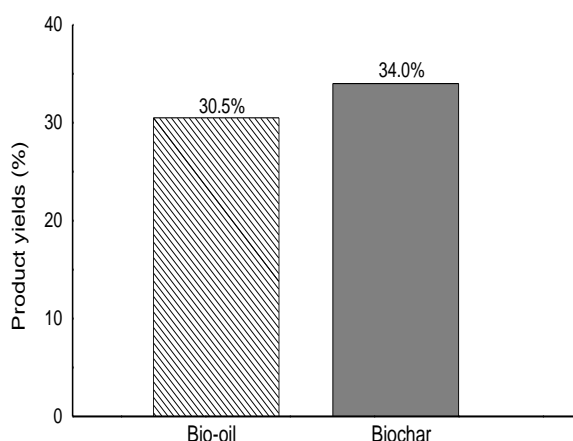
*Fig 1: Yields of pyrolysis products*

In the work developed by Bridgwater et al., [28] highlighted that the average biochar yield of slow pyrolysis residues varies from 30 to 35% in relation to the initial biomass, values close to those found in this study. The bio-oil yields presented in our research are compatible with the study by Lazzari et al.,[7] for coconut fiber (33%) and rice husk (30%). Silva [23] using pequi peel obtained a yield of 32.61% for biochar, Borba et al., [29] when studying the use of pequi peel biochar for glyphosate removal, identified a yield of 33.1%.

Maximizing the yields of biomass pyrolysis coal can be achieved with appropriate technology and operating conditions. Charcoal, with carbon content in the range of 80 to 90% and yields as high as 35%, can be obtained in a retort reactor. Even higher yields can be achieved by increasing the pressure of the carbonization process [30].

In their kinetic study Foong et al.,[25] highlighted in their study that, based on the calculation of the compound annual growth rate (CAGR) of 13.3% (2016-2024), the authors projected that the global demand for activated biochar by 2024, will be 5.1 million ton.

## 3.3 Biochar

The characteristics of the biochars (crude and activated) from the peel of the pequi are shown in Table 2. In this study, the potential use of biochars for use in agriculture and their properties were analyzed based on the revisions of the standards of the International Biochar Initiative - *IBI* (version 2.1) and European Biochar Certificate (EBC).

*Table 2. Approximate analysis, elemental, pH, and caloric value of the biochar*

| Analyze (%) | Activated Biochar | Raw Biochar |
|---|---|---|
| Humidity | $6.24 \pm 0.001$ | $5.4 \pm 0.001$ |
| Ashes | $9.01 \pm 0.001$ | $1.27 \pm 0.001$ |
| MV | $46.66 \pm 1.34$ | $59.07 \pm 0.430$ |
| FC | $38.09 \pm 0.001$ | $34.26 \pm 0.001$ |
| pH | $4.7 \pm 0.001$ | $9.5 \pm 0.001$ |
| C | $78.74 \pm 0.226$ | $71.57 \pm 0.053$ |
| H | $2.63 \pm 0.1284$ | $3.6 \pm 0.009$ |
| N | $1.66 \pm 0.0298$ | $1.49 \pm 0.002$ |
| O | $7.72 \pm 0.0194$ | $22.03 \pm 0.054$ |
| S | $0.25 \pm 0.668$ | $0.18 \pm 0.010$ |
| HHV (kJ. $g^{-1}$) | $29.59 \pm 0.045$ | $26.92 \pm 0.033$ |

VM: Volatile materials; FC: Fixed carbon; pH: Hydrogenionic potential; C: Carbon; H: Hydrogen; N: Nitrogen; O: Oxygen; S: Sulfur; HHV: Calorific Power.

According to *IBI* standards, the gross biochar produced is class 1, with organic carbon contents ($C_{org}$) > 60% falling into category "A". The carbon content may gradually increase due to the release of organic substances rich in hydrogen and oxygen during the pyrolysis and activation stages, but Costa et al., [16] found the opposite, after the process of activating the nut shell biochar with $ZnCl_2$, the carbon content decreases from 79.6% (biochar) to 78.4% in activated carbon. The activation of the pequi peel coal increased the carbon content, from 71.57% (raw coal) to 78.74% (activated carbon).

High carbon content contributes to better efficiency in energy conversion and gasification, due to the greater release of heat per unit mass of biomass [27]. Agbor et al. [30], in their review of biomass burning, highlight that biomass fuels have less carbon and nitrogen and more hydrogen and oxygen compared to fossil fuels. This relationship shows that biomass is less dense than fossil derivatives, however the results of the present study highlight the opposite, as the values of C (78.74%) and N (1.66%) are higher than H (2, 66%) and O (7.72%), demonstrating the potential of using the pequi peel biochar as an energy source.

After the activation process, it was observed that the ash and moisture contents also increased, in comparison to the raw biochar (Table 2). Regarding raw biomass (Table 1) reported by Scapin et al., [22] these

levels are close, except for the ash content of activated carbon, which reached 9%.

The moisture content of the biochar must be low (3 to 10%) in order not to affect the potential for adsorption of activated carbon and to enable its commercial use, in addition high humidity values compromise the costs of transportation, drying, storage and handling of biomass [31-32]. Both moisture content in raw coal (5.4%) and activated carbon (6.24%) are within this range.

As well as humidity, the ash content cannot be high either, since high ash contents interfere with the yield of pyrolysis products, decreasing the liquid organic fractions and increasing the gas fractions. In his report on the raw biochar of the pequi Silva [23], found 5.19% for ash content, while Khuenkaeo & Tippayawong [34] found different values of ash for the raw coals, 1.66% for the coconut husk biochar and 7.22% for bamboo residue.

The pH values changed after the activation process. The raw biochar has a basic nature (9.5) and the activated biochar has a slightly acidic nature (4.7). Abreu et al., [35] obtained similar pH values for activated charcoal from sugarcane bagasse (4.62). Coals of an acidic nature have the potential to adsorb protons. This characteristic is relevant for use in the soil, as it increases the capacity of retaining nutrients and water in the soil due to the high capacity of cation exchange and surface area.

In short, Silva [23] highlights in his research that the pequi peel biochar has characteristics that promote beneficial changes in soil acidity, raising the pH, and reducing exchangeable aluminum, making it possible to use it as a soil corrector.

The calorific value of the biochar increased after activation, (>29 kJ.g$^{-1}$) demonstrating the potential of using pequi activated carbon as solid fuels. The calorific power of biochars (raw and activated) is greater than that of biomass in natura (Table 1), this is due to the presence of recalcitrant aromatic compounds that store more energy, due to the pyrolysis process [23-27]. In their research with the pequi core Miranda et al.,[27] obtained calorific value close to 25 kJ.g$^{-1}$. The low moisture content of the pequi peel contributes to the calorific value of the coals, favoring their energy use [38].

According to data from IBGE [3], 21,495t of pequi fruit were produced, 70% of the fruit corresponds to the skin, thus generating 15t of waste. With the biochar calorific value (29.59 kJ.g$^{-1}$), we obtain a potential of 443.85 t/kJ.g $^{-1}$ annually. Thus, the biochar of the pequi peel has great potential for energy production, in addition to the correct destination of the waste, it prevents the spread of diseases, odor and soil contamination due to improper destination [23].

The biochar of the pequi sample did not show satisfactory values of surface area (BET and Langmuir) and micropore size (Table 3) when compared with activated carbon from other biomasses. According to the guidelines for the certification of the biochar (European Biochar Certificate version 4.8), the minimum specific surface area required is >150 m$^2$/g [39]. In the present study, the minimum value required by the standard was not reached. Therefore, the activating agent $ZnCl_2$, was not efficient to increase the values of surface area and microporous size.

*Table 3. BET, Surface area Langmuir and micropores the size of activated carbon from the peel of the pequi.*

|  | BET area Surface (m²/g) | Surface area Langmuir (m² / g) | Micropores of size (cm³ / g) | Authors |
|---|---|---|---|---|
| Activated Biochar | 30.3002 ± 0.3038 | 39.1146 ± 0.3639 | 0.023127 | Authors, 2020. |
| Activated Biochar Comercial | 597.33 | - | 0.22 | Linhares et al., 2016. |

After chemical activation of the pequi core biochar with potassium carbonate, Dias [41] found values of 54.03 (m²/g) for BET surface area and 0.045 cm³/g for pore volume and, just as the results found in this research, these values were also low.

## 3.4 FT – spectroscopy

FT-IR analysis (Figure 2) shows the spectrum of pequi biomass and biochars; indicating possible chemical transformations of the structure after pyrolysis and activation of the biochar.

Intense bands for the biochars produced were identified in regions between 3800 - 2700 cm$^{-1}$ are related

to the OH stretching vibration, possibly pointing to the existence of alcohols, phenols and organic acids [55].

Aldehyde and aliphatic compounds are identified in the raw biomass due to the elongation of CH, $CH_2$ and $CH_3$ in the bands between 3000 and 2800 $cm^{-1}$ [41].

The presence of C=O (esters, organic acids and aldehydes) were attributed to the peaks of 1710 and 1720 $cm^{-1}$ and the heteroaromatic compounds (CO) are in the bands between 1100 to 1200 $cm^{-1}$ [41].

The bands close to 940 $cm^{-1}$, are attributed to the COC stretching in cellulose, these bands are sensitive to the amount of crystalline and amorphous cellulose [42]. The presence of phenolic peaks ($RCH=CH_2$ and aromatic rings) was mainly attributed to lignin and undegraded cellulose during pyrolysis, clearly demonstrating the phenolic nature of charcoal for all spectra, showing that their structures resisted and remain after the processes [55].
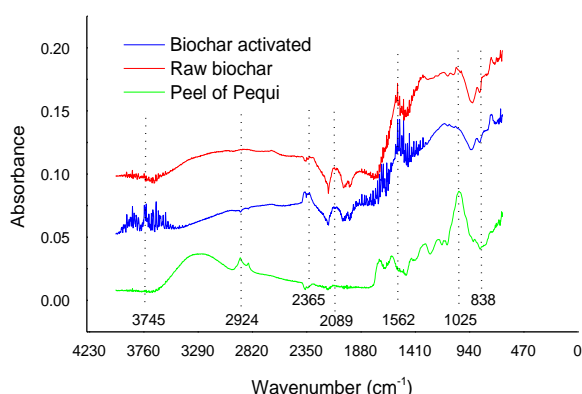


*Fig.2: FTIR analysis of pequi biomass and biochars.*

## 3.5 Bio-oil

Bio-oil consists of numerous compounds, among which acids, furans, phenols, alcohols, hydrocarbons, ketones, aldehydes and esters are highlighted. The recovery and use of bio-oil demonstrate the efficiency of the energy conversion of pequi peels [15].

In their survey on the chemical and physical characteristics of pequi, Oliveira et al., [43] reported that factors such as soil, water availability, fruit size and distance between trees interfere with the quality and quantity extracted from bio-oil, as well as its structural and operational variables.

The main compounds identified in the bio-oil (>1%) are described in Table 4. Among the main components of the bio-oils found in the pequi biomass are acids, aldehydes, phenols and hydrocarbons as shown in Figure 3.

These compounds were also the main products observed in other studies [41-45].

The vaccenic acid (21.23%), found in a percentage higher than the others recovered bio-oil, a fatty acid is used in fast food industries [44]. Another compound found in large quantities was palmitic acid or hexadecanoic acid (19.73%), very common as a dietary supplement and fortifying agent in dairy products [45].

Phenolic and aldehyde compounds from bio-oil can be used as meat browning and flavoring agents [47]. Within the bio-oil components of the pequi peel, we obtained 13.4% aldehydes and 12.7% phenols.

Tsai et al., [48] studied the coconut oil fiber bio-oil, the compounds found mostly were: 1,2-benzenediol (8.6%), phenol (7.8%), acetic acid (3.6 %), 2,6-dimethoxyphenol (2.8%) and 3-methyl-1,2 benzenediol (2.7%).

When researching the production of bio-oil from rice husk and straw, bamboo, cane bagasse and neem husks, Gautam and Chaurasia [49], highlighted that the presence of CH, C=C, alcohols and phenolic compounds in the bio-oil obtained from all biomass species leads to the possibility of being used as fuel.

The composition of bio-oil is influenced by the raw material and temperature. According to Lyu et al., [51] high temperatures lead to the formation of aldehydes and acids, decreasing phenols. As shown in Figure 3, we can observe this behavior, higher values were obtained for acid (50.7%) and aldehyde (13.74%) and less for phenol (12.7%), hydrocarbon (7.44%) and alkane (1.51%).
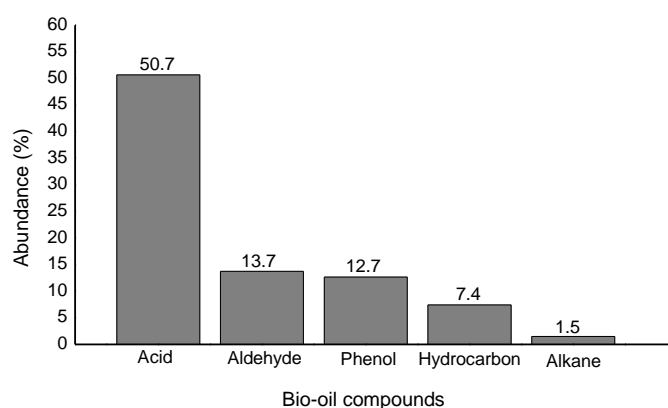


*Fig.3: Chemical composition of bio-oils from pequi peel.*

Bio-oils were also evaluated for their acid/alkaline nature. The recorded pH value is considered acid. The pH of the bio-oil obtained from the lignocellulosic biomass generally varies between 2 and 3 (acid), usually due to the presence of carboxylic acids.[41] The density of the bio-oil obtained was 1.09 $g/cm^3$, and is related to the water content

present in the liquid. Mohan et al.,[51] when reviewing biomass pyrolysis, highlight the density value of woody biomass bio-oil (1.2 g/cm³), whereas Santos et al., [56] obtained 1.05 g/cm³ of density for sugar cane straw. The density of fossil oil is 0.75-1.0 g/cm³, so the average density value of bio-oil becomes potential to replace fossil oils, employing some processes to bring the density even closer so that can be used on a commercial scale [52].

## IV. CONCLUSION

The yields of biochar (34%) and bio-oil (30.5%) are satisfactory and were obtained through pyrolysis, making it a good method for treating the pequi's raw waste. Biochars (Raw and Activated) can potentially be used as solid fuel in industries due to their high calorific value and carbohydrate content, associated with low moisture and ash content. Activated biochar, on the other hand, showed potential to be used in agriculture as a fertilizer, due to low pH values associated with significant amounts of nitrogen.

The chemical compounds of high added value present in bio-oil can be used in several areas of the industry, including vaccenic acid, palmitic acid and furfural acid, highlighting the value of the biomass that would be discarded.

## REFERENCES

[1] Melo, S. M. C. de., Aguiar, E. P. S., Erig, G. A. (2017). Percepções do Consumo do pequi em Palmas (TO): entre o contentamento e a indiferença. Caderno Virtual de Turismo, 7, 17 (1), 73-87. DOI: 10.18472/cvt.17n1.2017.1077.

[2] BRASIL. Ministério do Meio Ambiente. O Bioma Cerrado (2019). Disponível em: http://www.mma.gov.br/biomas/cerrado. Acessado em dezembro de 2019.

[3] Instituto Brasileiro de Geografia e Estatística – IBGE. Produção da Extração Vegetal e da Silvicultura. (2018). Disponível em: https://sidra.ibge.gov.br/tabela/289#resultado. Acessado em dezembro de 2019.

[4] Soares, J. S. M., Reis, R. C dos., Bassinello, P. Z.; Lacerda, D. B. C., Koakuzu, S. N., Caliari, M. (2009). Qualidade de biscoitos formulados com diferentes teores de farinha de casca de pequi. Pesquisa Agropecuária Tropical, Goiânia/GO. 2009, 39 (2), 98-104.

[5] Santos, F.S., Santos, R.F.; Dias, P.P., Zanão, J. L.A.; Tomassoni, F. (2013). A cultura do pequi (*Caryocar brasiliense* Camb.). Acta Iguazu, Cascavel, 2 (3), 46- 57.

[6] Qian, K., Kumar, A., Zhang, H., Bellmer, D., Huhnke, R. (2015). Recent advances in utilization of biochar. Renewable and Sustainable Energy Reviews, 42, 1055-1064. DOI: https://doi.org/10.1016/j.rser.2014.10.074.

[7] Lazzari, E., Schena, T., Marcelo, M. C. A., Primaz, C. T., Silva, A. N., Ferrão, M. F., Caramão, E. B. (2018). Classification of biomass through their pyrolytic bio-oil composition using FTIR and PCA analysis. Industrial crops and products, 111, 856-864. DOI: https://doi.org/10.1016/j.indcrop.2017.11.005.

[8] Pires, A., Han, Y., Kramlich, J., Garcia-Perez, M. (2018). Chemical composition and fuel properties of alternative jet fuels. BioResearch. 13, 2632- 2657.

[9] Kumar, R., Strezov, V., Kan, T., Weldekidan, H., He, J. (2018). Investigating the effect of Cu / zeolite on desoxigenation of bio-oil from pyrolysis of pine wood. Energia Procedia, 160, 186–193. DOI: 10.1016 / j.egypro.2019.02.135.

[10] Oni, A.B., Oziegbe, O., Olawole, O.O. (2020). Significance of biochar application to the environment and economy. Annals of Agricultural Sciences, 64 (1), 1-15. DOI: https://doi.org/10.1016/j.aoas.2019.12.006.

[11] Awad, Y. M., Lee, S.S., Kim, K-G., Ok, Y.S., KUZYAKOV, Y. (2018). Carbon and nitrogen mineralization and enzyme activities in soil aggregate-size classes: Effects of biochar, oyster shells, and polymers. Chemosphere, 198, 40-48. DOI:https://doi.org/10.1016/j.chemosphere.2018.01.034.

[12] Li, H., Li, Y., Xu, Y., Lu, X. (2020). Biochar phosphorus fertilizer effects on soil phosphorus availability. Chemosphere, 244, 125-471, DOI: https://doi.org/10.1016/j.chemosphere.2019.125471.

[13] Sun, X., Atiyeh H. K., Li, M., Chen, Y. (2020) Biochar facilitated bioprocessing and biorefinery for productions of biofuel and chemicals: A review. Bioresource Technology, 295, 122-252, DOI:https://doi.org/10.1016/j.biortech.2019.122252.

[14] Yu, H., Zou, W., Chen, J., Chen, H., Yu, Z., Huang, J., Tang, H., Wei, X., Gao, B. (2019) Biochar amendment improves crop production in problem soils: A review. Journal of Environmental Management, 232. 8-21. DOI: 10.1016/j.jenvman.2018.10.117.

[15] Rambo, M.K.D. (2012) Caracterização dos produtos de pirolíse de resíduos após a hidrolise ácida de Miscanthus. Tecnologia de biorecursos, 108, 258-263.

[16] Costa, P. D. de.; Furmanski, L. M.; Dominguini, L. (2015). Produção, Caracterização e Aplicação de Carvão Ativado de Casca de Nozes para Adsorção de Azul de Metileno. Rev. Virtual Quim, 7 (4), 1272-1285.

[17] American Society for Testing and Materials – ASTM International. ASTM D 3173-87. Standard method for determination of moisture content in biomass; 2003.

[18] American Society for Testing and Materials – ASTM International. ASTM D 3174-04. Standard method for ash in the analysis sample of coal and coke; 2004.

[19] American Society for Testing and Materials – ASTM International. ASTM D 3175-07. Standard method for volatile matter in the analysis sample of coal; 2007.

[20] American Society for Testing and Materials – ASTM International. ASTM-D3176-15.

[21] NREL/TP-433-7965: Um atlas de dados térmicos para biomassa e outros combustíveis. Laboratório Nacional de Energias Renováveis, 1995.

[22] Scapin, E., Rambo, M. K. D., Viana, G. C. C., Borges, M. S., Rambo, M. C. D., Santana Junior, C. C. (2020). Production of Furanic Compounds and Organic Acids from Brazilian pequi (*Caryocar brasiliensis* Camb.) Residues Using Green Chemistry. J. Braz. Chem. Soc. 2020, *00, (00), 1-9.* DOI: http://dx.doi.org/10.21577/0103-5053.20200023.

[23] Silva, M. S. A. Biochar de casca de pequi como condicionador de solo no desempenho agronômico de feijoeiro. Dissertação (Mestrado) - Área de Concentração em Produção Vegetal, Universidade Federal de Minas Gerais, 2017.

[24] Vital, B. R., Jesus, R. M., Valente, O. F. Efeito da constituição química e da densidade da madeira de Eucalyptus grandis na produção de carvão vegetal. Revista Árvore. 1986, *10, 2, 151-160.*

[25] Foong, S. Y., Liew, R. K., Yang, Y., Cheng, Y. W., Yek, P. N. Y., Mahari, W. A. W., ... & Aghbashlo, M. (2020). Valorization of biomass waste to engineered activated biochar by microwave pyrolysis: Progress, challenges, and future directions. *Chemical Engineering Journal*, *389*,124401.DOI:https://doi.org/10.1016/j.cej.2020.124401.

[26] Kan, T., Strezov, V., & Evans, T. J. (2016). Lignocellulosic biomass pyrolysis: A review of product properties and effects of pyrolysis parameters. Renewable and Sustainable Energy Reviews, 5?,1126-1140.DOI: https://doi.org/10.1016/j.rser.2015.12.185.

[27] Miranda, M. R. S da., Veras C.A.G., Ghesti, G.F. (2020). Charcoal production from waste pequi seeds for heat and power generation. Waste Management, 103, 177-186. DOI: https://doi.org/10.1016/j.wasman.2019.12.025.

[28] Bridgwater, A.V. (2012). Review of fast pyrolysis of biomass and product upgrading. Biomass and Bioenergy, *38, 68-94.* DOI: https://doi.org/10.1016/j.biombioe.2011.01.048

[29] Borba, L.L.L., Cuba, R.M.F.C., Terán, F.J.C., Castro, M. N., Mendes, T.A. (2019). Uso de biochar adsorvente de cascas de pequi (Caryocar Brasiliense para remoção de formulações comerciais de glifosato de meios aquosos. Arquivos Brasileiros de Biologia e Tecnologia, 2019, *62*. DOI: https://doi.org/10.1590/1678-4324-2019180450.

[30] Garcia-Nunez, JA, Pelaez-Samaniego, MR, Garcia-Perez, ME, Fonts, I., Abrego, J., Westerhof, RJM, & Garcia-Perez, M. (2017). Evolução histórica dos reatores de pirólise: uma revisão. *Energia e combustíveis* , *31* (6), 5751-5775. DOI: https://doi.org/10.1021/acs.energyfuels.7b00641.

[31] Agbor, E., Zhan, X., Kumar, A. (2014). Uma revisão da queima de biomassa na América do Norte. Renewable & Sustainable Energy Reviews, v. 40, p. 930-943. DOI: http://dx.doi.org/10.1016/j.rser.2014.07.195.

[32] RC Bansal, J.-B. Donnet, F. Stoeckli. (1988). Carbono ativo. Marcel Dekker Inc., Nova York e Basileia.

[33] Boateng, A. A., Mullen, C. A., Goldberg, N. M., Hicks, K. B., Devine, T. E., Lima, I. M., & McMurtrey, A. J. E. (2010). Sustainable production of bioenergy and biochar from the straw of high-biomass soybean lines via fast pyrolysis. Environmental Progress & Sustainable Energy, 29 (2), 175-183.DOI: https://doi.org/10.1002/ep.10446.

[34] Khuenkaeo, N., Tippayawong, N. (2020). Chemical Engineering Communications. Production and characterization of bio-oil and biochar from ablative pyrolysis of lignocellulosic biomass residues, *207: 2, 153-160.* DOI: 10.1080 / 00986445.2019.1574769.

[35] Abreu, M., De Andrade, J., Turbiani, F., Gimenes, M., Machado, N. Seixas, F. (2015). Aplicação de carvão ativado de bagaço de cana-de-açúcar na adsorção de Cd (II) e Cu (II), *1318-1327*. DOI: 10.5151/ENEMP2015-PS-749.

[36] Yunus, Z. M., Yashni, G., Al Gheethi, A., Othman, N., & Hamdan, R. (2020). Advanced methods for activated carbon from agriculture wastes; a comprehensive review. International journal of environmental analytical chemistry, *100,2-20.*DOI: https://doi.org/10.1080/03067319.2020.1717477.

[37] El-Naggar, A., El-Naggar, A. H., Shaheen, S. M., Sarkar, B., Chang, S. X., Tsang, D. C., . & Ok, Y. S. (2019). Biochar composition-dependent impacts on soil nutrient release, carbon mineralization, and potential environmental risk: a review. Journal of environmental management, 241, 458-467. DOI: 10.1016/j.jenvman.2019.02.044.

[38] Soares, M., Reis, R. C., Bassinello, P. Z., Lacerda, D. B. C., Koakuzu, S. N., Caliari, M. (2009). Qualidade de biscoitos formulados com diferentes teores de farinha de casca de pequi. Pesquisa Agropecuária Tropical, Goiânia/GO, *39 (2), 98-104*.

[39] Müzel, S.D., De Oliveira, K. A., Hansted, F.A.S., Prates, G.A., Goveia, D. (2014). Poder calorífico da madeira de Eucalyptus grandis e da Hevea brasiliensis. Brazilian Journal of Biosystems Engineering, *8 (2), 166 – 172*.

[40] European Biochar Certificate (EBC). Comparison of European Biochar Certificate Version 4. 8 and IBI Biochar Standards Version 2.0. EBC foundation, 2012.

[41] Dias, P. D. S. Caracterização dos carvões ativados obtidos a partir da casca do cupuaçu e do caroço do pequi e avaliação do processo de adsorção de azul de metileno em meio aquoso. Dissertação–Mestrado, Programa de Pós-Graduação em Ciências Ambientais da Universidade Estadual do Sudoeste da Bahia–UESB*;* 2013.

[42] Dai, L., Wang, Y., Yuhuan, L., Roger, R. (2019). Comparative study on characteristics of the bio-oil from microwave-assisted pyrolysis of lignocellulose and

triacylglycerol. Science of the total Environmet, *25, 235-253.* DOI: https://doi.org/10.1016/j.scitotenv.2018.12.241.

[43] Khan, A. S., Man, Z., Bustam, M. A., Nasrullah, A., Ullah, Z., Sarwono, A., Muhammad, N. (2018). Efficient conversion of lignocellulosic biomass to levulinic acid using acidic ionic liquids. Carbohydrate Polymers, *181, 208–214.* DOI: doi:10.1016/j.carbpol.2017.10.064

[44] MEB Oliveira, NB Guerra, AHN Maia RE Alves, NM Santos, FGM Sampaio, MMT Lopes. Características químicas e físicas de pequis da Chapada do Araripe – CE. Rev. Bras. Fruticult. 2010, *32, 114 -125.*

[45] Xiu S, Shahbazi A. Bio-oil production and upgrading research: a review. Renewable Sustainable Energy Reviews. 2012, *16, 4406–4414.* DOI: https://doi.org/10.1016/j.rser.2012.04.028

[46] Elias, S. L., Innis, S. M. (2002). Bakery foods are the major dietary source of transfatty acids among pregmant women with diets providing 30 percent energy from fat. Journal of the American Dietetic Association, *102,46-56.* DOI: https://doi.org/10.1016/S0002-8223(02)90015-5

[47] Batista, E. S. Costa, A. G. Pinheiro, H. M. S. (2007). Adição da vitamina E aos alimentos: implicações para os alimentos e para a saúde humana. Revista de Nutrição, *20, 525-535.* DOI:https://doi.org/10.1590/S1415-52732007000500008

[48] Czernik S. A. (2004). BridgwaterResumo das aplicações do óleo de pirólise rápida de biomassa. Energia Combustíveis, *18, 590-598.*

[49] Tsai, W. T., Lee, M. K., Chang, Y. M., J. (2006). Anal. Appl. Pyrol, *76, 230-237.*

[50] Gautam, N., & Chaurasia, A. (2020). Study on kinetics and bio-oil production from rice husk, rice straw, bamboo, sugarcane bagasse and neem bark in a fixed-bed pyrolysis process. *Energy*, *190*, 116-434.

[51] Lyu G, Wu S, Zhang H. (2015). Estimativa e comparação de componentes de bio-óleo de diferentes condições de pirólise Frente Energia Res, *3 (28).*

[52] D. Mohan, Charles U. Pittman, PH Steele. (2006). Pirólise de madeira / biomassa para bio-óleo. Uma revisão crítica. Energia Combustíveis, *20 (3), 848 – 889.*

[53] Mostafazadeh, A. K., Solomatnikova, O., Drogui, P., & Tyagi, R. D. (2018). A review of recent research and developments in fast pyrolysis and bio-oil upgrading. *Biomass Conversion and Biorefinery*, *8*(3), 739-773.

[54] Heidari, A., Khaki, E., Younesi, H., & Lu, HR. (20190. Avaliação de métodos de pirólise rápida e lenta para produção de bio-óleo e carvão ativado a partir de resíduos de eucalipto, utilizando uma abordagem de avaliação do ciclo de vida. Journal of Cleaner Production, 241, 118-394.

[55] Li, S.; Chen, G. (2018). Caracterização espectral termogravimétrica, termoquímica e infravermelha de matérias-primas e biochar derivadas em diferentes temperaturas de pirólise. Gestão de Resíduos*, 78, 198-207.* DOI: 10.1016 / j.wasman.2018.05.048.

[56] Santos, N. A. V., Vieira, S. S., Mendonça, F. G., Napolitano, M. N., Nunes, D. M., Ferreira, R. A. R.; Soares, R. R., Magriotis, Z. M., Araujo, M. H.; Lago, R. M.(2017).

Rejeitos de Biomassas Oriundas da Cadeia de Biocombustíveis no Brasil: Produção de Bio-óleo e Sub-produtos. Rev. Virtual Quim, *9 (1), 52-72.* DOI: 10.21577/1984-6835.20170007.

# Non-Technical Losses in Light's Concession Area

Lucas Merenfeld[1], Vanessa Huback[2], Gabriel Hidd[3], Pedro Vardiero[4], Antônio Pedro da Costa e Silva Lima[5]

[1,2,4,5]Federal University of Rio de Janeiro (UFRJ), Brazil
[3]Agerio, State Development Agency of Rio de Janeiro, Brazil

*Abstract*— *One of the critical problems that electricity distribution companies come across are non-technical losses, also known as commercial losses. These losses impact the economic and financial balances of the electricity distributors, limiting their ability to make further investments. In the state of Rio de Janeiro, the major non-technical losses take place in urban informal settlements (slums). They emerged in the city's hills as a response to hygiene policy in the early twentieth century. Throughout time, they expanded to peripheral zones and many are dominated by criminal groups, which are responsible for limiting the operation and supervision of electricity distribution companies, preventing adequate actions against non-technical losses. In this sense, the concession area of Light, a private utility located in Rio de Janeiro, has different geographic and socioeconomic characteristics. This paper aims to analyze the non-technical losses in Light's concession area, based on social aspects considered relevant by the international literature and Rio de Janeiro's social specificities.*

*Keywords*— *Non-technical losses; Theft of Electricity; Socioeconomic Aspects.*

## I. INTRODUCTION

The electricity sector can be divided into three different segments: generation, transmission and distribution. The generation units produce energy that the transmission companies carry from generation units to consumer centers. From there, distribution systems deliver electricity to their consumers. The main characteristic of the electric power sector is a substantial temporal and spatial interdependence among its components, since electricity is a non-storable product.

Considering its economic characteristics, power distribution constitutes a natural monopoly, operating in each concession area. To avoid the appropriation of extraordinary profits by a monopoly company, the prices charged for the service provided are duly regulated, in order to search for a balance between the interests of companies and consumers. In the case of the distribution segment, the payment received for the services provided is the electricity tariff.

The tariff aims to ensure that the service providers have enough revenue to cover efficient operating costs, compensate the investments made and assure the capital to expand their capacity and ensure quality services. The electricity tariff in Brazil is divided into two parts: Parcel A and Parcel B. The Parcel A involves non manageable costs of the utility, like generation and transmission activities, as well the legal charges (ANEEL, 2007; PWH, 2005). Parcel B represents directly manageable costs of the utility, that are subject to their control or influence, according to management practices adopted by the company. Among the components that form Parcel B, the Operating Costs are those that stand out. These costs are associated to the operation, maintenance, commercial and administrative tasks, including activities such as meter reading and billing errors, inspection of consumer units, pruning of trees, substation operations and actions against energy losses (PWH, 2005).

The electricity losses are divided into two parts: technical losses and non-technical losses (NTL). The former is intrinsically caused by the operation of the power grid and the use of installed equipment; and the latter are largely the result of inaccurate reading, meter issues and energy theft[1] (Navani et al, 2012; Smith, 2004). However, these last two factors predominate in most cases. NTL in electricity distribution can reach 40% of the total energy

---

[1] Clandestine connections in the distribution network.

distributed in certain countries (Coma-Puig; Caromona, 2019; Glauner et al., 2017). The international literature states that these illicit practices are related to the lack of state governance, and that it as a much more urgent topic in developing countries, reaching losses of up to 30% in India, for instance (World Bank, 2009). The informal urban settlements (slums) reflect the state's failure, characterized by the absence of the law and precarious housing conditions for lower income individuals. Therefore, this social problem is not manageable by companies and they have difficulties in operating in these areas.

NTL affect the companies' economic and financial balance and the quality of their service, increase the tariff of regular consumers, hamper network security, encourage waste of energy resources, pressure the expansion of the national electricity sector and may create a vicious cycle if there is not a correct arrangement between electricity distribution companies and the regulator to manage this problem.

This paper will specifically address the issue of NTL in electricity distribution, focusing on a study case of Light, a private Brazilian utility company. Light is located and operates in the city of Rio de Janeiro and in a few areas of the state of Rio de Janeiro in Brazil, a state marked by great social inequalities. As a result of these facts, which are beyond the utility's responsibility, the distributor operates in a very heterogeneous concession area. Furthermore, NTL and socioeconomic complexity are positively correlated: the higher the complexity, the greater the NTL.

It should be noted that most places of high social complexity are attended by militias[2] and criminal factions, responsible for preventing the operations of the company. One relevant fact is that the public safety program put in place by the state government to fight against these groups has affected the utility, impacting how it deals with NTL (Castro et al., 2019).

The present paper is divided into the following sections: the first section is dedicated to the introduction; the second section describes the methodology that was used; the third addresses the losses of electrical energy with a focus on NTL and the treatment of NTL in the Brazilian regulation; the fourth section reviews the international literature to understand the socioeconomic factors related to NTL and develops a specific analysis of the determinants of the state of Rio de Janeiro; the fifth section explores the case of Light, explaining the peculiarities of its concession area, besides presenting the loss indexes and the methodologies adopted to combat this problem; and the conclusion will identify possible scenarios for the reduction of losses in Rio de Janeiro.

## II. METHODOLOGY

NTL are a critical problem for companies in the Brazilian electricity distribution sector. This article aims to conduct a case study on Light, a utility that operates in the state of Rio de Janeiro, to analyze the impact of NTL for the company. The company was selected for this study because, at the national level, Light's problem has gained very serious outlines. In the utility's concession area, tariffs are one the most expensive in Brazil, which present a surplus of 17% due to the cross subsidy derived from NTL. Light has around 11 million consumers in 31 municipalities in the state of Rio de Janeiro, and its concession area holds the national record of NTL: 17% of total energy stolen in Brazil (Light, 2013; Light 2016; Castro et al., 2019).

In several areas of the state of Rio de Janeiro, the utility has difficulties in operating to provide, maintain and charge services, as a result of violence. For this purpose, the research question that guides this paper is to verify if part of the difficulty in combating NTL is associated with specific characteristics of the concession area, regardless of the observable variables related to the socioeconomic complexity of the Brazilian Electricity Regulatory Agency's (ANEEL)[3] complexity model.

In other to achieve this objective, this study crosses data from three sets of information: (i) variables that capture the socioeconomic heterogeneity of the empirical context, obtained through the 2010 Census developed by the Brazilian Institute of Geography and Statistics (IBGE); (ii) variables that locate areas of serious operational restrictions and NTL within Light's concession area, obtained through technical reports and studies developed by the company; and (iii) official indicators of violence, developed by the Institute for Work and Society Studies (IETS) and experts in the field.

## III.   NON-TECHNICAL LOSSES: DEFINITION AND THE IMPORTANCE OF THIS CONCEPT

---

[2] Militia are clandestine paramilitary groups made up of current and former police officers which carry out both vigilante and organized crime activities.

[3] ANEELis a government autarchy linked to the Ministry of Mines and Energy and has the mission of providing favorable conditions for the electricity market to be developed in a balanced environment for the benefit of the whole society

This section presents a definition of electrical power losses, subdividing them into technical losses and NTL. These concepts will be addressed throughout this section, highlighting its impact on electricity distribution companies and the population.

### 3.1 - Global energy losses, technical losses and Non-Technical Losses

The power losses in the distribution segment are defined as the difference between the energy injected into the grid and the amount that was effectively supplied and sold to the consumer. They can be divided into two categories: (i) technical losses and (ii) NTL. The technical losses are intrinsic to the operation of the distributor and are originated by physical factors. They are caused by the dissipation of energy in the components of transport, voltage transformation and measurement systems. On the other hand, NTL, also called commercial losses, arise from energy theft; fraud in supply or the measurement system; lack of meters in consumer units; failure or lack of gauging in the meters and errors in the reading or billing of the consumer units (Penin, 2008). Ahmad (2017) states that NTL may occur due to a series of factors, among which stand out the following aspects: unauthorized line diversion, that is, theft through meter fraud or illegal compliance; unauthorized line interception; lack of quality and inaccurate meter reading; or deficient techniques for poor revenue collection. Therefore, NTL may be caused not only by the inefficiency of the distributors but also by illicit consumer practices.

Technical losses may be minimized with company investment in modern market technologies. The solution for NTL, however, is not so simple, since the social factor is predominant in most cases. Hence, the problem becomes exogenous and unmanageable on many occasions, imposing a great challenge for the distributor's operations, who need to find different means to reduce NTL according to the reality of each concession area. The analysis of the socioeconomic factors involved will be done in more detail in the next section.

### 3.2 The relevance of the theme Non-Technical Losses

NTL causes negative impacts throughout society, entailing losses to the population, distribution companies and the government. The first agents directly impacted by this adversity are electricity distribution companies. It is estimated that, on average, commercial losses generate a reduction of 3% to 5% in revenues for these companies (USAID, 2004). This compromises their economic and financial balance sheets, harming their ability to make new investments and may lead to the bankruptcy of many utilities (Smith, 2004). It should be noted that the most

critical locations are precisely those where companies make a relatively larger investment because of the inadequate existing infrastructure to operate. These areas are still characterized by relatively low consumption, which induces many utilities to expect zero or negative returns for the investments made in these zones (UN Habitat, 2009).

Electricity distribution companies need to determine the amount of energy that should be supplied to regular and irregular consumers. Through this information, distributors will design the network that will be installed in a certain location. However, the energy needed to meet irregular consumers is not easily predicted, since its illegal consumption is often wasteful. Therefore, if planning is not correct, there is a possibility of overloading the network during peak periods, causing blackouts that cut off power supply, damage company's equipment and harm customers. The loss of safety can also jeopardize the lives of those who operate the network illicitly, in addition to the residents themselves, since the wires may release sparks. Thus, NTL directly affect the quality of the services, damaging the relationship between a company and their customers (Depuru, Wang and Devabhaktuni, 2011).

NTL are also responsible for increasing tariffs for regular consumers in order to help with the recovery of distributors revenues. This creates a kind of cross subsidy, as some customers may end up paying for energy consumed by others (Depuru, Wang and Devabhaktuni, 2011). In Brazil, in 2018, in terms of the percentage of the total energy injected into the grid, losses corresponded to 14%, with technical losses corresponding to 7.5% and NTL representing 6.5% of the total amount (ANEEL, 2019). ANEEL recognizes and authorizers the transfer of part of the NTL to energy tariffs to guarantee the financial operability of the distributors. In addition, NTL pressures costs of the national electricity system, since they increase the need to generate energy to compensate wasted resources and investments to fight against this problem.

The concern about NTL is even more relevant if we consider the possibility of introducing a vicious cycle in the system. Regarding tariffs, the recognition of higher levels of losses, maintenance costs and/or efficient investments required to fight this problem may affect the payment capacity of low-income consumers and may lead them to incur into irregular practices. This may lead to a new tariff increase, triggering a new cycle (Araújo, 2007; Tasdoven, Fiedler and Garayev, 2012). In this sense, the regulator needs to be aware of these aspects to avoid cyclical effect. NTL also generates loss of revenue for the government, due to the taxes that are not collected through electricity consumption.

### 3.3 The treatment of Non-Technical Losses in the Brazilian regulation context

Power losses were always present in the electricity tariff in Brazil. The first tariff review cycle (2003-2006) defined the reduction targets based on the historical averages of each company (ANEEL, 2010). The second cycle (2007-2010), in turn, brought regulatory innovations that radically changed the calculation of limits, such as starting to consider the recent history of each company and the most efficient levels of losses attained by distributors in places of great or equal social complexity. They were considered as a benchmark by the regulator; that is, the reference for achieved losses. ANEEL compared the social complexity of the concession areas through an index, formulated with an econometric data panel model with random effects. There is a relation between this rule and the traditional "Yardstick Competition" principle, widely used to stimulate efficiency in natural monopoly activities (ANEEL, 2006; ANEEL, 2008).

The third tariff review cycle (2011-2014) maintained the main guidelines of the second cycle, but improved some aspects, among which two will be highlighted. The variables used in the econometric model were violence, inequality, precariousness (an expansion of the concept of informality) and infrastructure. The other main change was in relation to the speed of loss reduction. In the previous cycle, the agency stipulated that companies should achieve their benchmark in a single cycle, but this disregarded differences between the concession areas and consequently their different capabilities. Thus, ANEEL began to consider different reduction rates between companies (ANEEL, 2010).

The fourth tariff review cycle, initiated in 2015, improves the methodology built in the previous two cycles, implementing two significant changes. The first concerns the construction of three econometric models to calculate three different indexes of socioeconomic complexity. The second is related to the fact that the agency relaxed the starting point limits for three cases: a) companies that have already been practicing low levels of NTL; b) companies with low comparison probability; and c) utilities whose established targets are higher than the starting point of the previous cycle and do not fit under item b (ANEEL, 2015).

## IV. SOCIOECONOMIC FACTORS RELATED TO COMMERCIAL LOSSES

This section presents the socioeconomic factors related to NTL, according to the international literature. In addition, it analyzes the specificities of the state of Rio de Janeiro.

### 4.1 Socioeconomic factors highlighted by the international literature

According to Smith (2004), NTL are related to governance, since this concept is used to explain patterns of social, economic and political development. Based on six governance indicators provided by the World Bank, the author evaluated this relation. The results of the research concluded that NTL are positively associated with the following indicators: lack of civil and political rights, overlapping of violence against government, hostile regulatory policies, corruption, disrespect for the legal rules of society and lack of quality in bureaucracy and in the public service.

One of the obvious consequences of this unfavorable government environment are the informal urban settlements, popularly known as "slums". They arise in places where there are economic opportunities, but not enough houses for everyone to live legally. Thus, low-income citizens occupy irregular places that are not authorized by public agents and characterized by insecurity and absence of law. Government planning generally does not prioritize the development of these areas, leading them to have precarious mobility, energy, communication, water and sanitation infrastructure. The need to access these services induces the residents of these locations to acquire them illegally (UN Habitat, 2009; Rufín, 2015). These negative governmental and social aspects impose many challenges for electricity distribution companies to act successfully in slums. Among them, four factors stand out: the non-payment culture, limited payment capacity of residents, "technological race" with illegal service suppliers and conflict between incentives and regulatory requirements (Lawaetz and Smyser, 2011).

### 4.2 - The socioeconomic factors of the state of Rio de Janeiro

According to the Institute for Work and Society Studies (*Instituto de Estudos de Trabalho e Sociedade* - IETS), the problem of the state of Rio de Janeiro is not a development problem, as measured by the work conditions of the households, per capita income and education of the population. Census data indicates that the population has a relatively high income per capita, a low illiteracy rate, and households with good water and sewage conditions. What explains the high rates of NTL in the state are informality, violence and the share of the cost of electricity in the family budget (IETS, 2008).

One of the measures of informality is "favelização". In the 2010 Census, this aspect was measured by the percentage of private occupied households in subnormal clusters. A subnormal cluster is a set of 51 or

more housing units occupied without property title and with irregularities in roadways, in the size and shape of lots and/or with a lack of essential public services such as garbage collection, sewage and water, electricity and street lighting (IBGE, 2011). If we calculate this index for the whole state, the number reaches 11.8%. When evaluating municipalities, the following percentages may be verified: Rio de Janeiro (19,9%), Duque de Caxias (6,8%), Belford Roxo (7,1%) e São João de Meriti (9,8%); all these municipalities are in Light's concession area. However, IETS (2008) argues that several criticisms may be made

regarding the methodology adopted by the Brazilian Institute of Geography and Statistics (IBGE), such as the fact that these metrics are underestimated.

The slums in the state are mostly controlled by armed criminal groups, known as "commands" and "militia". They are responsible for preventing the entry of a company in certain areas, preventing their operations, grid maintenance and the combat of NTL. Figure 1 shows that militia (identified by blue "balloons") and commands (identified by "balloons" in other colors) are spread over much of Light's concession area.



*Fig.1: Presence of Militia and Commands in Light's concession area in 2013. Source: Jornal o Dia, apud Light (2013).*

In order to regain control of the state over areas dominated by armed criminal groups, the government created the so-called Pacifying Police Units in 2008 (*Unidades de Polícia Pacificadora* - UPPs) (Leite, 2012). Currently, there are 38 UPPs, only one outside the capital, in the municipality of Duque de Caxias, but all within the concession area of Light. Evaluating the data provided by the Institute of Public Security (*Instituto de Segurança Pública* - ISP)[4], it is possible to verify that, in fact, there was an improvement of important indicators related to violence in with installed and operating UPPs.

Recently, the UPPs have been weakening due to the lack of resources to maintain them, as well as improve and expand the program. The state crisis promoted a 30% cut in the budget of the security summit in early 2016. In addition, violence has also grown with the worsening of economic indicators, which makes the future of UPPs even more uncertain.

Finally, regarding the cost of electricity, IETS (2008) argues that two factors contribute to a higher electricity bill in Rio de Janeiro than in other states: a) the state has the highest state tax rate in Brazil; and b) the hot weather and easier access to durable goods, especially air-conditioning, lead to increased consumption.

The reduction of the Industrialized Products Tax (*Imposto de Produtos Industrializados* - IPI) between 2012 and 2015 provided an incentive for the purchase of intensive electrical applications. In addition, the economic growth of recent years improved the financial conditions of Brazilian society, but this increase in income has not resulted in a transition from informal markets to the formal energy market (Light, 2013).

According to the Goods Asset Survey conducted in 2013, most of the households in communities (slums) in the concession area of Light rely on electro-intensive products. This survey did not include air conditioners. However, there is evidence of the increasing spread of this good in homes and especially in the informal areas,

contributing to further aggravate Light's losses problems. Since the population density of these areas is higher and residence ventilation is much lower than in formal areas, temperatures reach higher than normal levels, causing residents to use air conditioning and other electricity related equipment excessively. Studies conducted by Light (2013) show there is a strong correlation between temperature and losses.
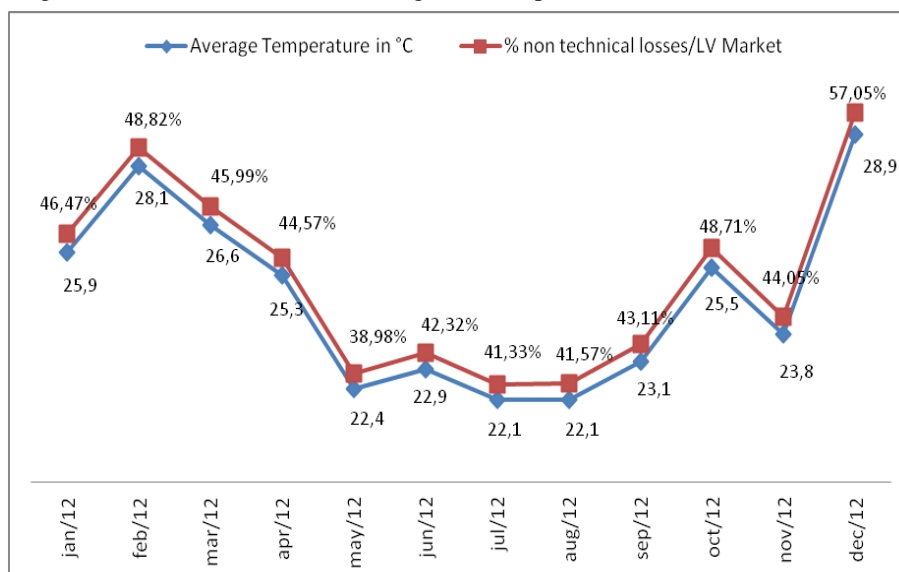


*Fig.2: Average temperature X NTL.* Source: Light (2013)

We can also point out that very few consumers benefit from discounts on their account provided by the Social Tariff[5]. This happens because to receive the benefit the family must have a monthly income per capita less than or equal to half a national minimum salary; in Rio de Janeiro the cost of living is very high, which makes it very difficult for a family to survive with that value.

## V.    RESULTS: NON- TECHNICAL LOSSES IN LIGHT'S CONCESSION AREA

Based on information collected with the company employees and in specialized reports, the objective of this section is to characterize Light's concession area in relation to socioeconomic indicators and losses. In addition, it will present the actions and initiatives adopted by Light in relation to regulation.

### 5.1 - Light's concession area

There are 31 municipalities in Light's Concession area in the state of Rio de Janeiro, with approximately 4.5 million customers (Light, 2016). The company divides its concession area into 5 regions: South Center, East, West, Baixada and Valley.

---

[5] The Electricity Social Tariff - TSEE was created by Law No. 10,438, of April 26, 2002. Due to the tariff discounts are granted to consumers in the Low Income Residential Subclass.

*Fig.3: Light's concession area. Source: Light (2013)*

The South Center region is mainly composed of the districts of South Zone, Center, Barra da Tijuca and a small portion of the North Zone, all of them belonging to the city of Rio de Janeiro. The main characteristics of this area include the predominance of large vertical apartment complexes, good urban organization, strong presence of an underground power network, high population concentration and substandard or precarious households in favelas. The Eastern region covers almost the entire Northern Zone of the same municipality. This region has the highest density of the concession area, horizontal residences, villages, medium-sized trade, a predominant air power network and a high number of communities.

The Western region encompasses the West Zone of Rio de Janeiro and the municipalities of Itaguaí and Seropédica. The presence of horizontal residences and subnormal or precarious households characterizes this area. The Baixada region includes the municipalities of São João de Meriti, Nilópolis, Belford Roxo, Mesquita, Nova Iguaçu, Japeri, Queimados, Paracambi and a portion of Duque de Caxias. High urban disorganization and a air power network are the main elements of this part of the state. Finally, a part of the municipalities of the regions Middle Paraíba, South Center Fluminense and Serrana compose the Valley region. The main aspects include the existence of an air distribution network, few subnormal or precarious households and large industrial loads (Light, 2013).

In 2016, according to Light (2017), NTL of the utility's concession area were 15.33%. The NTL index of the Paraíba Valley and the South-Centre were of 2% and 3%, respectively, in the same year. These percentages were well below Light's NTL and justified by the socioeconomic characteristics of these regions. In contrast to this reality, other regions had NTL higher than 30%, with socioeconomic conditions of those less-favored areas being a determinant aspect to explain high NTL (Castro et al., 2019), as we can see in the figure 4 below.
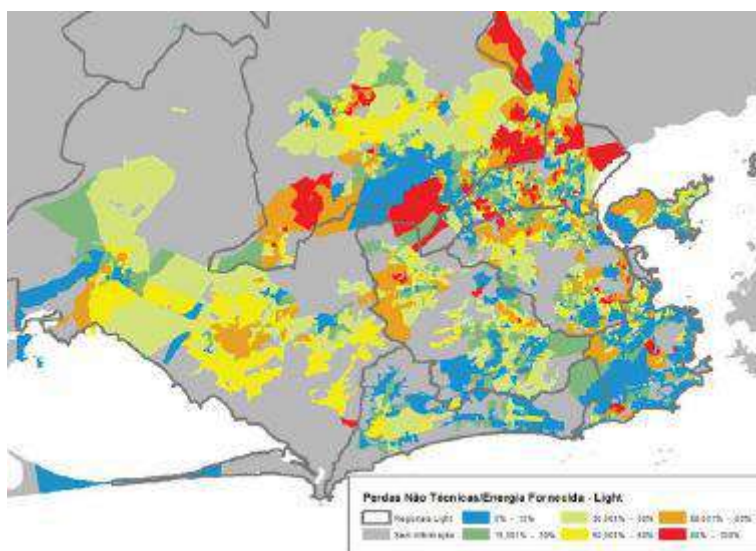
*Fig.4: Distribution of NTL/Supplied Energy. Source: Castro et al (2019)*

In 2016, NTL in the company's concession area reached 5,7 TWh. This is equivalent to 20% of all energy stolen in the country, and to the annual consumption of the state of Espírito Santo (Castro et al, 2019; Light, 2013). A large portion of this loss is associated to energy fraud, with an estimated 2.8 million fraudulent consumers in Light's concession area. As will be noted below, the company has difficulties to achieve the regulatory targets because of the NTL. In 2015, these losses caused an impact of R$ 400 million in the company EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) (Gomes, 2016).

Currently, almost half of the company's NTL are present in areas known as "Areas with Severe Operation Restrictions" (*Áreas com Severas Restrições Operacionais* - ASROs) while the other half located in areas considered possible to operate (although with some restrictions). High levels of NTL and regions dominated by criminal groups characterize the ASROs. These groups are responsible for making it impossible for the company to enter and, consequently, operate in these places. However, not all poor communities have this classification for the company. Around 642 of the 1340 communities in the Light concession area present severe restrictions on operation.

The company estimates that about 1.95 million of its customers are fraudsters, with 1.1 million located in possible areas and 850 thousand in ASROs. However, fraud does not, generally, correspond to 100% of the energy consumption, because consumers are usually concerned in continuing to receive the bill, which serves as a citizenship proof to gain access to benefits such as bank credit. Therefore, consumers often stole electricity from

applications that consume more electricity, such as air conditioning (Gomes, 2016).

The average monthly consumption estimated by the company in an ASRO is approximately 340 kWh. This bill is similar to the bill usually paid by regular customers and represents a relatively high burden on the budget of low-income families. Meanwhile, Light can only earn 60 kWh on average, resulting in a loss of 280 kWh (Gomes, 2016).

### 5.2 - Methods implemented by Light to combat Non-Technical Losses

In recent years, Light has sought to fight against NTL by optimizing conventional inspection, regularization actions and installing centralized metering and shielding systems in a great number of areas. In areas with UPPs, the company applied technical improvements in the network. Light also invested in education for their clients to consume less energy, as well as in the exchange of inefficient equipment, in credit offers in the case of trash recycling and progressive discounts on the tariff for consumers with a good paying history. In addition, the company applied the "Light Legal" program in small areas (called "Zero Loss Areas - ZLA"), which provides the installation of an independent microenterprise with electrical and commercial service agents to improve the losses and delinquency indicators. The remuneration of this project has a variable aggressive component, which is greater when the success in the improvement of these indicators is higher. In areas with ZLA's, NTL declined by an average of 20 percentual points.

In recent years, the UPPs program lost relevance. In this sense, Light abandoned some areas that resulted in

non-returns for invested capital and an increase in losses. This fact makes the future of NTL worrying in Light's concession area.

### 5.3 - Light and the regulation

In recent years, Light has found trouble to meet the regulatory targets for losses established by ANEEL. According to the utility, the estimation of the non-technical regulatory loss by the Brazilian regulator underestimates the social complexity faced by the company. As mentioned, there are areas in its concession area that the company cannot act due to criminality and, in theory, the model would capture this.

An important fact is that these areas often do not have high rates of violence and, therefore, indicators of deaths may not adequately reflect the correlation between crime and NTL. In addition, indicators of human development and subnormal clusters are not always good for identifying these areas, which leads to an underestimation of the losses by the ANEEL's model due to the specificities of Rio de Janeiro. Currently, losses are already 2% below the regulatory target.

## VI. CONCLUSIONS

The long period of economic crisis that negatively impacts Brazil is exacerbating an economic and financial imbalance for electricity distribution companies, specifically NTL, commonly entitled as electricity theft. This trend tends to expand due to the ongoing economic and social crisis characterized by reduced spending capacity on security, health and education, that are pillars of a reasonable level of well-being.

In view of the factors presented in this paper, it is possible to conclude that socioeconomic aspects and violence affect NTL. Due to these factors, the role of the State as a key agent for the improvement of these indicators is particularly important, thus helping distribution companies to offer their services to all residents with quality, as well as overcoming and fighting NTL.

In Rio de Janeiro, the problem of violence is very pronounced due to the presence of drug dealers and militiamen. They interdict the entry of Light's operational teams, which cannot act to reduce losses. In locations where it is possible to manage the provided service, Light is managing to reduce its level of NTL with higher indexes than those established by ANEEL.

The socioeconomic complexity of the state of Rio de Janeiro is related not only to NTL, as recognized by ANEEL in the regulatory treatment, but also to severe operating restrictions within Light's concession area. Although socioeconomic characteristics are relevant, there is still an unobserved heterogeneity that should be explained. The complexity in Rio de Janeiro's context is, to a large extent, associated with the fact that specific locations are controlled by criminal factions, regardless of socioeconomic characteristics or the provision of public services. This characterizes an extremely adverse and peculiar unobservable dimension in Rio de Janeiro, simultaneously correlated with the existence of areas with severe operation restrictions and difficulties in combating NTL.

In recent years, ANEEL developed regulatory incentives in order to induce a downward trend in NTL. For this, the agency started to carry out different regulatory treatments, according to the complexity of utilities in their respective contexts. However, almost half of Brazil's utilities have failed to reduce their NTL rates in recent years. This article sought to present that the complexity of the empirical context on which utilities operate are more restrictive than expected, due to relevant variables not considered in the complexity model. Therefore, it is important to differentiate regulatory treatments from one area in comparison to another within the concession space.

## REFERENCES

[1] Agência Nacional de Energia Elétrica (ANEEL), (2006). *Resolução Normativa Nº234*. Brasília, Brasil: ANEEL.

[2] Agência Nacional de Energia Elétrica (ANEEL), (2007). *Perguntas e Respostas Sobre Tarifas das Distribuidoras de Energia Elétrica*. Brasília, Brasil: ANEEL.

[3] Agência Nacional de Energia Elétrica (ANEEL), (2008). *Nota Técnica nº.342/2008-SRE*. Brasília, Brasil: ANEEL.

[4] Agência Nacional de Energia Elétrica (ANEEL), (2010). *Nota Técnica nº.271/2010-SRE*. Brasília, Brasil: ANEEL.

[5] Agência Nacional de Energia Elétrica (ANEEL), (2015). *Nota Técnica nº.106/2015-SGT/SRM*. Brasília, Brasil: ANEEL.

[6] Agência Nacional de Energia Elétrica (ANEEL), (2019). *Relatório de Perdas de energia na distribuição*. Brasília, Brasil: ANEEL.

[7] Ahmad, T. (2017), Non-technical loss analysis and prevention using smart meters. *Renewable and Sustainable Energy Reviews*, 72(3), 573-589.

[8] Castro, N.; Miranda, M.; Vardiero P. (2019), Perdas não técnicas na distribuição de energia elétrica: o caso da Light. Rio de Janeiro, Brasil: Publit.

[9] Depuru, S. S. S. R.; Wang, L.; Devabhaktuni, V. (2011). Electricity theft: Overview, issues, prevention and a smart meter based approach to control theft. *Energy Policy*, 39(2), 1007-1015.

[10] Glauner, P.; Meira, J.A.; Valtchev, P.; State, R.; Bettinger, F. (2017). The Challenge of Non-Technical Loss Detection

Using Artificial Intelligence: A Survey. Int. J. Comput. *Intell. Syst*., 10(1), 760–775.

[11] Gomes, R. A. (2016). *Contexto atual das perdas em áreas de risco na Light.* Rio de Janeiro, Brasil: Light.

[12] IBGE. (2011). *Censo 2010: Aglomerados subnormais - Informações territoriais*. Rio de Janeiro, Brasil: IBGE.

[13] IETS (2008). *Efeito do ambiente socioeconômico sobre as perdas não técnicas na distribuição de energia elétrica: Estudo realizado para a Light*. Rio de Janeiro, Brasil: IETS.

[14] Lawaetz, S.; Smyser, C. (2011), Challenges and opportunities in electricity service provision for urban BOP communities. In: Márquez, Patricia; Rufín, Carlos (Ed.) Private Utilities and Poverty Alleviation: Market Initiatives at the Base of the Pyramid, pp. 134-156, Edwrd Elgr.

[15] Leite, M. P. (2012). Da "metáfora da guerra" ao projeto de pacificação: favelas e políticas de segurança pública no Rio de Janeiro. *Revista Brasileira de Segurança Pública*, 6(2), 374-389.

[16] Light. (2013). *Contribuição à Audiência Pública n° 089/2013: Perdas Não Técnicas*. Rio de Janeiro, Brasil: Light.

[17] Light. (2016). Workshop de Perdas não técnicas em áreas com severas restrições à operação. Rio de Janeiro, Brasil: Light.

[18] Navani, J.; Sharma, N.; Sapra, S. (2012). Technical and non-technical losses in power system and its economic consequence in Indian economy. *Int J Electron Comp Sci Eng*, 1, 57–61.

[19] Penin, C. A. S. (2008). *Combate, prevenção e otimização das perdas comerciais de energia elétrica.* São Paulo SP: Universidade de São Paulo.

[20] PricewaterhouseCoopers (PwC), 2005. Estudo sobre Tributos e Encargos do Setor Elétrico Brasileiro. https://www.pwc.com.br/pt/publicacoes/setores-atividade/assets/energia/2020/estudo_acende_brasil_2020.pdf (accessed 10 Nov 2019).

[21] Coma-Puig, B.; Carmona, J. (2019). Bridging the Gap between Energy Consumption and Distribution through Non-Technical Loss Detection. *Energies*, 12, 1748.

[22] Rufin, C, 2015. Politics of Utility Service Provision in Brazil's Favelas. https://projects.iq.harvard.edu/files/dominguez_2015/files/rufin.politics_of_urban_utility_services_in_brazil.pdf (accessed 7 Oct 2019)

[23] Smith, T. (2004). Electricity theft: a comparative analysis. *Energy Policy*, 32(18), 2067-2076.

[24] Slum Electrification Programmes: An Overview of Global versus African Experience. Nairobi: [s.i], 2009.

[25] Tasdoven, H; Fiedler, B.; Garayev, V. (2012). Improving electricity efficiency in Turkey by addressing illegal electricity consumption: A governance approach. *Energy Policy*, 43, 226-234

[26] UN Habitat, 2009. *Slum Electrification Programmes: An Overview of Global versus African Experience*. https://mirror.unhabitat.org/downloads/docs/7803_91408_Overview%20of%20Slum%20Electrification%20in%20Africa.Final%20report.pdf (accessed 4 Jul 2019)

[27] USAID. Innovative Approaches to Slum Electrification. Washington, 2004.

[28] World Bank, 2009. Reducing Technical and Non-Technical Losses in the Power Sector. https://siteresources.worldbank.org/EXTESC/Resources/Background_paper_Reducing_losses_in_the_power_sector.pdf (accessed 10 Nov 2019).

# Study of public transportation of the city of Campinas, using the smart city concept, and specific equipment, for the accurate data collection, and improving this segment in the ergonomic concept

Gabriel Gomes de Oliveira, Yuzo Iano, Diego Pajuelo, Daniel Katz, Euclides Chuma, Michell Miranda and Daniel Izario

Department of Communications, State University of Campinas, São Paulo, Brazil.

*Abstract*— *The focus of the analysis is the public transport of the municipality, specifically the bus line No. 330, (Central Corridor / Central Terminal / Unicamp by Bus)., can be replicated to other city lines, other municipalities of the MRC (Metropolitan Region of Campinas) and even other national and international municipalities. To achieve the objective of this work, a descriptive and comparative analysis method was used, taking taking into account the perspective of the city's public sector. With this, it is intended to take the reflection to the public management of the city, to obtain public transport in an intelligent way, it is necessary to achieve its sustainable and more qualified, efficient and comfortable development for its customers and third parties.*

*Keywords*— *Smart Cities, Government, Sustainable Development, Quality of Life, Revolution, Public Transport, Predictions, Transport Quality.*

## I. INTRODUCTION

According to the WFF Organization, I defined the concept of sustainable development, as: "Development capable of meeting the needs of the current generation, guaranteeing the ability to meet the needs of future generations". [2]

It is development that does not exhaust resources for the future. [3]

This definition emerged from the World Commission on Environment and Development, created by the United Nations to discuss and propose ways of harmonizing two objectives: economic development and environmental conservation. [4]

In recent years, corporate social responsibility practices have become part of the strategy of an increasing number of companies, aware of the necessary relationship between economic returns, social actions and nature conservation and, therefore, the clear link that unites prosperity itself with the state of environmental health and the collective well-being of society. [4]

It is increasingly important for companies to be aware that they are an integral part of the world and not consumers of the world. The recognition that natural resources are finite and that we depend on them for human survival, for the conservation of biological diversity and for economic growth itself is fundamental for sustainable development, which suggests the use of natural resources with quality and not in quantity. [5]

The consumer is increasingly aware of the ecological and social weight of his own choices. Thus, for the company to guarantee consumer satisfaction, it will

increasingly have to provide coherent answers to these issues, recognizing the growing market sensitivity to issues such as sustainability and striving to achieve positive results in favor of the environment. [4]

Companies that want to maintain competitiveness in the long run must therefore respond to the expectations of citizens-consumers, valuing responsible behavior. [4]

For WWF-Brazil, collaboration and partnerships with the private world represent an essential assumption for a sustainable future, thus helping to bring the concept of sustainability from theory to practice. [2]

According to the European Union, Smart Cities are systems of people interacting and using energy, materials, and services and financing to catalyze economic development and improve the quality of life. These interaction flows are considered intelligent because they make strategic use of infrastructure and services and of information and communication with urban planning and management to respond to the social and economic needs of society. According to the Cities in Motion Index, from the IESE Business School in Spain, 10 dimensions indicate the level of intelligence in a city: governance, public administration, urban planning, technology, the environment, international connections, social cohesion, human capital and the economy. [6]

Despite being a relatively recent concept, the Smart City concept has already consolidated itself as a fundamental issue in the global discussion on sustainable development and moves a global market for technological solutions, which is estimated to reach US $ 408 billion by 2020. Currently, cities in emerging countries are investing billions of dollars in smart products and services to sustain the economic growth and material demands of the new middle class. At the same time, developed countries need to improve their existing urban infrastructure to remain competitive. In the search for solutions to this challenge, more than half of European cities over 100,000 inhabitants already have or are implementing initiatives to become de facto Smart Cities. [7]

"Instead of defining which cities should or should not be considered" smart ", it is constructive to think about the activities and factors that can make a city smarter." [8]

According to Blog Sonda: "The bigger the city, the greater the concern with resource management - especially natural resources. This is where the implementation of technology in public administration comes in, which can significantly increase energy and water savings, in addition to enabling more effective distribution to the inhabitants". [9]

According to a report by the World Population Prospects, revised in 2017 and released by the UN (United Nations), the world population in 2017 was 7.6 billion people. However, the perspective is 8.6 billion in 2030, 9.8 billion in 2050 and, in 2100, 11.2 billion inhabitants on planet Earth. Based on these numbers, we can identify that there is an unprecedented population growth, as well as countless challenges ahead, related to education, energy, environment, security, health, public services, among others.

Soon after the industrial revolution, which occurred in the 18th century, cities became major centers, with a high rate of urbanization and a complex social ecosystem, but in which their sustainable development cannot be guaranteed. From this scenario, we can mention technology, an extremely important element, which comes to assist in the creation of enterprises in harmony with nature and society, thus giving rise to the concept of smart cities.

The present work aims to make a study on how the city of Campinas, in the state of São Paulo, and the municipal bodies that represent it, have been behaving in relation to the development of a smart city.

## II.  HEADINGS

After collections of 03 (three) periods per day;

- Morning, afternoon and night.

During 7 (seven) days of the week;

Monday Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday;

The works were carried out and collected, during three periods of the year, as shown above;

- Collections made during school vacation periods, between January 30, 2020, until February 05, 2020;

- Collections on Carnival days, one of the main events in Brazil, which took place this year between February 20, 2020, until February 26, 2020;

- Collections carried out on the normal days of that year, carried out between March 2, 2020, until March 8, 2020;

Note: The collections of normal days meet the academic guidelines chosen by the Unicamp program, see figure 02, in which the majority of users who use this line, are university students at Unicamp;

*Fig.1: DAC / UNICAMP 2020 calendar*

Source: DAC / UNICAMP (2020)

More than 2 (two) thousand data were obtained and analyzed, referring to the temperature of 20 (twenty) points, noise, speeds, maximum number of people and minimum inside the bus, the data also shows the delay time, as shown in some images results obtained.

This data information was obtained from line No. 333, with an itinerary leaving the Central Terminal of Barão

Geraldo, and arriving at the Central Terminal of Campinas. In this section, all data were collected as shown in the figure below, specifically collected the route of the Professor Zeferino Vaz Highway;



*Fig.2: Bus Line 2020*

Source: Google Maps (2020)

For research, it is fundamental and extremely important to choose a specific section along the entire line, since the objective of the work is to pass information and concrete data to companies, city halls and users, as shown in the diagram below;
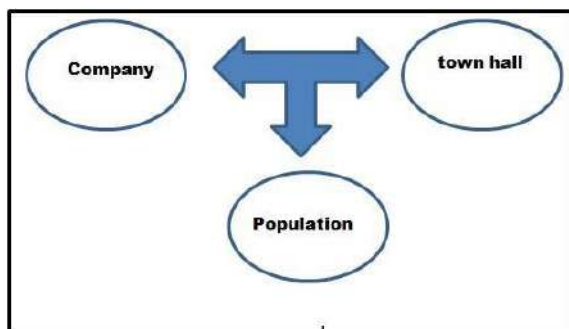


*Fig.3: Pyramids of Strands 2020*

Source: Gomes Gabriel (2020)

The validation on this data makes it necessary to choose a section along this line, in which when collecting the data, always having an identical scenario for all collections.

Differently if these data were collected along this line, which may cause a tendency in the collected factors, and analyzed, because the factors analyzed as well as (temperature, noise, number of people, speed, waiting time), are different over the your stretch.

Right after collecting all the data, following all the metrics and standards already evidenced in this work, I found values that allowed me to analyze them, compare them, and work on them using concepts of statics, in order to correlate them, and identify valid results. Always seeking to understand, see the data analyzed, being able to act on them in a clear, and objective, economical and meaningful way, for a better development of public transport, for society.

The analyzes and calculations were searched using the book of General and Applied Statistics, 6th edition, by the authors Gilberto de Andrare Martins and Osmar Domingues. Making understand and learn, several metrics of statistics, from my analyzes, and results obtained.
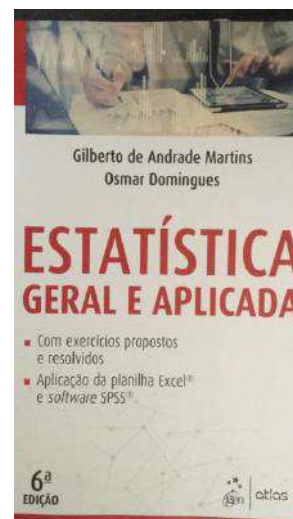


*Fig.4: General and Applied Statistics Book -2020*

Source: Gomes Gabriel (2020)

The collected data were used in the book General and Applied Statistics, by the authors, Gilberto de Andrade Martins and Osmar Domingues, 6th edition, by Atlas. The research aims to describe, explain to the reader all the concepts of statics that served in this work, to analyze the information and data collected,

## III. INDENTATIONS AND EQUATIONS

The first paragraph under each heading or subheading should be flush left, and subsequent paragraphs should have a five-space indentation. A colon is inserted before an equation is presented, but there is no punctuation following the equation. All equations are numbered and referred to in the text solely by a number enclosed in a round bracket (i.e., (3) reads as "equation 3"). Ensure that any miscellaneous numbering system you use in your paper cannot be confused with a reference [4] or an equation (3) designation. The research extracted from the book General and Applied Statistics reports that the arithmetic mean is: [25]

It is the most used, and most intuitive of the measures;

It suits a large number of practical situations;

It is influenced by all the values present in it, so it is necessary to be cautious;

It is represented by:

X ► for a sample;

μ ► for a population;

Calculation of arithmetic mean

Simple series = data list = raw data

The arithmetic mean of a sample of n observations x1, x2 ... xn is represented by the symbol $\dot{X}$ (reads x bar), and is calculated by: [25]

$$\dot{X} = \frac{x1 + x2 + \cdots xn}{n} = \frac{\sum x1}{n} \quad [1]$$

The arithmetic mean of a population of N observations X1, X2 ... Xn is represented by the symbol $\dot{X}$ (reads X bar), and is calculated by: [77]

$$\dot{X} = \frac{X1 + X2 + \cdots Xn}{N} = \frac{\sum X1}{N} \quad [2]$$

Observation: The difference between sample and population average is conceptual, since the calculation takes place in an absolutely identical way, that is, adding all the values of the sample (or population) and dividing them by the number of observations in the sample (or of the population).

## IV.  FIGURES AND TABLES

4.1 Temperature
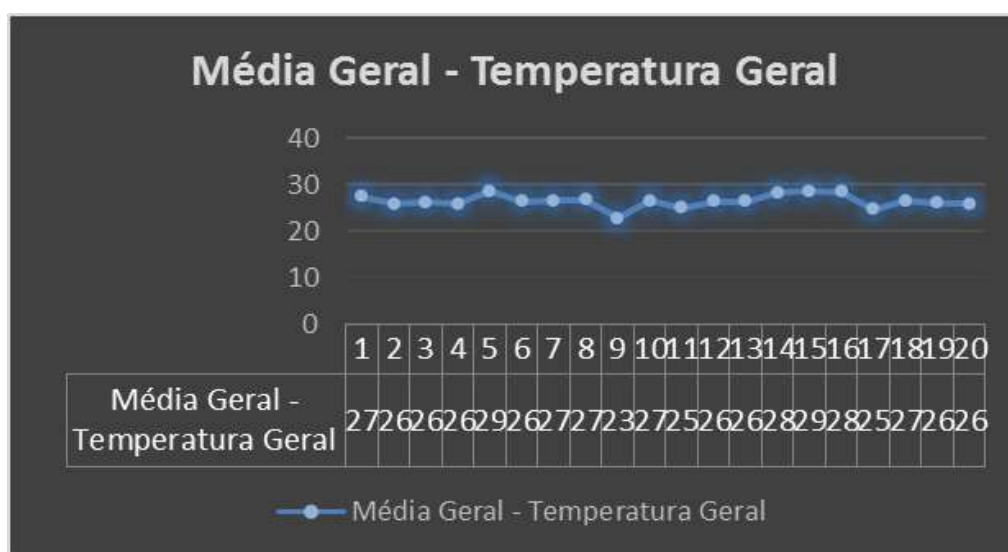


*Graph: 01 General Averages - General Temperature*

Source: Gomes Gabriel (2020).

Graph n ° 01, is the average of the general temperature, that is to say, which is the comparison of all the trips, days and periods mentioned above, in relation to the temperature.

I identified that the general temperature inside the bus is adequate, according to the guidelines established by WHO, (World Health Organization).

According to ANVISA (National Health Surveillance Agency), the temperature in the environment must be between 23 ° C to 26 ° C in the summer, (collected period), the collected and verified studies pointed out that only points 01, 05, 07, 08 , 10, 14, 15, 16 and 18 are outside the established guidelines.

The general average surveyed is adequate; this is because of air conditioning, a great ally for this factor; public transport is between 41.22% to 57.66%, greater than allowed.

The general average is inadequate, this is due to several factors, such as: external traffic a lot of engine and Bosnian noises, there are also noises from the vehicle's engine, air conditioning is very loud, with all these noises together, people in inside the bus they are forced to speak louder so that the other can hear, added to all these negative factors the quality of the noise is much higher than what is allowed for people;

4.2. Noise
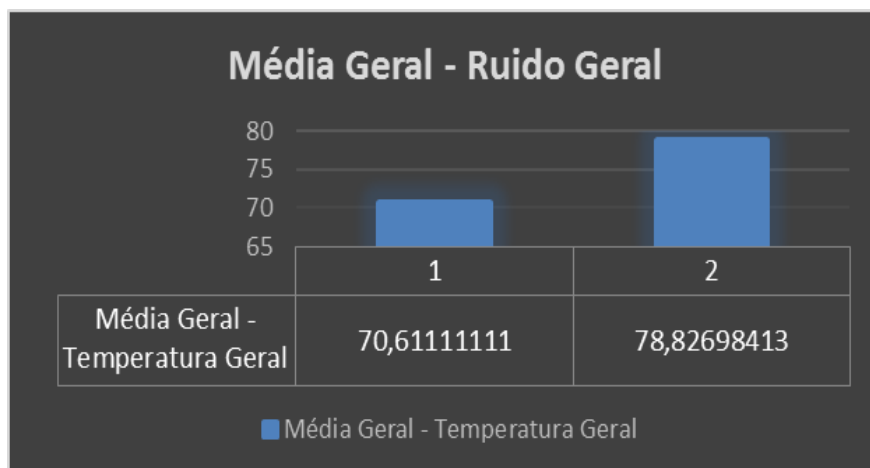
*Graph: 02 General Averages - General Noise*

Source: Gomes Gabriel (2020).

Graph n ° 02, is the average of the general noise, that is to say, that is the comparison of all the trips, days and periods mentioned above, in relation to the noise.

The collection identified and verified that the general noise inside the bus is inadequate, according to the guidelines established by the WHO, (World Health Organization).

According to WHO, (World Health Organization). The permitted noise is up to 50 dB (A) in the environment, therefore, the collection identified that the variation in public transport is between 41.22% to 57.66%, greater than allowed.

The general average is inadequate, this is due to several factors, such as: external traffic a lot of engine and Bosnian noises, there are also noises from the vehicle's engine, air conditioning is very loud, with all these noises together, people in inside the bus they are forced to speak louder so that the other can hear, added to all these negative factors the quality of the noise is much higher than what is allowed for people;

4.3. Number of People
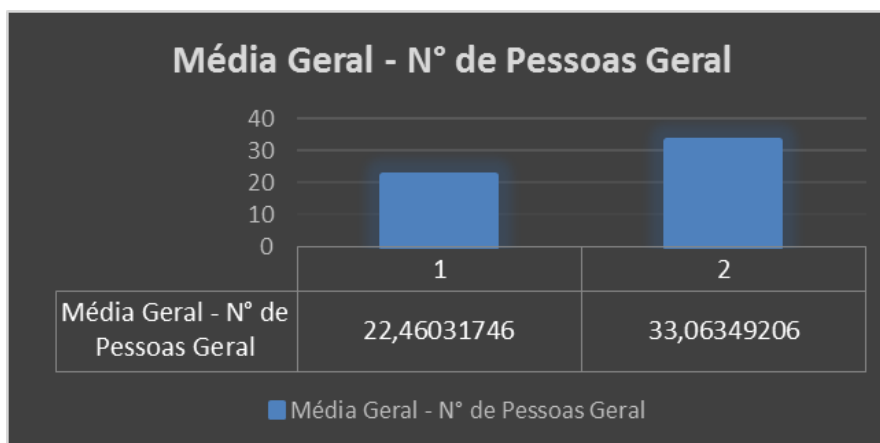


*Graph: 03 General Averages - No. of People General*

Source: Gomes Gabriel (2020).

Graph No. 03, is the average number of people in general, that is to say, which is the comparison of all trips, days and periods mentioned above, in relation to the number of people.

The Survey Identified that the number of general people on the bus is adequate, according to the guidelines established by Brazilian road transport legislation.

According to the Brazilian road transport legislation, the maximum number of people allowed within 1 (one) bus is up to 50 people; the survey pointed and measured a capacity of people between 66.12% to 44.92% lower established by the legislation Brazilian.

The general average collected is adequate, this is due to the fact that there are enough buses keeping the flow of people on the line, the study identified, that people prefer to wait to go comfortably, often even seated.

4.4. Speed
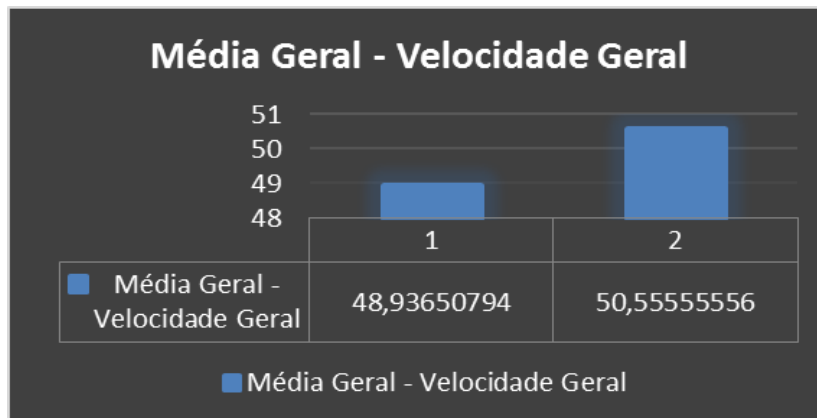


*Graph: 04 General Averages - General Speed*

Source: Gomes Gabriel (2020).

Graph 10, is the average of the general speed, that is to say, which is the comparison of all trips, days and periods mentioned above, in relation to the permitted speed of the road, (highway Zeferino Vaz).

We found that the overall speed of the bus is inadequate, according to the guidelines established by EMDEC (Campinas Municipal Development Company).

According to EMDEC (Campinas Municipal Development Company), the maximum speed allowed on the road, (highway Zeferino Vaz), is up to 40km / h, so we identified that the variation in public transport is between 20% to 25% higher established by the Campinas legislation.

The overall average is inadequate, this is due to the fact that it is a well-paved track, with numerous lanes, tight schedules, causing drivers to exceed the permitted speed of the road, and thus can even cause very serious accidents.

3.4 Waiting Time
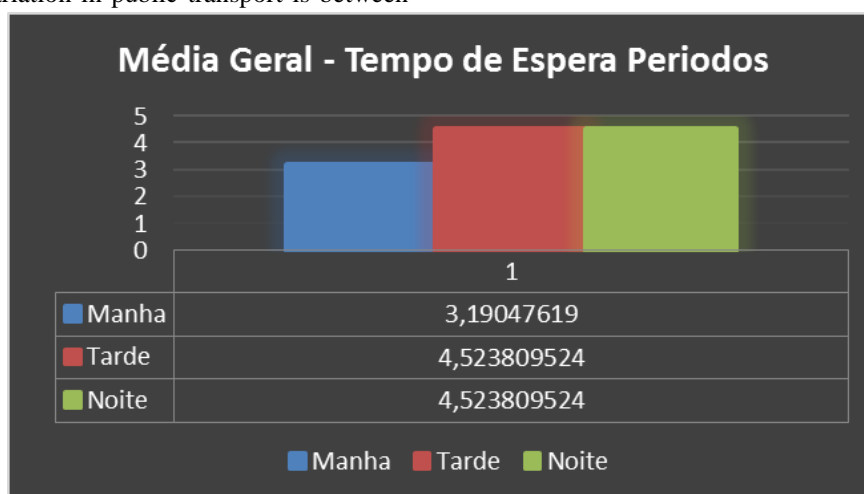


*Graph: 05 Overall Averages - Waiting Periods*

Source: Gomes Gabriel (2020).

Graph n ° 05, the average overall waiting time, is a comparison of all trips, days and periods mentioned above, in relation to the waiting time that people wait at the bus stop.

## V. CONCLUSION

With the emergence of new innovative technologies, it has opened up a rhythm of growth and greater urban development, which has made cities increasingly complex; to face the most varied types of challenges every day, such as: urban mobility.

It is important and necessary that cities develop in a sustainable manner, in all forms and aspects, such as: environmental, social, cultural, political, economic and others, in order to promote the quality of life for their population, maintain and develop good urbanization policy and quality of life, promoting actions that make it possible, and always looking for new innovative techniques, are necessary measures for several future generations.

Good planning, transparency, respect for society, are necessary measures for public management to work and manage any municipality.

They are undoubtedly tools to improve all sectors and segments of a municipality, with teams of trained, committed, sincere and honest people, the results will appear immediately for everyone.

The research, gave a very immense north of various situations, measures, actions, and control, as it is fundamental, necessary, and of utmost importance the Public Transport of a City, because it makes possible to take several actions to promote the public health of people on the planet .

A more recent example were the measures and actions that authorities on the planet took in the Corona virus Pandemic, it is clear how important urban public transport is in people's lives.

Cities need to develop in a sustainable way, both at an environmental, as well as a social and economic level, in order to promote the quality of life of their citizens, their equity and the appreciation of future generations. It is, therefore, necessary to develop and seek new techniques and strategies, which allow better management of public transport in cities.

The concept of intelligent transport arises from the logic that technological progress must be submitted to the interests of sustainable, ergonomic and quality of life development for its citizens. But if public transport is the means that, on the one hand, create problems, on the other,

they are also means that daily assist the transfer of thousands of people to get around different places, in various regions of Brazil and all over the world, being thus, conducive to the creation of innovative solutions and ideas, not only because they are centers of science and technology, but also because of their importance in society.

The topic of public transport is a hotly debated topic, both internationally and nationally, achieving sustainable development must be seen as a metal and a global objective.

In this sense, government officials and businessmen in this segment are in a privileged position and promote actions that go against unsustainable trends, as they are negative impacts that prevent the results of major improvements for the population.

It is up to government officials and businessmen to promote more integrated programs with new innovative techniques enabling intelligent improvements in municipal public transport, it is necessary to monitor actions and goals, promoting tools and control programs, and training of the people involved.

Implementation of new programs, concepts, methods, and techniques, makes it necessary to verify, control, monitor, the results and deviation found, are of paramount importance to be studied, researched and analyzed, as they are important information for decision making. Cities that look for the electric bus as a potential ally to mitigate global warming and improve air quality encounter a number of barriers in adopting clean technology. High investment, lack of incentive and information, rigid bidding models, in addition to technological limitations, delay change.

The difficulties of transition in the transport sector, which accounts for a quarter of global greenhouse gas (GHG) emissions, distance countries from meeting targets to combat climate change. There are plenty of reasons to invest in clean public transport.

In the long run, the low operating cost outweighs the initial investment. Quiet and stable, electric buses save the populous urban centers from atmospheric and noise pollution, and provide more comfortable travel with less vibration. The environmental benefits are even greater if the electricity that drives the engines comes from a clean energy matrix like that of Brazil.

The research is based on line No. 333, in the city of Campinas / SP. Studies have shown that this line is on the right path, but there are other barriers that prevent it from being a totally sustainable line, it is a strategy that is not yet well specified and elaborated.

However, the research shows flaws in the system, presenting concrete and coherent information, for the three pillars of the municipality (government, business and society).

The research has the main objective of always identifying and showing the possible and diverse problems and points out reasons for investing in clean public transport.

It should also be noted that the issues addressed were of the utmost concern, responsibility and respect. Seeking and pointing out innovative solutions that can change, the current scenario we live in, and pointing out several solutions and medium term

Showing that, with political Will, it is possible to coordinate efforts to overcome institutional barriers. In 2017, the government launched an electro mobility plan with the goal of electrifying all public transport by 2050. The country sees the transition as a development engine that will bring many benefits, from combating high levels of pollution to stimulating the battery market in the the country itself is an important supplier of raw materials. To make the transformation feasible, he adapted bidding processes, created subsidies for the transition and included all interested parties in the conversation.

## ACKNOWLEDGEMENTS

## REFERENCES

[1] K. Jack, "One day I will be reborn in a great ...".
[2] WWF, "Sustainability".
[3] "ECOLOGICAL - FOR AN ENTIRE ENVIRONMENT," 2011.
[4] ECOLOGY - FOR AN ENTIRE ENVIRONMENT, "SUSTAINABILITY - FROM THEORY TO PRACTICE," 2011.
[5] NATURAL FIBER - Natural Furniture and Decorations, 2010.
[6] BRAZILIAN NETWORK OF INTELLIGENT CITIES, "What is a smart city?".
[7] Environment Energy environment, sustainability and innovation. , "Solar energy and electric vehicles are some of the attractions of Itaipu at Smart City Expo Curitiba 2018," Curitiba, 2018.
[8] Piraí Inteligente, "Welcome to Piraí a smart and connected city," Piraí, 2020.
[9] Blog Sonda, "Smart City: what is it and how to apply this concept in your company ?," 2018.
[10] Diário de Noticias, "Two thirds of the world population will live in cities in 2050," 2018.
[11] News. frog, by, "UN predicts that the urban population will reach 2.5 billion by 2050," 2018.
[12] FEJ d. Bremaeker, "MUNICIPAL INFORMATION OBSERVATORY," Rio de Janeiro, 2016.
[13] WDS CARDOSO, "REAL ESTATE MARKET AND VERTICALIZATION OF RESIDENTIAL ENTERPRISES IN THE PRODUCTION OF SOCIO-SPACE SEGREGATION IN BELÉM," Belém / Paá, 201.
[14] BAT d. SP Fernandes, "Smart Cities A new urban paradigm," Porto, 2016.
[15] V. Martins, "Barcelona - the Smart City project," 2018.
[16] JB Richter, "SMART CITIES IN THE WORLD: EVERYTHING YOU NEED TO KNOW," 2018.
[17] N. Alves, "Smart City: the 7 smartest cities in the world," 2018.
[18] Build Business, "Smart City: The 7 Smartest Cities in the World," 2019.
[19] Campinas City Council, "Meet Campinas," Campinas.
[20] Campinas Virtual, "História de Campinas," Campinas.
[21] JAD LIMA, "Dictionary of Ecology".
[22] SP Intercamp, "História de Campinas," Caampinas, 2011.
[23] Family Search, "Campinas, São Paulo - Genealogia".
[24] M. Camera, "Tudo sobre Campinas," Jornal Livre, Campinas, 2013.
[25] e. e. a. l. a. M. A. f. u. o. l. E. d. A. M. e. O. D. Para descrever, Estatística Geral e Aplicada, Attlas.

# The Importance in choosing the team in project management

## Gabrielly Raquel Izidio Ramos

MBA in Total Quality Management- Federal Fluminense University , Niteroi- RJ- Brazil

*Abstract— In project management, it is necessary that the tools, techniques and solutions are applied in pursuit of a goal. It is also essential that the scope, deadline and costs are met. As a result, the satisfaction of the stakeholders, who are the interested party in the projects, are satisfied. For this reason, developing an efficient and qualified team can be considered a great challenge for the Project Manager, but it is something totally necessary for effective results. For this reason, it is required that the manager has good characteristics such as: being a good facilitator, innovator, motivator, goal-oriented, and above all, knowing how to lead their leaders. Therefore, to build a highly qualified team he has to analyze the type of project in which he has been assigned, analyze employee profiles and experience, so that they are compatible with the project and the number of people who will be available. It is also important that team members know the life cycle phases of a project (start, plan, execute, control and close). In view of all these prerequisites, it is essential that the manager, besides having the leadership profile capable of being flexible according to the maturity of the team, has the discernment to choose the people who will be part of the team, in order to achieve success.*

*Keywords— project, management, team.*

## I. INTRODUCTION

Teamwork is often challenging, being attributed to a team project, in which sometimes the solution of a problem can bring the increase to this challenge.

The quality in the development of each phase of a project: start, plan, execute, control and close, will depend on each person chosen to execute each action. Therefore, as important as managing a team is to choose good professionals who will form your team.

For this reason, it is one of the main roles of a manager, besides being an exemplary leader and facilitator, to choose people who are within the project profile. In this case, one must first analyze the curriculum and experience of each one and the choice of the characteristics of the collaborators that suit the type of project required. Ideally, they should be motivated people, with good interpersonal relationships, empathic, organized, and that above all remain until the end of the project.

## II. PROJECT DEFINITION

A project is a unique enterprise, with a defined beginning and end, that uses limited resources, conducted by people, aiming to achieve pre-defined goals and objectives established within the parameters of time, cost and quality (PMI 2008).

The project can be defined by some characteristics as temporary, unique and progressive. The fact that it is temporary becomes very important, because every project must have a defined beginning and end. The project ends when it reaches the objectives for which it was created or when it becomes clear that the project objectives will not or can no longer be achieved (PMI 2008).

One of the main differences between process and project is that the project has a set deadline or goal.

There are difficulties in managing a project and building a team capable of progressing with the project, and many unforeseen events can occur during the process, so it is up to the manager to analyze possible risks and build a high performance team.

According to Ricardo Vargas (2016), the projects reach all levels of the organization. They can involve a large or small amount of people, and can take days or years. The projects often go beyond the boundaries of the organization, reaching suppliers, customers, partners and governments, being part of the company's business strategy most of the time.

Some examples of projects:

- Installation of a new industrial plant;

-Restructuring of a certain sector or department of the company;

-Construction;

- Launch of a new product or service;

- Writing of a book;

- Construction of a new career plan;

- Implementation of a system;

1.1 Features of a project

The main characteristics of a project are

Temporary: means that every project, product or service developed must have a certain beginning, middle and end, the project is an event with pre-defined duration. A project can have a useful life of one day, one week or ten years.

Individuality: A project must have its identity, its individuality, this means that each project has its own particularity and unique characteristics..

## III. THE IMPORTANCE OF LEADERSHIP IN THE PROJECT

"The leader is the person who has the ability to motivate and influence the leaders, acting ethically and positively, so that they contribute voluntarily and enthusiastically to achieve the objectives of the team and the organization, always exploring each team member's strengths.

However, leadership can be complex, because the good leader, besides technical skills, must have emotional intelligence to manage the employees and the team, be able to develop their leaders meeting personal and professional expectations, and all this always aligned with the interests of the organizations". (Slacoaching, 2017)

For this reason, the ideal is leadership model is when it is not imposing. Therefore, the leaders are influenced so that they exercise their role on a voluntary basis.

There are some styles and types of leadership that should be applied according to the situation or according to the team (Slacoaching, 2017) :

- Autocratic or Authoritarian Leadership: This style of leadership is ideal for situations of pressure and low maturity of the team, this leadership style is based on the disinterest of the participation of those led. The leader is usually autocratic. In a project in which the emergence of new ideas is required, for example, this leadership style is not usually ideal.

- Democratic or participatory leadership: This leadership style requires high participation of team members, with ideas and suggestions, but the final decision rests with the leader. In democratic leadership, the team should preferably be composed of technicians and experts in the subject. And in the absence of the leader, those led will be able to successfully carry out the project. Democratic leadership is ideal for secure leaders, who do not let themselves be led only by the components of the team and for projects that require high productivity.

-Delegated leadership: In this style of leadership, the leader assigns tasks to the team members. It is effective when exercised with highly qualified and motivated team members. Delegative leadership is ideal when the team has high maturity and the project has little time and high goals. The leader must be highly motivated and qualified. The control of the activities of the subordinate elements is small.

-Situational Leadership: "When a manager can choose among the types of leadership according to the task that will be executed, the people and the situation in which it will be framed. This leadership is known as situational, where the manager orders the subordinates to fulfill orders, as well as suggests to carry out certain demands with a prior consultation before taking decisions. The idea is to adapt the best choice according to the type of situation in which the person is living.

Successful leaders manage to adapt their behavior and according to the needs of their leaders. "He tends to face situations with variations in the ability and commitment of the development of employees when performing tasks". (Edools, 2018)

-Motivating Leadership: In times of crisis, motivating leadership is extremely important. The motivating leader usually plays an important role in moments of crisis, because he is able to unite people, purposes and goals only with his words and his example. By infecting others with his trust and his optimism, he ends up stimulating the entire group to follow the best way with the ongoing processes and, thus, achieve the planned results.

By proposing different leadership styles, the authors condition the effectiveness of their job to some variables, such as: relevance of the quality of the task or decision; importance of the acceptance of the decision by subordinates to obtain their involvement in the implementation of a certain line of action; time available for the realization of the mission; risks involved; levels of priority in terms of productivity or group satisfaction; and level of psychological and professional maturity of subordinates. Highlighting only the latter variable as an

example, it can be generally stated that the identification of a low level of maturity (professional and/or emotional).

## IV. THE IMPORTANCE IN CHOOSING TEAM MEMBERS

One of the main roles of the manager when he is assigned to lead a project is: choosing which company members will participate in his new project. This choice can bring positive or negative results. Negative results can have as consequences: delay in the progress of the project, loss of team members and even the cancellation or failure of the project.

As a positive result, it is notorious: good integration between the teams, easy leadership, agility in the stages of the process, high development and satisfaction of all interested parties.

For the success of the project, the team has to be integrated, preferably, by expert/technical and experienced professionals, who have a great interpersonal relationship, who know how to take advantage of the designated resources

and know how to put into practice their designated function, in addition to the communication that must be the essential factor throughout the process.

When the team is assembled, some factors are taken into consideration:

1. Creativity in solving problems, through a multidisciplinary approach. During the project, unforeseen events may occur, for this reason, the team must include members who have the creative profile and bring solutions to possible problems.

2. Specialization and division of labor, promoting economies of scale and learning as well as minimizing project costs: One of the essential steps is the division of tasks of the team.

3. Commitment of the team to the success of the project, since it implies the personal success of each one of them.

4. Team with common objectives: Without common objectives, the project has no development. The members must have in mind a common objective:

5. Team experience with projects of the same type: The greater the experience, the greater the chance of development.

A well-developed team will consequently bring good results in development and success at the end of the project.

6. Project development: The manager is responsible for analyzing the development of the project and, if necessary, making changes in the team: changing the functions of the members, changing the development or even calling new members.

of the process, high development and satisfaction of all interested parties.

For the success of the project, the team has to be integrated, preferably, by expert/technical and experienced professionals, who have a great interpersonal relationship, who know how to take advantage of the designated resources

and know how to put into practice their designated function, in addition to the communication that must be the essential factor throughout the process.

When the team is assembled, some factors are taken into consideration:

1. Creativity in solving problems, through a multidisciplinary approach. During the project, unforeseen events may occur, for this reason, the team must include members who have the creative profile and bring solutions to possible problems.

2. Specialization and division of labor, promoting economies of scale and learning as well as minimizing project costs: One of the essential steps is the division of tasks of the team.

3. Commitment of the team to the success of the project, since it implies the personal success of each one of them.

4. Team with common objectives: Without common objectives, the project has no development. The members must have in mind a common objective:

5. Team experience with projects of the same type: The greater the experience, the greater the chance of development.

A well-developed team will consequently bring good results in development and success at the end of the project.

6. Project development: The manager is responsible for analyzing the development of the project and, if necessary, making changes in the team: changing the functions of the members, changing the development or even calling new members.

## V.   CONCLUSION

A job or project are not built alone. Everything is elaborated in team. And to have a strategic vision, aiming at the future, in the elaboration of a team is primordial for the manager, who has as main mission, to choose a good team in favor of a common goal. It is an arduous task, which consists in unifying a group as heterogeneous, experienced and engaged as possible, composed of good professionals and specialists in their area.

However, there are many qualified people looking for a first opportunity to be part of a team of excellence. It can be highlighted that within the main characteristics of this type of professional, we can highlight the focus on results, high responsibility, constant updating through training, courses and personal and professional qualification, as well as the ability to work on a project in the medium and long term.

In addition, to attract candidates from the top of the quality scale, the company needs to be prepared to offer conditions for the full development of its employees, in addition to working on their motivation and promoting the constant qualification of its team. A well motivated team has as a consequence high productivity, which will bring good results for the company. In other words, the organization also has an important role.

A good leader needs to have the ability to influence his or her leaders. It must have as a characteristic: the ability to influence, power of persuasion, empathy, good internal communication. And, moreover, he needs to know how to adapt the best leadership style/type to each situation. Knowing how to apply it in the best possible way and supervise/monitor the development of the project, that is, follow up, control the schedule, analyze the risks, apply the best tools. And if necessary, apply preventive or corrective measures.

The team members need to have some characteristics. Among the characteristics are: be engaged, dedicated, have common objectives and goals, flexible and adaptable, have self-management, be a good listener, communicative, energetic, good interpersonal relationship, creative, be sensitive to people and situations, proactive, self-confident, try new ideas, detailed. These characteristics are of extreme importance for a team to work and act in a cohesive way, without more problems.

Therefore, it is noted that the performance between organization, manager/leader and team members, should be together, mainly for the development of a good team and project progress. Therefore, all these factors are essential for the success of the project, especially within the stipulated schedule.

## REFERENCES

[1] VARGAS, Ricardo V. Project Management: Establishing Competitive Differentials. 6th ed. Rio de Janeiro: Brasport, 2005.

[2] VARGAS, Ricardo V. Project Management: Establishing Competitive Differentials. 8th ed. Rio de Janeiro: Brasport, 2016.

[3] VARGAS, Ricardo. Practical Manual of the Project Plan - Using the PMBOK Guide - 4th Ed. - Brasport - 4th Edition, 2009.J.

[4] Leadership. Available at: https://www.edools.com > Access at: 17 feb.2020 PMI. A Knowledge Guide in Project Management. PMBOK® Guide. Fourth Edition - USA: Project Management Institute, 2008.

# Critical Factors of Success for Franchises

Iasmin dos Santos Almeida

Postgraduate in Quality Engineering with emphasis on Project Management – UniBF College, Brazil.

*Abstract*— *The objective of this research is to analyze the critical success factors of a franchise. Factors that generate the survival of the franchise and its competitiveness. For this, a literature review was carried out in order to analyze what these critical success factors would be: I) Elaboration of a long-term strategic plan; II) Franchisee profile; III) Well-defined and implemented marketing strategy; IV) Choice of the commercial point; V) Partnership with suppliers and VI) Service provided by the franchisor. Once these success factors are discovered, the entrepreneur can use them in his business as a support guide.*

*Keywords*— *Critical Factors of Success, Critical Factors of Success in Franchises, Fashion Business, KPI in Franchises.*

## I. INTRODUCTION

With the increasing competitiveness observed since the last century, the interest regarding the dynamics that involve organizations is present, including the franchise and is directly linked to studies of entrepreneurship in the relationships between franchisees and franchisors, characterized mainly by the mortality rate for new businesses, where franchisees have a 20% lower rate compared to traditional enterprise formats [1].

In this sense, the research aims to analyze the indicators that guarantee the sustainability of franchises in the market. Thus, proposing a business model aimed at people and students who want to join as a franchisee. The methodology used will be the systematic literature review.

## II. KPI FRANCHISING

The elaboration of indicators and targets must take into account the main activities related to the sector, with the objective of increasing profit in the activities carried out, in order to represent the amount of previously elaborated strategies and the ability to place the defined plans for short and long term in action, efficiently and dynamically with fluctuations inherent to business dynamics [2].

Key Performance Indicators (KPIs) or Performance Indicators are also a tool for measuring performance, capable of assisting organizations in assessing their level of success in relation to the context of a specific activity, or in the set of processes inherent to it , reflected by the strategic drivers defined based on the needs identified before the market [3].

Critical Success Factors (FCS), on the other hand, are defined as key elements that determine the success or failure of the specified objectives, aligning the characteristics and capabilities of the companies evenly, in order to provide the user with real feedback on the status of the processes, the which serves as a basis not only for controlling internal processes and the individuals involved, but also for reflecting on the pattern of leadership, resource allocation, knowledge and teamwork [2].

Once these factors are well defined and thus well monitored, the franchise will guarantee its survival in the market, and maximum consolidation to its customers, in addition to loyalty, greater profit, delivered quality that are the consequences of a whole planning previously prepared .

Thus, the critical factors, which are identified as successful franchises, mention that companies have been seeking through a continuous effort to point out the importance of Franchising.

Therefore, the topics below will present the main FCS found in the literature. They are: Elaboration of a long-term Strategic Planning; Franchisee profile; Marketing strategy well defined and implemented; Geolocation of the commercial point; Partnerships with suppliers and Services provided by franchisors.

### 2.1 Critical Success Factors: Elaboration of a long-term Strategic Planning

"Strategic Planning" refers to the way in which a company intends to apply a certain strategy to achieve the proposed objectives. It is generally a long-term global plan "[4].

Long-term strategic planning is required for franchises, which is a critical success factor. Since it reveals the expansion of the enterprise, backed by customer satisfaction, and the market. Its analysis indicates the economic and financial viability of the franchise, and the actual acceptance of the products / services offered [5].

## 2.2 Critical Success Factors: Franchisee Profile

The franchisor's goal is to expand its network and strengthen its brand. This occurs with the franchise system, for this it is necessary that the franchisee has a work profile and experiences compatible with the business. A franchisee with a different profile than expected by the franchisor, can damage the brand and consequently blacken the image of an entire chain. It is not uncommon to find some stores that have lost their credibility due to the mismanagement of an entrepreneur, whether by recruiting their employees at the time of providing a customer service, or even by the entrepreneur's own profile. Therefore, the franchisee's profile is a critical success factor [5].

Among the desirable characteristics of a franchisee are: risk aversion, interest in the sector of activity and previous experience in project management [6]. When interest in being a franchisee arises, the franchisor performs a profile analysis of his entrepreneurial, leadership, psychological capacity [6]. However, it is noted that, in some cases, the franchisee's profile is not such a relevant issue [7]. The authors describe the results of their research as follows:

Regarding the selection process, most of the interviewees did not perceive an interest on the part of the franchisor in analyzing the profile or in verifying "whether the candidate was suitable for the system and the system for the candidate" [7].

With the methods established on the factors that contribute to the success of the franchise, its main factor is the good relationship between franchisee and franchisor, since it is the main and initial link of the entire process. Transparent relationships, understanding of processes and sharing of experiences must be carried out daily [5].

The profile of the entrepreneur is a determining factor, as it represents the action of running the franchise in a profitable manner, enabling innovations continuously, in addition to achievements that provide greater business development [1].

## 2.3 Critical Success Factors: Well-defined and implemented Marketing Strategy

The main objective of Marketing is to study and develop strategies that satisfy the needs of customers [10]. Certainly, Marketing is one of the great differentials perceived by franchisees. Even if worked well, it is an important attraction when a candidate is evaluating his entry into a certain franchise network [1]. Having a marketing strategy is an essential tool in a franchise system for generating a successful Franchising process.

Choosing a personalized business model for the franchisee, following the same thinking as the previous item, franchisees have different styles and profiles, are unique and need aligned marketing strategies. It is essential that the franchisor knows his franchisee and proposes well-defined marketing plans, together and in support of the franchisee. In addition to adapting to the business and placing the franchisee in the scenario he lives. Therefore, well-defined marketing strategies are critical success factors [8].

## 2.4 Critical Success Factors: Geolocation of the commercial point

A good commercial point is known to everyone as something positive. When inserting a franchise in an inappropriate location, it can negatively impact the entire network. The Franchising Portal [1] reinforces the importance of the franchisor's active participation:

"The best point is not necessarily the one that will provide the highest revenue, but the one that will bring the best result. To do so, one must deeply understand the particularities of the business in question and the history of the chain's units, which make the franchisor's involvement an essential factor for the success of the study. " [11].

It is essential that the franchisor directs the franchisee to the ideal location to establish the franchising unit, since he has well-defined know-how techniques capable of identifying strategic points. In summary, the franchisor has in-depth knowledge for the operation of the unit, which proves the relevance of providing field consultancy services [7].

## 2.5 Critical Success Factors: Partnerships with suppliers

The establishment of partnerships with suppliers is a critical success factor, since they present favorable price conditions and greater credibility in supply [5].

Suppliers are also one of the critical success factors. Since to have the final product it is extremely necessary that the first part involved, the raw material, is not lacking. An item that is not delivered on time or that even comes with malfunctions, hinders the entire production process, and compromises the brand name [5].

Analyze in their study that the provision of services by the franchisor is a critical success factor. They concluded that the main complaint of the interviewees, the ex-franchisees, was regarding the price. The entrepreneurs

declared that the prices charged by the franchisor's Central were more expensive than those obtained directly from the suppliers [7].

### 2.6 Critical Success Factors: Services provided by the franchisor

In the late 1990s, Elango and Fried identified "the franchisee's dissatisfaction as the main motivation for abandoning the relationship". Ten years later, it was found that one reason for breaking the franchise contract is the franchisee's dissatisfaction with the service provided by the franchisor [9].

Also analyzed the dissatisfaction of ex-franchisees with the services provided by the franchisor as a critical success factor. Punctuating this dissatisfaction: non-compliance with the promised support, technical assistance, inefficiency of the central purchasing and centralized advertising, among other points [7].

In the field research undertaken, it was found that the franchisors did not contribute to a positive climate because they did not care about the performance of the franchisees, did not provide the promised or expected support and, mainly, did not communicate adequately and intensely with the network [7].

Thus, it is worth considering that the final consumer is an individual customer. The complexity in the management of fashion retail organizations demands an adequate governance process based on strategic, tactical and operational actions, aimed at meeting the dynamics related to the renewal of inventories, so that the organization can meet the demands of the various collections that occur during the year.

It is worth mentioning that Franchising has the characteristic of presenting a binding agreement between two autonomous organizations being the franchisee and the franchisor, that is, the latter being paid first to sell their products and the other uses a brand in a certain location [1].

## III. CONCLUSION

With the current success of Franchising in Brazil and the "low mortality rate" compared to other forms of entrepreneurship, it is necessary to understand the critical success factors. Given these perspectives, it is possible to answer the key question of this work: "What are the critical success factors in a fashion franchise?". These being cited by the authors, such as: I) Long-term strategic planning is necessary [5]; II) The profile of the entrepreneur is a determining factor, as it represents the action of running the franchise profitably [10]; III) Having a marketing strategy is a tool for generating a successful Franchising process [12]; IV) The franchisor needs to direct the franchisee to the ideal location to establish a franchise [7]; IV) The establishment of partnerships with suppliers is a critical success factor [8] and VI) Services provided by the franchisor also work as a critical success factor [9].

## ACKNOWLEDGEMENTS

## REFERENCES

[1] ASSOCIAÇÃO BRASILEIRA DE FRANCHISING – ABF. Evolução do Setor de Franchising Brasileiro entre 2003 e 2014. <http://www.abf.com.br/numerosdo-franchising/evolucao-do-setor-2003-2014/>.

[2] Folan, P. and Browne, J. (2005). A review of performance measurement: towards performance management.Computers in Industry, 56, 663-80.

[3] Toor, S.U.R.; Ogunlana, S. O. (2008), Constructionprofessionals' perceptionofcriticalsuccessfactors for large-scaleconstructionprojects. ConstructionInnovation, 9, 149-167.

[4] CHIAVENATO, Idalberto; Teoria Geral da Administração. 3ª ed, São Paulo: McGraw-Hill, Ltda, 1987.

[5] SEBRAE. O que analisar e avaliar antes de adquirir uma franquia. https://www.sebrae.com.br/sites/PortalSebrae/artigos/o-que-analisar-e-avaliar-antes-de-adquiriruma-franquia,41cdf925817b3410VgnVCM2000003c74010aRCR D

[6] EXAME. 7 pistas que você tem o perfil certo para abrir uma franquia. https://exame.abril.com.br/pme/perfil-ideal-franquia-franqueado/

[7] TOLEDO, G. L.; PROENÇA, C. Fatores críticos de sucesso da franquia – uma análise sob a óptica de ex-franqueados no município de São Paulo. REGE Revista de Gestão, v. 12, n. 1, p. 43-53, 2005.

[8] SEBRAE. Como funciona o sistema de franquias. https://www.sebrae.com.br/sites/PortalSebrae/sebraeaz/como-funciona-o-sistema-de-franquias,46cf39407feb3410VgnVCM1000003b74010aRCR D

[9] VANCE, P.; FÁVERO, L.P.L; LUPPE, M. Franquia empresarial: um estudo das características do relacionamento entre franqueadores e franqueados no Brasil. Revista de Administração, v. 43, n. 1, p. 59-71, 2008.

[10] KOTLER, P.; KELLER, K. L. Administração de marketing. 12a ed. São Paulo: Pearson Prentice Hall, 2006.

[11] SOUZA, G.; LOURENZANI, A. A importância do perfil do franqueado para o sucesso das franquias: uma análise da capacidade empreendedora. Revista Brasileira de Estratégia– REBRAE, Curitiba, v. 4, n. 2, p. 115-127, 2011.

[12] DE FREITAS, E.; BARTH, M.; LEDUR, P. Franquias como apoio às estratégias de marketing e de competitividade: um estudo de caso na empresa Dumond. Estudos do CEPE, n. 33, p. 128, 2011.

# The Importance of Environmental Awareness for Minimizing impacts in a Food Company

Érika Dávila Cardoso[1] , Waldinei Rosa Monteiro[2], Tamilyn Alencar Fontes de Freitas[3], Vanessa Martins Fernandes Pinheiro[4]

[1,3,4]Master's Student in Science and Environment from the Federal University of Pará - UFPA.

[2]PhD in Ceramic Materials at the University of Limoges (Unilim) - France and Professor of the Postgraduate Course in Science and Environment - Professional Master's Degree, at the Federal University of Pará - UFPA.

*Abstract— Environmental management is a continuous and adaptive process, through which an organization determines its objectives, goals and strategies related to the protection of the environment and the safety of internal employees, customers and the community, based on the quality management of processes, products, services and interaction with the external environment. In this way, this work aims to raise awareness based on the relationship of environmental responsibility to minimize the organizational impacts on the lives of employees of a company in the food industry. The main interest is to examine in a more systematic way the perception of employees of a chain of sushi about their social responsibility in the activities they perform, in order to better understand their dynamics, their obstacles, possible solutions, as well as the reception of these employees for actions of this nature. First, there was a bibliographic survey of studies that discuss the issue of environmental education as well as the management of solid waste. Then, the chosen research sites were visited, in the Municipality of Manaus, capital of the State of Amazonas, where the way the employees perform their tasks and dispose of their waste was observed. At the same time, a questionnaire was applied to these professionals, in order to understand their knowledge about the theme. Lectures were also held in order to make them aware of the importance of their involvement in the processes and dynamics to be proposed. The study revealed that although there is a certain awareness about the negative impacts caused by the interference of solid and liquid waste, there is a gap between being aware of the problem and being aware that it is possible, with sincere dedication and few resources, to encourage some changes conducts, aiming at higher environmental quality, and even greater profitability for the company. The goal of being a green company must be incorporated into the future vision of the enterprise and that all employees are engaged in these results.*

*Keywords— Sustainability, Environmental education, Waste.*

## I. INTRODUCTION

Recently, it is beginning to realize that the socio-ecological damage caused by the adopted model of capitalist development is significant. Therefore, the environmental issue has been gaining more and more space on the public agenda and is increasingly visible in the various sectors of civil society.

The indiscriminate use of natural resources, from obtaining raw materials, production processes and services to the final disposal of the product after use, and the consequent negative impacts that this causes on the environment, has caused society to worry more and more about the decrease in the quality and quantity of resources available in the chain in which you live (REIS; QUEIROZ, 2002).

Growing environmental concerns around the world compel companies to engage in environmental education, solid waste management, such as reusing products and materials for recycling.

The environment has been attacked daily due to the various types of comfort and amenities required by human life, several sectors are involved, from clothing and technology to food, in this sense, on a punctually smaller scale, but worrying when considered as a whole macroscopic, restaurants are part of this problem.

Sustainability in a restaurant involves several issues in addition to simply providing a healthy diet, it is linked to recommendations for agriculture, suppliers, transport and product packaging until arrival at the restaurant, includes the standardization for handling procedures, portioning and management of the waste produced , involves the architectural planning of the site, energy saving and optimization in the use of natural resources (NUNES, 2012).

Several measures have been taken to remedy possible problems (waste of food, materials, indiscriminate use of chemicals, among others) and, in the case of restaurants, these are lately promoting and implementing sustainability initiatives. Entrepreneurs in the sector are beginning to realize that they must sustain the environment as a lifestyle and not as a problem, which increases the need to incorporate sustainability initiatives into their companies. Environmental sustainability is an important practice for this segment, mainly because they generate large amounts of waste, and still use a large amount of energy, thus using a large amount of natural resources (BRASIL, 2010; LEITE, 2005).

There are several ways for the food industry to contribute to environmental degradation processes, in the case of restaurants, they contribute through the operation, construction and design of their activities. The waste produced by restaurants includes: food scraps, paper and cardboard , plastics, metals and glass. In Brazil, food waste is the largest contributor to landfills and incinerators, with the restaurant industry representing 15% of this food waste (PORTO et al., 2011).

In terms of energy, a large amount of energy consumption in restaurants is due to long hours of operation, also considering a large amount of equipment using energy, most of which is often the result of waste. Reducing waste and energy use in restaurants is a fundamental issue that needs to be addressed by the sector, as these are contributing to the problems of depleting Earth's resources (SEBRAE, 2014).

Informal Environmental Education works mainly through popular campaigns that aim to generate acts and attitudes that lead to knowledge and understanding of environmental problems and the consequent awareness for the preservation of natural resources as well as the prevention of risks of environmental accidents and correction of degenerative processes of quality of life on earth (DIAS, 2010). The author adds that these campaigns, most of the time, require the use of environmental marketing techniques, so that they use mass media a lot.

Dias (2010) also points out that it is noticed that many environmental campaigns are fleeting and only when a serious accident (pollution of rivers, soil, among others) is reported does it recognize that such a preventive attitude should have been adopted. Furthermore, the mass media are expensive instruments. Dias (2010) also mentions that "for the execution of an informal Environmental Education program that achieves the objectives of dealing with the focused theme in an efficient and practical way, it is necessary to elaborate the environmental profile of the community, group or institution for which the Environmental Education program will be planned, evaluated and executed ”and for this reason it recommends an environmental perception survey.

Restaurants have found many ways to introduce initiatives that preserve the environment, but a challenge in the industry is to change the behavior and mentality of employees. Employees must be willing to follow the policies of the initiative and truly believe in the ideal of environmentalism to really make a change (SIROTA, MISCHKIND, & MELTZER, 2005). The success of the initiative depends on the employee's response and, without the support of the employees, the sustainability initiatives of the restaurants will not be successful (GOVINDARAJULU & DAILY, 2004). The Theory of Planned Behavior (AJZEN; 1985) states that broad work attitudes affect specific work attitudes, which lead to the intention of behavior. Attitudes at work may predict important behaviors, such as employee performance and employee misappropriation, but they are not about their behavior. The theory embraces the concept that human beings are rational and, in order to decide for their realization, they use the available information, evaluating the implications of their behaviors. In addition, as the name implies, it is assumed that human beings are sensible in their actions (JUDGE & KAMMEYER-MUELLER, 2012).

Work attitudes are feelings about points of view on a given subject, and the connection to work and the attitude of job satisfaction is the expression of gratification and positive feelings towards employment. Attitudes towards behavior can predict intention, which includes action including action to properly follow policies and procedures (JUDGE & KAMMEYER-MUELLER, 2012). Individual differences make human beings practically unique and that some behaviors that could be similar are different between individuals.

Using this logic, it was assumed in this study that employees who have a positive attitude towards sustainability will support the policies and programs of a

possible proposed initiative (EDWARDS & CABLE, 2009).

It is assumed in this study that employees who value environmental sustainability and work in companies that also value environmental sustainability will have greater job satisfaction. Greater employee involvement with the organization will lead to supportive behaviors for the organization. This study assumes that employees who have an environmental conscience will behave positively in restaurants that share the same beliefs about the environment and defend environmental sustainability initiatives.

Environmental sustainability is defined as maintaining or at least not depleting natural resources and their capital, which includes environmental assets such as soil, atmosphere, forests, water and wetlands that provide a flow of useful goods and services that can be renewable or non-renewable. , and marketed or not marketed. The restaurant industry can focus on environmental sustainability through responsible purchasing, efficient construction and materials, waste management, water conservation and energy management (LEWIS, CACCIOLA, & DENNILL, 2011).

Thus, this work aims to raise awareness based on the relationship of environmental responsibility to minimize organizational impacts on the lives of employees.

## II. MATERIALS AND METHODS

The applied methodology employed involved research techniques which were used for data collection and results tabulation. Initially, a bibliographic search was necessary, among other attributions, to define the parameters to be monitored so that a field research was structured, where the sustainable practices of a chain of fast-food restaurants were raised, offering data for the chapter results and analysis.

Literature prescribes that research is the set of systematic procedures based on logical reasoning. It aims to find solutions to problems proposed through the use of scientific methods (ANDRADE, 2006).

According to Vergara (2014), bibliographic research is a study developed through material published in books, newspapers, magazines, electronic networks, that is, material accessible to the general public. In the view of Lakatos (2010 p. 166) "Its purpose is to put the researcher in direct contact with everything that has been written, said or filmed on a given subject". Such a precept was applied to this study.

Among the types of research are: exploratory, descriptive and explanatory. In Vergara's (2014) view, exploratory research is carried out in a field of little accumulated knowledge. It has a probing nature and does not contain a hypothesis. In descriptive research, the study, analysis, recording and interpretation of the facts are carried out, without interference from the researcher (BARROS and LEHFELD, 2006). The explanatory one is a research that identifies the facts that determine or contribute to the occurrence of the phenomena (GIL, 2008).

The type of research addressed was descriptive, as according to Gil (2008) it is a research that describes the characteristics of certain populations and consists of the use of standardized data collection techniques, such as a questionnaire and systematic observation.

Descriptive research exposes characteristics of a specific population or a specific phenomenon. You can also establish correlations between variables and define their nature. They have no commitment to explain the phenomena it describes, although it serves as the basis for such an explanation (VERGARA 2014, p. 42).

This descriptive design uses a case study approach to illustrate sustainability initiatives on the attitude and behavior of its employees. The scope of the research included environmental sustainability initiatives, waste management and reduction, recycled and biodegradable disposable products, pollution reduction, sustainable food and sustainable furniture, as well as employee attitudes and behaviors, including work and attitudes towards the initiative , job satisfaction, initiative, subjective norms related to the initiative, perceived behavioral control and performance behaviors in the initiative.

Regarding the type of research approach, it can be qualitative or quantitative. The qualitative approach is characterized by the attempt to deeply interpret the meaning and characteristics of the information collected (OLIVEIRA, 2008).

According to Oliveira (2008 p. 62), quantitative research consists of "quantifying data obtained through information collected through questionnaires, interviews, observations (experiments) and the use of statistical techniques".

The analysis of the results was made through the quantitative method through the application of a structured questionnaire, with fifteen questions applied to the employees of the chain's restaurants.

Japanese fast-food restaurants were chosen, as they are considered a current trend and are subject to generating

more waste, as they produce a large amount of food daily (AMORIM; JUNQUEIRA; JOKL, 2005). Which can generate greater environmental impact.

The samples were chosen due to the easy access to the managers so that the research could be carried out and, thus, obtain the expected results to encourage the discussion of the proposed theme. The investigator approached the samples via an email requesting permission to interview her restaurant employees, obtain documents and observe employees and management. After permission was granted, the researcher made an appointment with restaurant managers to visit for observation and interviews.

The interviews took place at the restaurant site for several days on several occasions during the day and night and depended on the convenience of the staff and management. At the beginning of each interview, the interviewer explained to the interviewee that his identity would be kept confidential and participation would be voluntary and extremely appreciated. Participants' rights were explained and participants were informed that the interview would be recorded and transcribed. In addition to the interviews, data collected by the Investigator was sought. The observation of the restaurant was conducted by the researcher over the course of several during several shifts to observe the duties, operations, attitudes and behaviors of management and employees.

## III. RESULTS

First, we sought to outline a socioeconomic profile of the employees interviewed, as shown in the graphs below.

Graph 1 shows the age of the professionals.
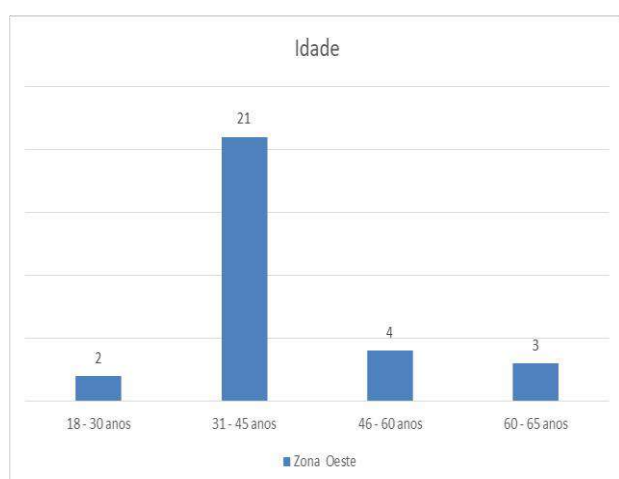


*Graph 1: Age of respondents.*

Source: Field research, 2019.

As shown in Graph 1, the prevalence of employees is in the age group from 31 to 45 years old (21); four are in the 46 - 60 age group; three from 60 to 65 years old and only 2 from 18 to 30 years old.

The population between 30 and 59 years of age continues to represent the highest percentage of the workforce in the country. According to the National Household Sample Survey (Pnad), of the Brazilian Institute of Geography and Statistics (IBGE), for the year 2011, they represent 61.9% of the total employed persons, totaling 57.271 million workers.

In 2009, the number of employees in the 30 to 59 age group was 55.4 million, representing 60.6%. In comparison with the 2011 data, the percentage increased by 3.3%.

The total number of employed persons in 2011 was 92.5 million, an increase of 1 million in relation to 2009, that is, there was an increase of 1.1%. The data considers employed persons aged 15 years or older.

Graph 2 reveals the marital status of the interviewed professionals.
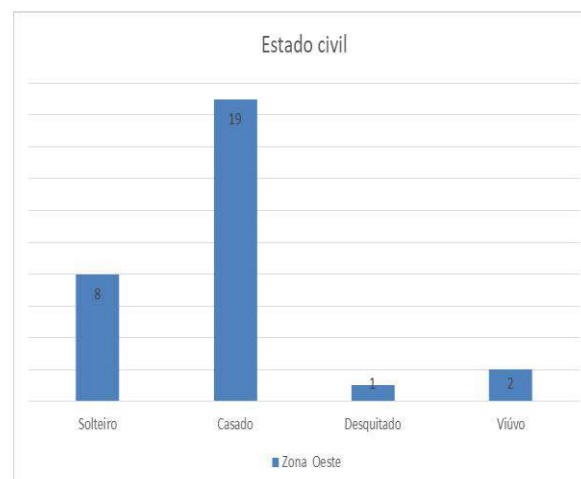


*Graph 2: Respondents' marital status.*

Source: Field research, 2019.

As shown in Graph 2, there are more married employees (19) than single (8) and a small number of widowers (2) and unemployed (1).

Among PNAD respondents, 42.9% (64.3 million Brazilians) said they were not in any type of marital union. Among those who claimed to live in union, the majority indicated civil and / or religious marriage (37.2% of the total), compared to those who reported only consensual union.

Graph 3 signals the data about the professionals' education level.
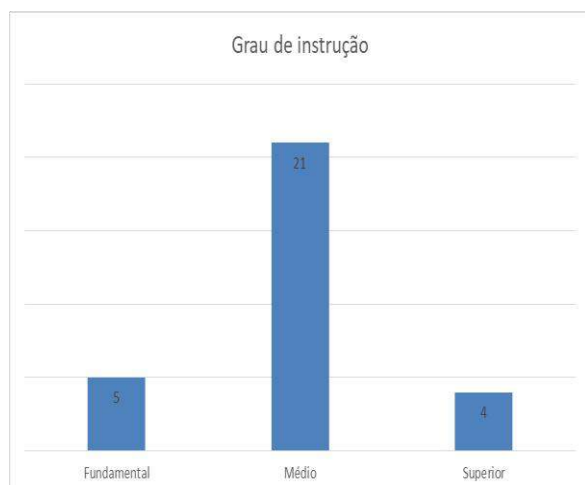
*Graph 3: Education level of respondents.*

Source: Field research, 2019.

It appears that the prevalence is of employees with secondary education (21) and lower education in elementary education (5). Attention is drawn to the number of professionals with higher education (4).

The job market was greatly affected by the recent economic crisis, especially in 2015 and 2016. However, even in this most critical period, the more educated employed population - with higher education - continued to increase, while all other levels of education suffered significant losses .

The results of a survey carried out by the Institute for Applied Economic Research (IPEA) show that, although the number of workers with higher education in the Brazilian labor market has been growing, part of this contingent is unable to obtain a function compatible with their level of education . Therefore, despite having an unemployment rate below the other categories, more than a third of the most graduated individuals are occupying jobs that do not require their level of knowledge. In addition, the effects of the economic crisis on the labor market further reinforced this situation, so that, in the third quarter of 2018, of every ten employed workers, four were in functions that did not require their qualification. In the case of the youngest, the study reveals that their insertion in the occupation segments corresponding to their education level is even more difficult. If at the end of 2014 38% of individuals aged 24 to 35, with higher education, had jobs below their level of qualification, in the last quarter this percentage had already increased to 44.2%.

Graph 4 illustrates the income of professionals.
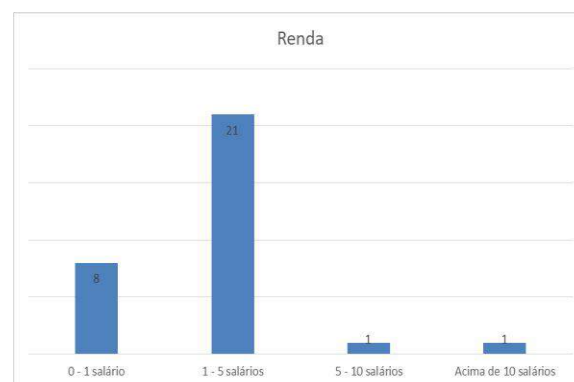


*Graph 4: Income of respondents.*

Source: Field research, 2019.

Most professionals (21) receive from 1 to 5 minimum wages; 08 receive up to a minimum wage; one of 5 to 10 minimum wages and only one above 10 wages.

Graph 5 reveals whether employees consider the issue of concern for the environment and sustainability in companies to be important.
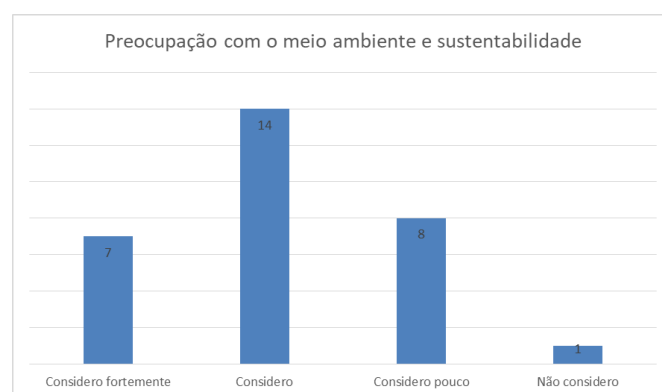


*Graph 5: Concern of respondents with the environment and sustainability.*

Source: Field research, 2019.

As shown in Graph 5, most employees (14) consider the issue of concern for the environment and sustainability; 7 consider strongly; 8 consider little and only 1 do not.

It was possible to perceive that, in general, most of them show some concern with the environmental issues that involve the processes of their productive activities and try, in one way or another, to do something to minimize the impacts. However, the sector still needs greater awareness, especially with regard to the issue of waste recycling, since the city of Manaus has the support of the public authorities through selective collection, although still in a not so expressive number.

Graph 6 reveals whether there is any concern with this aspect when planning restaurant activities.



*Graph 6: Concern of the interviewees with the environment and sustainability when planning the restaurant's activities.*

Source: Field research, 2019.

Graph 6 reveals that, for the most part (13), there is sometimes concern for the environment and sustainability when planning restaurant activities; 8 point out that this happens frequently; 3 that always happens; 3 point out that rarely and the other 3 say never.

According to studies by Leite (2005), restaurants, as well as other sectors of the service production society, are responsible for providing quality services. It is important that they satisfy human needs and bring quality of life and reduction of environmental impact and consumption of natural resources. In addition to reducing the amount of waste produced and rationalizing environmental resources, the adoption of sustainable practices provides savings, since the companies that adopt them may have their costs reduced by the rational consumption of natural resources, raw materials and reduction of waste generation. and waste.

According to Masdar Gen Z Global Sustainability analysis, new adults believe that it is the responsibility of their generation to deal with environmental issues. The survey revealed that currently young workers (corroborating the findings of this survey) believe that protecting the environment is more important than the economy. The text also indicated that, for them, education and social awareness are fundamental for sustainable development. In total, approximately 5,000 people - from all over the world - responded to the survey, aged between 25 and 45 years old, and revealed what are the main challenges they point to in the future.

Graph 7 illustrates whether employees consider it important to implement sustainability and environmental protection standards.
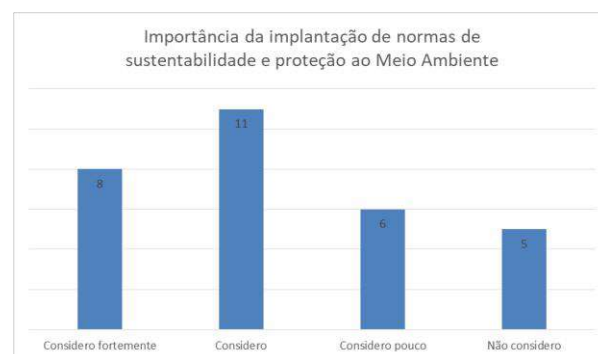


*Graph 7: Regarding the importance of implementing sustainability and environmental protection standards.*

Source: Field research, 2019.

As shown in Figure 7, it is confirmed that 11 employees consider it important to implement sustainability and environmental protection standards; 8 consider strongly; 6 consider little and 6 do not consider.

Companies are increasingly concerned with implementing sustainability practices in their business, as the subject has become a market requirement since more and more customers consider companies considered sustainable to be a great differential. The adoption of these practices helps to build customer loyalty, which is increasingly demanding and concerned with environmental issues, generates savings and also contributes to the environment.

Employees answered whether they agree that it is important to encourage conscious consumption of products that promote the environment (eg natural, organic products, products that generate less waste after consumption). The results are shown in graph 8.
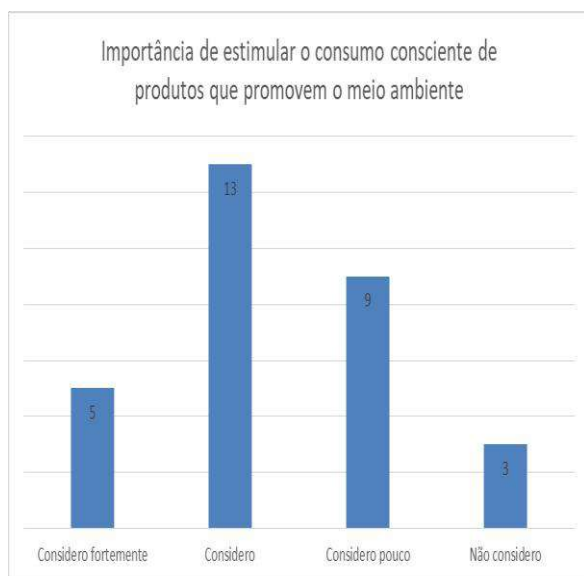
*Graph 8: Regarding the importance of encouraging conscious consumption of products that promote the environment.*

Source: Field research, 2019.

According to Graph 8, 13 employees consider it important to encourage conscious consumption of products that promote the environment; 5 consider strongly, 9 consider little and 3 do not consider.

Creating a restaurant with sustainable characteristics is a big responsibility and a long-term commitment. This means that respect for the environment must be the guide for each work routine, from the selection of suppliers to the correct disposal of waste.

Zimmerman and Mesquita (2011) highlight some points necessary to stimulate conscious consumption:

1. Invest in water savings

When it comes to a change in the culture of the restaurant to follow a sustainable line, saving water needs to be one of the fundamental pillars. For this reason, it is essential to develop training for the team, create awareness notices and invest in structural reforms so that there is no waste in the bathrooms and in the kitchen.

2. Give preference to local traders

Stimulating the region's economy is also an attitude of a sustainable restaurant. First, you save a lot on transportation and have the opportunity to buy smaller quantities more often. This means that the products are always fresh, and waste is reduced.

3. Reuse food for a sustainable restaurant

Investing in food reuse systems is essential to create a sustainable restaurant. Of course, there is no way to reuse the food that remains on the customers' plate, but it can stimulate conscious consumption practices and create menus that take into account the leftovers from the previous day.

4. Minimize the use of paper

The limitless consumption of paper harms the environment too much, considering that this product usually decomposes after six months, and many plug the mouths of the sewers and contribute to the floods. It is necessary to review the use of this resource in the daily life of the restaurant, in order to minimize unnecessary expenses.

To facilitate this part, the authors suggest that technological resources can be used, such as automated systems, that can be used to manage the most varied processes, such as cash control, the use of electronic controls, speed in deliveries, etc. Modifying this paradigm is crucial to improve management and make the environment much cleaner.

5. Bet on sustainable gastronomy

For this to really happen, the first step is to buy from local producers or to have your own garden, because, in addition to reducing costs, possible waste in transportation will be avoided. The chance of obtaining fresher food and without the use of pesticides is also an excellent advantage, since stock control needs to be up to date.

It is necessary to be concerned with the foods used when preparing meals, that is, reusing fruits, vegetable stalks, peels and seeds to the maximum. This does not necessarily mean that you must have a vegetarian restaurant, but that you need to be aware that the preparation of the dishes influences the sustainable process.

6. Invest in ecological decoration

Offering greater comfort to the consumer is one of the trends of eating out of the home, because what has gained loyalty, in fact, is not only the delivery of tasty food, but an unforgettable consumption experience. The decoration of the environment, for example, manages to make the place more cozy and attractive to the public.

7. Use water and electricity consciously

Water is one of the most important resources for human beings and unfortunately one of those that suffer the most aggressions. Avoiding waste of water, besides taking care of the environment, brings incredible savings to the

establishment. For this reason, the authors suggest opting for appliances with low electrical consumption, put motion sensors in bathrooms and invest in solar panels and other greener alternatives.

Smart flushes in bathrooms, taps with timers and the work of raising awareness among employees and customers are very important proposals.

Employees were asked whether they consider it necessary to implement a waste management program with the client's participation to encourage the collection of toxic materials or post-consumer recycling (Graph 9).



*Graph 9: Regarding the importance of implementing a waste management program with the client's participation to encourage the collection of toxic materials or post-consumption recycling.*

Source: Field research, 2019.

According to the data recorded in Graph 9, it is possible to observe that 12 employees consider it unimportant to implement a waste management program with the customer's participation to encourage the collection of toxic materials or post-consumption recycling; 11 only consider, 4 consider strongly and 3 do not consider.

As shown in figure 1, the restaurant has a lot of leftover food.



*Fig.1: Leftover food from the restaurant.*
Source: Field research, 2019.

It is observed that most of the food thrown in the trash is the leftover fish, essential for the preparation of the most consumed dishes in the restaurant. Amorim, Junqueira and Jokl (2005) found that the sum of leftover and unused food would be able to feed 20% of the average volume of meals served daily, which compromised the management of material, financial and human resources of organizations. Venke (2001) also demonstrated this concern when, when analyzing an industrial kitchen producing 1000 meals / day, he estimated that it was generating 3.97 tons of organic waste monthly, a value that could be underestimated, since post-leftover leftovers were not considered. consumption.

In this sense, Krause and Bahls (2013) consider that food waste must be analyzed in two moments, in pre and post-consumption. Pre-consumer residues are those that were not used to go to the customers' dishes, generally resulting from the low quality of the ingredients from the moment of purchase or the lack of care during storage, which ends up leading them to disposal, to main action to reduce this waste is to avoid excessive purchases and observe greater care during the stock. An alternative to avoid post-consumption waste, is the adequate sizing of portions, which in addition to reducing the amount of waste produced, optimizes the use of resources generating greater profitability for the establishment (KRAUSE; BAHLS, 2013).

It was also questioned about the importance of adopting purchase criteria that consider the guarantee of origin of products that are in compliance with environmental standards (graph 10).
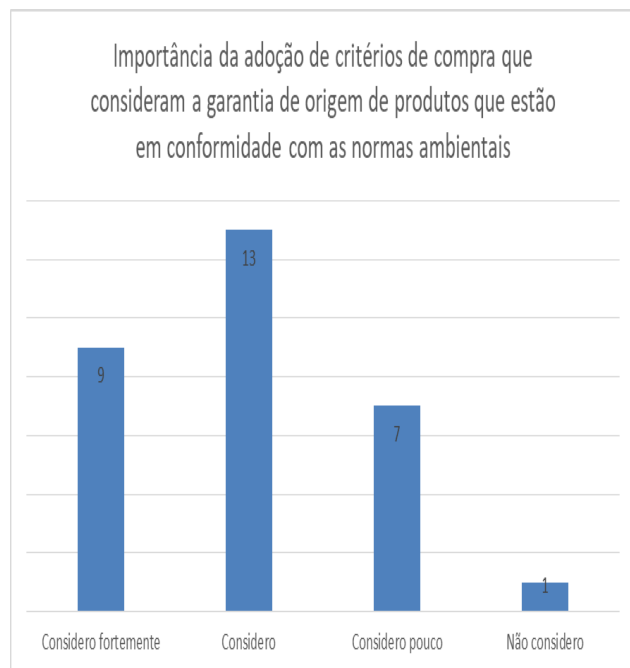
*Graph 10: Regarding the importance of adopting purchasing criteria that consider the guarantee of origin of products that are in compliance with environmental standards*

Source: Field research, 2019.

The research findings explained in Graph 10 reveal that 13 employees consider the importance of adopting purchasing criteria that consider the guarantee of origin of products that are in compliance with environmental standards; 9 consider strongly; 7 consider little and only 1 do not. Employees in the 31 to 45 age group read better about this importance.

Graph 11 shows whether employees consider the needs of the community in relation to the disposal of waste produced.



*Graph 11: Regarding the needs of the community in relation to the disposal of produced waste.*

Source: Field research, 2019.

As shown in Graph 11, 10 employees strongly consider the needs of the community in relation to the disposal of waste produced; 9 consider little; 8 consider and 4 do not consider.

At the end of the application of the questionnaires, lectures were given (Figure 2) with the collaborators in order to show the importance of the theme and how they could use the acquired knowledge.



*Fig.2: Conducting lectures.*

Source: Field research, 2019.

The units of the surveyed restaurants conduct training related to raising awareness on some topic related to sustainability for employees, with emphasis on the adequacy of portioning and use of dietary techniques in the pre-preparation and preparation of fruit and vegetable items. The relevance of such practices is highlighted, as both aim to reduce food waste, and, as stated by Zimmermann and Mesquita (2011), this waste is what most contributes to the volume of waste in a restaurant. Another important aspect regarding the generation of this waste is that the production of meals generates costs in the processes of food production, transportation and preparation, in addition to the water consumption necessary for these steps (COUTINHO; PINTO; DAHMOUCHE, 2014). In addition, we have the impact of disposing of organic waste on the environment, since more than half of the capacity of uncontrolled landfills (dumps) is occupied with organic waste, which could have been inserted back into the production chain, through processes composting, increasing the useful life of these landfills (CORREA; LANGE, 2013). In this context, training is important not only for improving the quality of the service provided, but also for reducing waste (OLIVEIRA; CE, 2012, BATTISTI; ADAMI; FASSINA, 2015). All of this underscores the importance of campaigns and training aimed at reducing organic waste.

## IV.   CONCLUSION

The case study carried out, through the application of the questionnaires, revealed that although there is a certain awareness about the negative impacts caused by the interference of solid and liquid waste, there is a gap between being aware of the problem and being aware that it is possible , with sincere dedication and few resources, encourage some changes in conduct, aiming at higher environmental quality, and even greater profitability for the company. The goal of being a green company must be incorporated into the future vision of the enterprise and that all employees are engaged in these results.

As evidenced in the results, most employees consider the issue of concern for the environment and sustainability; there is sometimes concern for the environment and sustainability when planning restaurant activities; consider it important to implement sustainability and environmental protection standards; consider it important to encourage conscious consumption of products that promote the environment; consider it unimportant to implement a waste management program with the client's participation to encourage the collection of toxic materials or post-consumption recycling; consider the importance of adopting purchasing criteria that consider the guarantee of origin of products that are in compliance with environmental standards; strongly consider the needs of the community in relation to the disposal of produced waste;

Through the application of the questionnaire, it was possible to perceive the view of the employees of the restaurant units of the typology chosen for analysis of this study, although this subject has not yet been widely publicized or addressed with greater dedication among the restaurant managers, in general there is a concern on the part of the establishment to reduce the impacts caused by its activities, since they consider environmental preservation the main reason for the implementation and practice of sustainable actions in the restaurant. However, there is a need for greater commitment on the part of all those involved, whether they are playing the role of managers, employees, or even consumers since the degradation of the environment has reached practically irreversible points and it is from it that raw materials are obtained essential for the performance of this professional activity.

In the lectures, issues related to sustainability were presented, reinforcing that environmental education is the most appropriate method to raise awareness of those who have not yet realized that environmental responsibility is inherent to any and every citizen, regardless of the role played at home, in the company or in society.

## REFERENCES

[1] ACRE, D. M.; CASTILHO, F. R. Gestão ambiental aplicada ao setor gastronômico: proposta para Dourados-MG. **Revista Rosa dos Ventos**, v. 5, n. 2, p. 248-263, abr./jun. 2013.

[2] AJZEN, I. **From Intentions to Actions: A Theory of Planned Behavior**. IN: KUHL, J.; BECKMAN, J. (Org.) Action Control: From Cognition to Behavior. Berlin: Springer, 1985. p. 11-39.

[3] ALMEIDA, E. R. DE; MORENO, A. L. Terapia cognitivo-comportamental breve para transtorno de ansiedade social: estudo de caso. **Perspectivas em Psicologia**, v. 18, n. 2, 30 dez. 2014.

[4] AMORIM, M. M. A.; JUNQUEIRA, R. G.; JOKL, L. Adequação nutricional do almoço self-service de uma empresa de Santa Luzia, MG. *Revista Nutrição*, Campinas, v. 18, n. 1, p. 145-156, jan./fev 2005. Disponível em<http://www.revistas.usp.br/rta/article/view/99186> acesso em: 30 abr. 2018.

[5] ANDRADE, M. M. **Introdução à Metodologia do Trabalho Científico: elaboração de trabalhos na Graduação**. 5 ed. São Paulo: Atlas, 2006.

[6] AVILA, G. J.; PAIVA, E. L. Processos operacionais e resultados de empresas brasileiras após a certificação ambiental ISO 14001. **Gest. Prod**., v. 13, n. 3, p. 475-487, 2006.

[7] ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). ISO 14.001:2004. Sistema de gestão ambiental: requisitos com orientações para uso. Disponível em http://www.abntcatalogo.com.br/norma.aspx?ID=1547. Acesso em: 22 abr. 2020.

[8] BABAKRI, K. A.; BENNETT, R. A.; FRANCHETTI, M. Critical factors for implementing ISO 14001 standard in United States industrial companies. **Journal of Cleaner Production**, v. 11, p. 749–752, 2003.

[9] BARBIERI, J. C. **Gestão ambiental empresarial: conceitos, modelos e instrumentos**. 3. ed. São Paulo: Saraiva, 2011.

[10] BARROS, A. J. P.; LEHFELD, N. A. S. **Fundamentos de Metodologia Científica**. PÓSGRADUANDO. As diferenças entre pesquisa descritiva, exploratória e explicativa. Disponível em: <http://posgraduando.com/?p=3354>. Acesso em: 30 abr. 2018.

[11] BATTISTI, M; ADAMI, FS; FASSINA, P. Avaliação de desperdício em uma Unidade de Alimentação e Nutrição. **Revista Destaques Acadêmicos**, Lajeado, v. 7, n. 3, 2015.

[12] BRASIL. **Lei nº 9.795**, de 27 de abril de 1999. Dispõe sobre a educação ambiental, institui a Política Nacional de Educação Ambiental e dá outras providências. Diário Oficial da União, Brasília, DF, 28 abr. 1999. Disponível em: <http://www.planalto.gov.br/ccivil_03/Leis/L9795.htm> Acesso em: out. 2018.

[13] BRITO, A. U. Certificação ISO 14001 e Educação Ambiental: estudo de caso do Sistema de Gestão Ambiental da Usina Hidrelétrica Coaracy Nunes- AP. 125 p.

**Dissertação de Mestrado** – Programa de Pós- Graduação em Direito Ambiental e Política Públicas. Universidade Federal do Amapá, 2008.

[14] CARRARA, K. **Behaviorismo radical: crítica e metacrítica**. 6.ed. São Paulo: editora UNESP, 2012.

[15] CHAN, E. S. W.; WONG, S. C. K. Motivations for ISO 14001 in the hotel industry. **Tourism Management**, v. 27, n. 3, p. 481-492, 2006.

[16] CORREA, MS; LANGE, LC. Gestão de resíduos sólidos no setor de refeição coletiva. **Pretexto 2011**, Belo Horizonte v. 12, n.1, p. 29 - 54 jan. /mar., 2013.

[17] COUTINHO,L; PINTO, S; DAHMOUCHE, M. SUSTENTABILIDADE - O QUE É ISSO? In: **Congreso Iberoamericano de Ciencia, Tecnología, Innovación y Educación, Buenos Aires** (Argentina), Nov., 2014.

[18] DELMAS, M.; TOFFEL, M. W. Organizational responses to environmental demands: opening the black box. **Strategic Management Journal**, v. 29, p. 1027–1055, 2008.

[19] DIAS, R. **Responsabilidade social e sustentabilidade**. 2. ed. São Paulo: Atlas, 2010.

[20] EDWARDS, J. R., & CABLE, D. M. The value of value congruence. **Journal of Applied Psychology**, 94(3), 654, 2009.

[21] GIAMPIETRI, E., FINCO, A., DEL GIUDICE, T. Exploring consumers' behaviour towards short food supply chains. **British Food Journal**, v. 118, n. 3 p. 618-631, 2016.

[22] GIL, A. C. **Como Elaborar Projetos de Pesquisa**. 4 ed. São Paulo: Atlas,2008.

[23] GAVRONSKI, I.; FERRER, G.; PAIVA, E. L. ISO 14001 certification in Brazil: motivations and benefits. **Journal of Cleaner Production**, v. 16, p. 87- 94, 2008.

[24] INOUE, E.; ARIMURA, T. H.; NAKANO, M. A new insight into environmental innovation: Does thematurity of environmental management systems matter? **Ecological Economics**, v. 94, p. 156–163, 2013.

[25] LACOMBE, F. J. **Recursos Humanos: princípios e tendências**. 2 ed.. São Paulo: Saraiva, 2011.

[26] JACOBI, P. Educação Ambiental, Cidadania e Sustentabilidade. **Cadernos de Pesquisa**, nº118, p. 189-205, março/2003.

[27] JACOBI, P. et al. (orgs.). **Educação, meio ambiente e cidadania: reflexões e experiências**. São Paulo: SMA, 1998.

[28] JUDGE, T. A.; KAMMEYER-MUELLER, J. D. Job attitudes. **Annual Review of Psychology**, 63, 341-367, 2012.

[29] LACEY, H. **Psicologia experimental e natureza humana: ensaios de filosofia da psicologia**. Florianópolis: UFSC/NEL, 2011.

[30] LAKATOS, E. M. **Fundamentos de metodologia científica.** 7º ed. São Paulo: Atlas, 2010.

[31] LEITE, B.Z; PAWLOWSKY, U. **Alternativas de minimização de resíduos em uma indústria de alimentos da região metropolitana de Curitiba**. Eng. sanit. ambient. Vol.10 - Nº 2 - abr-jun, 96-105. 2005.

[32] LEWIS, A., CACCIOLA, K., & DENNILL, R. B. **Sustainability in the food service environment**. In International Facility Management Association (Ed.), Sustainability "how-to guide" series, 2011.

[33] MATOS, M. A. **Behaviorismo metodológico e behaviorismo radical**. In: RANGE, B. Psicoterapia comportamental e cognitiva. Campinas:Psy II 2015.

[34] NUNES, R. Gastronomia Sustentável. Interação - **Revista Científica da Faculdade das Américas**, São Paulo, ano III, n. 1, jan./jul. 2012.

[35] OLIVEIRA, S. L. **Tratado de metodologia cientifica: projetos de pesquisas, TGI, TCC, monografias, dissertações e tese**. São Paulo: Pioneira, 2008.

[36] OLIVEIRA, CBP; CE, N. estudo comparativo entre o processo de planejamento de cardápio de um restaurante de hotel e de um restaurante convencional. **Competência**, Porto Alegre, RS, v.5, n.2, p. 83-99, jul./dez. 2012.

[37] POMBO, F. R.; MAGRINI, A. Panorama de aplicação da norma ISO 14001 no Brasil. **Gest. Prod.,** v. 15, n. 1, p. 1-10, 2008.

[38] PORTO.L. R., QUEIROGAB, A. F. F.; NÓBREGAC, E. M. M. A.; ALMEIDA, E. P.; SILVAE, T. C. B. P; COSTA, I. **A Produção Mais Limpa Aplicada ao Setor de Alimentação Fora do Lar da Paraíba**. 2nd International Workshop / Advances in Cleaner Production. São Paulo, 2011.Disponível <http://anaisct.ouropreto.ifmg.edu.brQ/wp-content/uploads/2013/09/V3-25SUSTENTABILIDADE-NA-PRODUÇÃO-DEREFEIÇÕES-EM- UM RESTAURANTE-INSTITUCIONAL-DO-MUNICÍPIO-DE-OURO-PRETO.pdf > Acesso em: 30 abr. 2018.

[39] REIGOTA, M. **O que é Educação Ambienta**l. São Paulo: Brasiliense, 2013.

[40] REIS, L. F. S. S. D.; QUEIROZ, S. M. P. **Gestão ambiental em pequenas e médias empresas**. Rio de Janeiro: Qualitymark, 2002.

[41] ROBBINS, S. P. **Comportamento Organizacional**. 14 ed. São Paulo: Pearson Prentice Hall, 2010.

[42] SATO, M. **Educação Ambiental.** 3 ed. São Paulo: RiMa, 2011.

[43] **SEBRAE**. O que são resíduos e o que fazer com eles. (2014). Disponível em: <http://www.sebrae.com.br/sites/PortalSebrae/artigos/o-que-sao-residuos-e-o-que-fazer-com-eles,ca5a438af1c92410VgnVCM100000b272010aRCRD. >Acessado em: 30 abr. 2018.

[44] SIROTA, D., MISCHKIND, L., & MELTZER, M. 33 beliefs about work and workers'. The Enthusi-astic Employee. Retreived August 27, 2013, from http://www.enthusiasticemployee.com/_vti_bin/shtml.dll/reg istration.htm. Acesso em: 29 abr. 2018.

[45] SKINNER, B.F. (1982/1974) **Sobre o Behaviorismo**. São Paulo: Cultrix/Edus, 2006.

[46] TAMAIO, I. A **Mediação do professor na construção do conceito de natureza**. Dissert.(Mestr.) FE/Unicamp, 2000.

[47] TEIXEIRA, C. A.; SOUZA, J. P. Análise da Certificação ISO 14001 para a Sustentabilidade em Conformidade com a Legislação Ambiental. **Revista Meio Ambiente e Sustentabilidade Versão on-line** Volume 10, número 5. Curitiba – PR. Jan/maio, 2016.

[48] VERGARA S. C. **Projetos e relatórios de pesquisa em administração.** 15. ed. São Paulo: Atlas, 2014.

[49] WATANABE, E. A. M. Teoria do comportamento planejado: uma aplicação na análise do consumo de carne bovina gorda entre universitários. 2014. 217 p. **Tese** (doutorado) - Universidade Estadual de Campinas, Faculdade de Engenharia de Alimentos, Campinas, SP. Disponível em: <http://www.bibliotecadigital.unicamp.br/document/?code=000927907&opt=1>. Acesso em: 30 jun. 2018.

[50] ZIMMERMANN, AM; MESQUITA, MO. Campanha resto zero em restaurante universitário. **Disc. Scientia**. Série: Ciências da Saúde, Santa Maria, v. 12, n. 1, p. 115-125, 2011.

# Study on Rainwater Viability for Non-Drinking use in an Agricultural Research unit in Brazil

Henrique Luis da Silva[1], Gislaine Gabardo[2], Roger Daniel de Souza Milléo[3]

[1,3]Science and Technology Analyst, Rural Development Institute of Paraná, Ponta Grossa, PR, Brazil
[2]UniCesumar, Ponta Grossa, PR, Brazil

*Abstract— The reduction in the availability of drinking water to populations has stimulated the search for alternative forms of technologies that enable the use and reuse of rainwater for non-drinking purposes, which are associated with practices that contribute to the reduction of waste. Thus, the aim of the present work was to propose a model for capturing rainwater and to identify the demands for the use of non-potable water for an agricultural research unit, in order to replace the current model with a more sustainable one. The work was carried out in a research station of IDR-Paraná-Institute of Rural Development of Paraná – Iapar-Emater, in the municipality of Ponta Grossa, Paraná. Three factors were evaluated: precipitation, collection area and demand quantity in each activity. The system is feasible to be implemented. The maximum demand for a month of higher consumption was estimated at 56.700 liters. It was possible to estimate the intake for the month with the lowest precipitation at the site, with this volume exceeding 46.000 liters of water, a value sufficient to meet the unit's demand for washing vehicles and for use in agricultural spraying, contributing to the reduction of use of drinking water at the station. Water use technologies are sustainable solutions and contribute to the rational use of water, providing the conservation of water resources for future generations.*

*Keywords— Efficiency in the use of water, sustainability, use.*

## I. INTRODUCTION

We are currently experiencing aggravations regarding the availability of drinking water in several regions. This lack of water reflects a set of situations that range from prolonged periods of drought to high levels of pollution in rivers and lakes, associated with not using alternative sources such as the capture and use of rainwater [29]; [22]; [7]; [32]; [27]; [4].

Concern about the lack of drinking water is growing worldwide. Brazil, despite being one of the richest in relation to this element, has presented serious problems that are not restricted to the northeastern semiarid. These facts contribute to the discussion that we are all responsible and that we can all contribute to the reduction of waste [9].

The lack of water is a reality in several regions of our country [33]. According to Almeida et al [5]., Brazil has huge reserves and great potential for water production, but this does not occur in the regions with the highest population density, a factor that would require the adoption of practices to maximize the management of this valuable resource, a fact that are not occurring, at least not on the scale that would be necessary.

Good practices such as reducing bath time, turning off the tap while brushing teeth and not washing the car with a hose are advertised and disseminated among the population as ways of reducing waste and helping the preservation movement, however despite these efforts, and in Depending on the number of our current population, new forms and methods need to be implemented to overcome this problem [24]; [4].

Water losses in Brazil are gigantic, either due to misuse or through leaks in the supply system, this is unacceptable above all when it comes to drinking water for human consumption [8]. According to the Brazilian Association of Engineering and Sanitary and Environmental - ABES [1], the national supply system loses 40% of all water, when compared to countries like Germany and Japan, which presents 11% losses, we realize that a better management of that system.

In addition to reducing losses in the supply system, other alternative ways can be implemented, the use of rainwater and the reuse of water are two practices that have great potential for expansion and are currently being used in new projects for houses and buildings [13]; [9].

The reuse of rainwater has been shown to be a viable alternative. This capture and reuse of water is an ancient technique used for agricultural and domestic purposes. The technique, over time, became less common as piped water systems expanded [22]. Currently, due to the increased need, water reuse has been rescued and practiced more frequently [26]; [4].

Assunção et al., [6] found a reduction in spending on the water bill, in addition to the indirect environmental gain through the use of non-potable water for less noble purposes such as flushing the toilet, washing the floors and using gardens through adoption rainwater collection and storage system.

For Salla et al. [28], it is necessary to present and encourage the use of rainwater collection and conservation systems. In view of the fact that water is a limited natural resource and essential to life, questions about the conservation and preservation of water resources have been the focus of studies by conservation organizations that seek alternatives for a better use of natural resources. Water use technologies are sustainable solutions and contribute to the rational use of water, providing the conservation of water resources for future generations [11], [21].

The lack of sustainability of agricultural projects, associated with increased water demands, whether for direct consumption or food production, has been growing worldwide [32], [25], [23], [15], [4]. This work aimed to identify components that allow the replacement of the current model of water supply in an agricultural research unit by the use of water collected from the rains. We sought to analyze demanding activities, volume used and quantity needed to be stored in order to replace the current model with a more sustainable one.

## II. MATERIAL AND METHODS

The work was carried out at the research station of IDR-Paraná-Institute of Rural Development of Paraná-Iapar-Emater, in the municipality of Ponta Grossa, Paraná, in 2015. The total area of the unit is 438 hectares (ha), of which of these 170 ha are used for agricultural research purposes and the rest of the area comprises: permanent reserves, legal reserves and construction areas. The agricultural areas of the farm where the research experiments are carried out are managed with the use of agrochemicals during the year, this practice demands water as a means of transport for the other sprayed products.

Vehicle washing is carried out at the unit itself, which has a fleet of 05 wagon vehicles for travel, 05 popular vehicles, 05 utility vehicles 06 field vehicles, 14 tractors, 02 harvesters, 03 trucks and 01 buses.

Among the various buildings found on the property, a 13.6 m wide and 50 m long shed with a total area of 680 m2, with a fiber cement roof, was identified as potential for use in rainwater harvesting. and that has a gutter system installed, those with dimensions of 0.2 m wide and 0.1 m high, in addition to conductors of PVC pipes that direct rainwater to the drainage system of the station.

We sought to identify the demands for water use in the unit. For the design of the rainwater collection and storage system, the methodology proposed by the ABNT - NBR 10,844.1989 [2] standard was used. In order to calculate the ratio of intensity, duration and frequency - IDF, equation 1, below, was used:

Equation (1) $I = ((K.(Trm))/((t + t0)n)$,

Where: I = intensity (mm / h); Tr = return time; t = time of concentration (minutes); K, m, t0, n = parameters determined on the spot, we used the values obtained by Frendrich apud Festi [14] we consider: K = 1902.39; m = 0.152; t0 = 21; n = 0.893. According to ABNT - NBR 10844 [2] the concentration time is 5 minutes (t) and the return time for roofs and roofs Tr = 5 years.

To calculate the collection area (roof), equation 2 was used:

Equation (2) $A = (a + h/2).b$,

Where: A corresponds to the contribution area (m²); a corresponds to the roof width (m); h represents the height of the scissors (m); b is the length (m), to calculate the total passive volume of water to be captured in that coverage [2].

Precipitation values were obtained from the website of the Instituto de Águas do Paraná [16], Table 01, which presents the monthly average for the municipality of Ponta Grossa in the last 40 years, in addition to the number of rainy days during the months in that period. [17].

Where: A corresponds to the contribution area (m²); a corresponds to the roof width (m); h represents the height of the scissors (m); b is the length (m), to calculate the total passive volume of water to be captured in that coverage [2].

Precipitation values were obtained from the website of the Instituto de Águas do Paraná [16], Table 01, which presents the monthly average for the municipality of Ponta Grossa in the last 40 years, in addition to the number of rainy days during the months in that period.[18].

*Table 01 - Average rainfall in (mm) and number of rainy days in the last 40 years.*

| Month | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sep. | Octo. | Nov. | Dez. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average (mm) | 171 | 162,7 | 142 | 100 | 123 | 111,4 | 115 | 82,5 | 147,4 | 156,5 | 142,8 | 164,3 |
| Rainy days | 14,4 | 13,5 | 11,6 | 7,9 | 7,8 | 7,7 | 7,2 | 6,4 | 9,9 | 10,9 | 10,7 | 12,6 |

Source: Adapted from: Instituto de Águas do Paraná Station installed on 10/01/1975. Tibagi basin. Lat: 25 12 '00" Lon 50 09 '00".

Dornelles et al. [12], consider months of little or no rain to show rainfall below 100 mm, with rainfall data representing the amount of rain for a given region, with 1 mm of water being equivalent to 1 liter of rainwater that falls. in a square meter.

Next, the project flow rate was calculated which corresponds to the total volume that can be collected in the area, using equation 3

Equation (3) $Q = ((I \cdot A)/60)$

Where: A = contribution area (m²); I = rainfall intensity (mm / h); Q = design flow (L / min) [2].

The use of rainwater for non-potable use in Brazil is standardized by ABNT NBR 15.527 [3], in which rules are established for the collection system through gutters and conductors, observing the need to install devices for the minimum disposal of the first two milliliters (mm).

As it is necessary to consider that not all collected water is used, since it is recommended that the first water be discarded, since it cleans the collection area, thus ABNT - NBR 15.527 [3], suggests the disposal of first 2L / m², to calculate the disposal volume, equation 4 was used:

Equation (4) $V = Ac \cdot 2,$

Where V is volume (L), Ac is the collection area (L) and 2 mm is the value considered necessary for the initial cleaning of the roof, the volume (precipitation) necessary for cleaning the roof was calculated, with the equation 5:

Equation (5) $V = P \cdot A \cdot C \cdot \eta$

Where, V = the precipitation volume in (L), P = precipitation in (mm), A = contribution area and C. ŋ = runoff coefficient, whose adopted value was 0.8 to calculate the usable rainfall volume.

In sizing the reservoir, the Azevedo Neto methodology was used, as recommended by ABNT - NBR 15,527 [3], to calculate the volume of rainwater, equation 6,

Equation (6) $V = 0,042 \times P \times A \times T$

Where: P - average annual precipitation, (mm); T - number of months of little rain or drought; A - collection area, (m²); V - volume of water in the reservoir, (L). We emphasize that ABNT - NBR 15,527 [3], establishes the need for maintenance in the entire system for the use of rainwater.

## III. RESULTS AND DISCUSSION

The rainwater harvesting system for non-potable consumption is an unconventional measure in southern Brazil. Currently, the use of rainwater is practiced in countries such as the United States, Germany, Japan, among others [19], [31], [20].In Brazil, the system is used in some cities in the Northeast as a source of water supply. The feasibility of using rainwater is characterized by a decrease in the demand for water supplied by the sanitation companies, with the consequence of lowering the costs with drinking water and reducing the risk of flooding in the event of heavy rains [10].

In the present work, a technical analysis of the site was carried out in order to map demand systems for the water used in the unit. The station uses water in flushing boxes, showers, toilets, washing environments, washing vehicles and spraying agrochemicals, in addition to human consumption.

With this information, two demand systems were established that can be replaced by the use of non-potable water, rain collection, with relative ease of installation and low investment, the vehicle washing system and the use in agrochemical applications.

Through a survey with those responsible for the sector, it was possible to ascertain that vehicle washes are carried out throughout the month, in addition, tractors, buses, seeders and harvester are washed, but in a much lower frequency, thus an average of 25 washes during each month.

The washing system installed has an average flow rate of 24 L / minutes, which is measured with a gallon with graduation through the volume of water collected in one minute. Due to the great variation of types of vehicles that

pass through the washing system and the situation that reaches it, from dusty to very muddy, it is difficult to establish an exact amount of water used in the system, thus the average quantity was measured of water used when washing vehicles, with an average of 196 liters of water being washed. Silva et al., [30] observed 90 to 110 liters of water spent per vehicle in a car wash.

In order to work with a safety margin, we will set the value recorded in the local wash as the reference value. Therefore, as the monthly consumption is 196 L / vehicle, multiplied by 25 (number of vehicles washed during the month), it totals 4.900 liters of water.

The station uses several agrochemicals to manage its annual crop areas that are sprayed at a rate of 200 liters of water per hectare (ha), with the total arable area being 170

ha, it is necessary to note that spray rates and species cultivated crops change from one crop to another, so an estimate for the 2014/2015 crop was considered. Table 02 shows the main crops produced in the season, as well as the demand for agrochemical applications in each of them during the 2014/2015 season.

Thus, it is estimated that 242.000 liters of water are used per year for the application of agrochemicals. These applications are carried out during the crop phases (Table 03), with the month of November presenting the highest consumption demand, with an estimated need of 51.800 liters for this purpose during that month, currently the water used comes from an artesian well dug in the property.

*Table 02: Water demand for total spraying and for each crop. Ponta Grossa, Paraná. 2015.*

| Culture | Total area (ha) cultivated in summer | Total cultivated area (ha) Winter | Number of Agrochemical Applications | Volume of water used per crop L / ha | Total water expenditure (Liters) |
|---|---|---|---|---|---|
| Soy | 70 | 0 | 8 | 1.600 | 112.000 |
| Corn | 70 | 0 | 5 | 1.000 | 70.000 |
| Bean | 10 | 0 | 7 | 1.400 | 14.000 |
| Wheat | 0 | 10 | 5 | 1.000 | 10.000 |
| Ground cover | 20 | 160 | 1 | 200 | 36.000 |
| Total | | | | | 242.000 |

Source: Data obtained from the administration of the experimental station 08 oct. 2015.

*Table 03: Water consumption (L) by crop during the 2014/2015 season.*

| Month | Soy | Corn | Bean | Wheat | Ground cover | Total |
|---|---|---|---|---|---|---|
| Jan. | 21.000 | | 1.200 | | | 22.200 |
| Feb. | 7.000 | | | | | 7.000 |
| Mar. | | | | | 12.000 | 12.000 |
| April | | | | | 12.000 | 12.000 |
| May | | | | 1.200 | 12.000 | 13.200 |
| June | | | | 800 | | 800 |
| July | | | | | | |
| Aug.o | | 14.000 | | 2.000 | | 16.000 |
| Sep. | 7.000 | 9.000 | 800 | 2.800 | | 19.600 |
| Octo. | 14.000 | 23.000 | 2.800 | 3.200 | | 43.000 |
| Nov. | 28.000 | 19.000 | 4.800 | | | 51.800 |
| Dez. | 35.000 | 5.000 | 4.400 | | | 44.400 |

Source: Data obtained from the administration of the experimental station 08 oct. 2015.

In this condition, the total value of water that can be replaced by non-potable water collected from the rain is 58.800 L for vehicle washing plus 242.000 L for spraying, totaling 300.800 L of water. In relation to the period of greatest demand, we have 4.900 L for vehicle washing plus 51.800 L for spraying, totaling 56.700 L for the month of greatest demand. For the calculation of the intensity, duration and frequency (IDF) ratio, equation 7 below was used:

Equation (7) $Imax = (K.(Trm))/(t + t0)n$

$Imax = (1902,39 . (50,152))/(5 + 21)0,893$

$Imax = 2429,65/18,35$

$Imax = 132,41$ mm

A maximum intensity of $Imax = 132.41$ mm was obtained for this station. According to ABNT –NBR 10,844 [2], it establishes for Ponta Grossa a value of $Imax = 126$ mm.

Through ABNT - NBR 10.844 [2] the surface area for rainwater collection was determined using equation 8

Equation (8) $A = ((a + (h/2)) .b$

$A = ((13,6 + (1,2/2)) .50$

$A = 14,2 . 50$

$A = 710$ m2

Where: A = Contribution area (m²); a = Roof width 13.6 m; h = Scissor height 1.20 m; b = Roof length 50 m, with a contribution area of 710 m2. The collection area is represented by a 710 m2 shed with a gutter system already installed. The month of August represents the period of lowest monthly precipitation for the city of Ponta Grossa according to data from the Instituto do Águas do Paraná [16], in a 40-year historical series the average rainfall recorded was 82.5 mm.

The average rainfall and the number of monthly rainy days, the average annual rainfall for the period 1975 - 2015 was 1601.9 mm according to data from the Instituto de Águas do Paraná [18]. Next, the project flow rate was calculated using Equation 9:

Equation (9) $Q = ((I .A)/60)$

$Q = ((132,41 . 710)/60)$

$Q = 94011,10/60$

$Q = 1566,85$ L/min

Where: A = contribution area (m²); I = rainfall intensity (mm / h); Q = design flow (L / min), with a flow rate of 1566.85 L per minute, ABNT - NBR 10844, [2].

According to ABNT -NBR-15527 [3] it is recommended the initial disposal of 2 liters of water for each m² of the area collected in this way, the self-cleaning reservoir is calculated by the equation 10 V = Ac .2 where V is the volume (L), Ac is the collection area (L) and 2 mm is the value considered necessary for the initial cleaning and a value of 1.420 L is calculated for cleaning the collection area.

Equation (10) $V = Ac . 2$

$V = 710 . 2$

$V = 1.420$ L

Using equation 5, the usable volume of rain was calculated for the month with the lowest precipitation (V1), August and for the month with the greatest demand (V2), November, with A = 710 m2, C. ɳ = 0.8, and P = 82.5 mm for August and P = 142.8 mm for November.

$V1 = P . A . C . ɳ$

$V1 = 82,5 . 710 . 0,8$

$V1 = 46.860$ L

$V2 = 142,8 . 710 .0,8$

$V2 = 81.110$ L

It is noted that the month of August, corresponding to the lowest annual precipitation, it is possible to collect more than 46 thousand liters, and the estimated demand in that month is 20.900 liters. In addition, for the month of November, the month with the highest demand of 56.700 L, it is possible to capture 81.110 L, with the values likely to be raised higher than the demands, providing viability to the system.

Applying equation 11, it was possible to determine the size of the reservoir, which was 47.768 liters, where P = 1601.9 mm; A = 710 m2 and T = 1:

Equation (11) $V = 0,042 x P x A x T$

$V = 0,042 . 1601,9 . 710 . 1$

$V = 47.768,87$ L

For the use of the system it is important to install a filter that performs the retention of solid particles and allows the removal of leaves. It is intended that the collected water is conducted by PVC pipes of 100 mm to a reservoir with 2 boxes of 10.000 L installed next to the shed where the water will be collected, which is used for the car wash system that is 20 m from the reservoir and has a 5 hp pump.

The system will be composed of PVC pipes, swirling reducer and outlet thief which, after complete filling, will lead the water to a second reservoir through PVC pipes 100 mm, via gravity this second 10.000 L reservoir located at 120 m will be used to supply the sprayers.

In this regard, the implementation of the evaluated system is suggested, since most of the material needed for installation is available at the unit and there are employees available to perform the installation, the shed that will serve as the collection area already has PVC gutters and conductors that currently direct rainwater to the station's drainage system. This set of factors provided a great reduction in the initial investment costs, being a stimulating factor for the implementation of the system.

## IV. CONCLUSION

The presented system proves to be viable since the shed that will be used has a collection system and conductors are already installed, in addition to the labor available for the installation of the other components, factors that greatly reduced the cost of implementing the collection system rainwater.

The washing of vehicles and the use of water for agricultural spraying can be carried out using the water collected from the rain.

The use of rainwater for non-potable purposes contributes to the decrease in the demand for water supplied by the sanitation company, with the consequence of lowering the costs with potable water. Contributing to the rational use of this resource.

## REFERENCES

[1] ABES – Associação Brasileira de Engenharia Sanitária e Ambiental. Perdas em sistemas de abastecimento de água: diagnóstico, potencial de ganhos com sua redução e propostas de medidas para o efetivo combate. Setembro de 2013. Disponível em <http://www.abes-sp.org.br/arquivos/perdas.pdf>. Acessado em 22/09/2015

[2] ABNT – ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS NBR 10.844/1989. Instalações prediais de águas pluviais. Rio de Janeiro, 1989.

[3] ABNT – ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS NBR 15.527/2007. Água de chuva – Aproveitamento de coberturas em áreas urbanas para fins não potáveis – Requisitos. Rio de Janeiro, 2007.

[4] Albornoz, L. L., Centurião, T. C., Giacobbo, A., Zoppas-Ferreira, J., & Bernardes, A. M. (2020). Influence of rain events on the efficiency of a compact wastewater treatment plant: a case study on a university campus aiming water reuse for agriculture. Environmental Science and Pollution Research, 1-11. https://doi.org/10.1007/s11356-020-10102-w

[5] Almeida, N. C. C., Santos Junior, C. F. D., Nunes, A., & Liz, M. S. M. D. (2019). Educação ambiental: a conscientização sobre o destino de resíduos sólidos, o desperdício de água e o de alimentos no município de Cametá/PA. Revista Brasileira de Estudos Pedagógicos,

100(255), 481-500. https://doi.org/10.24109/2176-6681.rbep.100i255.4007

[6] Assunção, L. V., Assunção, R. V., de Castro Bolina, C., Gomes, M. I. L., Moreira, S. J., & Junior, A. B. M. (2019). Residencial pontal das brisas: estudo dos benefícios gerado pelo aproveitamento de água de chuva para fins não potáveis/Pontal das brisas residential: study of the benefits generated by the use of rainwater for non-potable purposes. Brazilian Journal of Development, 5(5), 3501-3509. https://www.brazilianjournals.com/index.php/BRJD/article/view/1512/1394

[7] Bacci, D. D. L. C., & Pataca, E. M. (2008). Educação para a água. Estudos avançados, 22(63), 211-226. Disponível em <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-40142008000200014&lng=en&nrm=iso>. Acessado em 03/10/2016

[8] Boian, R. F., Macedo, D. O., Oliveira, P. J. A. D., & Janzen, J. G. (2019). Comparação entre as equações de FAVAD e geral para avaliação da vazão perdida por meio de vazamentos em sistemas urbanos de distribuição de água. Engenharia Sanitaria e Ambiental, 24(6), 1073-1080. https://doi.org/10.1590/s1413-41522019195402

[9] Cardoso, D. K., Fernandes, L. V. O., Fernandes, C. E., de Araújo Fernandes, L. I. F., & Argolo, E. D. (2020). Reutilização de água: uma alternativa para o desperdício e economia da água em residências/Water reuse: an alternative to waste and saving water in homes. Brazilian Journal of Development, 6(5), 24566-24581. https://doi.org/10.34117/bjdv6n5-056

[10] Couscous, A., Baali, A., & El Kamel, T. (2020). Study of the Possibility of Reusing Rain and Purified Water in the City of Fez, Morocco. Journal of Water Resource and Protection, 12(02), 120. https://doi.org/10.4236/jwarp.2020.122008

[11] de Souza Celente G, Colares GS, Machado ÊL et al (2019) Algae turf scrubber and vertical constructed wetlands combined system for decentralized secondary wastewater treatment. Environ Sci Pollut Res 26:9931–9937. https://doi.org/10.1007/s11356-019-04425-6

[12] Dornelles, F., Tassi, R., & Goldenfum, J. A. (2010). Avaliação das técnicas de dimensionamento de reservatórios para aproveitamento de água de chuva. Revista Brasileira de Recursos Hídricos, 15(2), 59-68. Disponível em <https://www.abrh.org.br/sgcv3/UserFiles/Sumarios/69a0515c226924e0ca62c586e8f5cbbe_53a7198f8288dc36d419639d3f37702c.pdf>. Acessado em 02/10/2018.

[13] El Tugoz, J., Bertolini, G. R. F., & Brandalise, L. T. (2017). Captação e aproveitamento da água das chuvas: o caminho para uma escola sustentável. Revista de gestão ambiental e sustentabilidade, 6(1), 26-39. http://revistageas.org.br/ojs/index.php/geas/article/view/396

[14] FESTI, A. P. Coletânea das Equações de Chuvas do Brasil. XVII Simpósio Brasileiro de Recursos Hídricos, São Paulo,

2007. Disponível em <http://www.abrh.org.br/sgcv3/UserFiles/Sumarios/ 13d9cc04b7caac079904ef66fcb35ee3_b43668dc3c5475341b32596fab9ac0b8.pdf>. Acessado em 03/10/2015.

[15] Gabardo, G., Dalla Pria, M., Silva, H., & Harms, M. (2020). Alternative Products to Control Soybean Downy Mildew in the Field. Journal of Agricultural Science. 12. 160. https://doi.org/10.5539/jas.v12n8p160

[16] INSTITUTO DE ÁGUAS DO PARANÁ. Sistemas de informações hidrológicas - Relatório de Alturas Mensais de Precipitação. Disponível em: < http://www.sih-web.aguasparana.pr.gov.br/sih-web/gerarRelatorioAlturasMensaisPrecipitacao.do?action= carregarInterfaceInicial>. Acessado em 22/09/2015a.

[17] INSTITUTO DE ÁGUAS DO PARANÁ. Sistemas de informações hidrológicas - Relatório de dias de chuva. Disponível em: <http://www.sih-web.aguasparana.pr.gov.br/sih-web/gerarRelatorioDiasChuva.do?action=carregarInterface Inicial>. Acessado em 22/09/2015b.

[18] INSTITUTO DE ÁGUAS DO PARANÁ. Sistemas de informações hidrológicas – Alturas de precipitação resumo anual. Disponível em: <http://www.sih-web.aguasparana.pr.gov.br/sih-web/gerarRelatorioAlturasAnuaisPrecipitacao.do?action=c arregarInterfaceInicial>. Acessado em 22/09/2015c.

[19] Lazarova, V., Levine, B., Sack, J., Cirelli, G., Jeffrey, P., Muntau, H., & Brissaud, F. (2001). Role of water reuse for enhancing integrated water management in Europe and Mediterranean countries. Water Science and Technology, 43(10), 25-33. https://doi.org/10.2166/wst.2001.0571

[20] Li, W. W., Yu, H. Q., & Rittmann, B. E. (2015). Chemistry: reuse water pollutants. Nature, 528(7580), 29-31. doi:10.1038/528029a

[21] Masmoudi Jabri K, Nolde E, Ciroth A, Bousselmi L (2020) Life cycle assessment of a decentralized greywater treatment alternative for non-potable reuse application. Int J Environ Sci Technol 17:433–444. https://doi.org/10.1007/s13762-019-02511-3

[22] Miller, G. W. (2006). Integrated concepts in water reuse: managing global water needs. Desalination, 187(1-3), 65-75. https://doi.org/10.1016/j.desal.2005.04.068

[23] Moretti M, Van Passel S & Camposeo S (2019) Modelling environmental impacts of treated municipal wastewater reuse for tree crops irrigation in the Mediterranean coastal region. Sci Total Environ 660:1513–1521. https://doi.org/10.1016/j.scitotenv.2019.01.043

[24] Norete, D. N., Correia, Q. B., & José, J. F. B. S. (2018). Qualidade da água utilizada em quiosques de praia. Revista Ambiente & Água, 13(2). http://dx.doi.org/10.4136/ambi-agua.2003

[25] Petousi I, Daskalakis G, Fountoulakis MS, Lydakis D, Fletcher L, Stentiford EI, Manios T (2019) Effects of treated wastewater irrigation on the establishment of young grapevines. Sci Total Environ 658:485–492. https://doi.org/10.1016/j.scitotenv.2018.12.065

[26] Santos, M., Carvalho, C. L. S., Dias, F. C., Reis, M. F., & Ramos, J. C. (2016). ANÁLISE DA VIABILIDADE ECONÃ MICA DE UM SISTEMA DE CAPTAÇÃO DE ÁGUA DA CHUVA: ESTUDO DE CASO DE UMA INDÚSTRIA DE REFRIGERANTES. Revista Produção Industrial e Serviços, 3(1), 50-63. http://periodicos.uem.br/ojs/index.php/rev_prod/article/view/52351

[27] Santos, G. G., França, R., Duarte, S. F. P., Figueredo, R. M. de, Sousa, B. R., David, I. R., Bittencourt, F. de O., & Souza, F. M. de. (2019). Physical-Chemical and Microbiological Evaluation from Domiciliary Reservoirs. International Journal of Advanced Engineering Research and Science, 6(5). Recuperado de http://journal-repository.com/index.php/ijaers/article/view/798

[28] Salla, M. R., Lopes, G. B., Pereira, C. E., Moura Neto, J. D. C., & Pinheiro, A. M. (2013). Viabilidade técnica de implantação de sistema de aproveitamento de água pluvial para fins não potáveis em universidade. Ambiente Construído, 13(2), 167-181. https://doi.org/10.1590/S1678-86212013000200013

[29] Shiklomanov, I. A., & Rodda, J. C. (Eds.). (2004). World water resources at the beginning of the twenty-first century. Cambridge University Press. Disponível em <http://webworld.unesco.org/water/ihp/db/shiklomanov/summary/html/summary.html>. Acessado em 07/08/2015.Llllll

[30] Silva, A. A. R. D., Camara, C. A. P. D., Lobo, I., Scarmínio, I. S., & Alves, J. C. (2017). Otimização dos parâmetros operacionais de eletrocoagulação aplicada à recuperação de efluentes de lavagem de veículos. Engenharia Sanitaria e Ambiental, 22(1), 179-186. http://dx.doi.org/10.1590/s1413-41522017111063

[31] Snyder, S. A., Leising, J., Westerhoff, P., Yoon, Y., Mash, H., & Vanderford, B. (2004). Biological and physical attenuation of endocrine disruptors and pharmaceuticals: implications for water reuse. Groundwater Monitoring & Remediation, 24(2), 108-118. https://doi.org/10.1111/j.1745-6592.2004.tb00719.x

[32] Svehla P, Radechovsky J, Hrncirova H, Pacek L, Bartacek J (2015) Effect of influent nitrogen concentration on feasibility of short-cut nitrification during wastewater treatment in activated sludge systems. Chem Pap 69:921–929. https://doi.org/10.1515/chempap-2015-0095

[33] Zulauf, W. E. (2000). O meio ambiente e o futuro. Estudos avançados, 14(39), 85-100. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-40142000000200009&lng=en&nrm=iso>. Acessado em 03/10/2015.

# Surface Water Quality Modeling of a watershed in the north of Rio Grande do Sul

Rodrigo Henryque Reginato Quevedo Melo[1], Mozara Benetti[2], Evanisa Fátima Reginato Quevedo Melo[3], Ricardo Henryque Reginato Quevedo Melo[2]

[1]Postgraduate Program in Civil Engineering, IMED, Passo Fundo-RS-Brazil
[2]PhD Program in Civil Engineering, UFRGS, Porto Alegre-RS-Brazil
[3]Department of Engineering and Architecture, UPF, Passo Fundo-RS-Brazil

*Abstract—The water crisis and the degradation of surface water resources through pollution, combined with the progressive increase in consumption has made it necessary to search for alternative sources of supply.. Because it is a finite natural resource, water is a public good that needs to be allocated among different uses and has its integrity compromised by factors such as industrial development, rapid urbanization and population growth. Considering these issues recognize and evaluate the potential of local water resources is necessary, since the River Inhandava is inserted in the north-northeastern state of Rio Grande do Sul, in the Uruguay river basin and watershed belongs to Apuaê-Inhandava. The objective of this research was to perform the modeling of surface water quality of the River Inhandava-RS. The data were inventoried quality of studies conducted in Rio were considered diffuse agricultural loads, animal waste and sewage. To assess the water quality of the Rio Inhandava, the computer model was used QUAL2Kw. The water quality has been shown, for most parameters, according to Resolution CONAMA 357/2005. The calibrated model QUAL2Kw, became an instrument to in the management of water resources, since the analysis of the results showed the selfpurification in downstream river study.*

*Keywords—Water Resources, Environmental Quality, Modeling.*

## I. INTRODUCTION

Water availability represents one of the limiting factors for a region's socioeconomic development. Water, which is a finite natural resource, is also a public domain asset, which needs to be allocated between different uses and whose integrity is compromised by factors such as industrial development, accelerated urbanization and demographic growth. Considering these issues, recognizing and evaluating the potential of local water resources is necessary, since the Inhandava River is inserted in the north-northeast region of the state of Rio Grande do Sul, in the Uruguay hydrographic region and belongs to the Apuaê-Inhandava hydrographic basin, being an important source of public supply for the municipality of Sananduva and a place of leisure in at least eight points along the river. According to the Environmental Secretariat of Rio Grande do Sul State, the largest polluting loads in the basin, where the river is located, are from domestic effluents and pig farming.

The management of water resources is the way in which it is intended to equate and resolve issues of relative scarcity of water resources, as well as to make the appropriate use, aiming at the optimization of resources for the benefit of society, which is carried out through integrated planning and management procedures. administration [1].

The water quality models are essential links to management, since they aim to predict a concentration of a certain pollutant in the water body as a function of a specific polluting load or not [2].

The use of water quality modeling can be considered as an important tool to be used in studies of framing rivers, especially with regard to meeting progressive goals, according to what is established by CONAMA Resolution No. 357/05 [3].

For the modeling of surface water quality, it is necessary to identify the sources of pollution and their launch points in the water bodies. In addition to, the

knowledge of the forms of interaction existing between the processes that take place in the basin, with the physical, chemical and biological processes that occur in the rivers. With the modeling of certain water quality variables, it is possible to estimate the acceptable limit of self-purification of these rivers, in order to guarantee the necessary quality for the use for which they are destined and, therefore, their real condition of framing [4].

The modeling of water quality emerged in order to provide useful information on mechanisms and interactions that justify the varied dynamic behaviors of water, constituting a rational basis for decision making in the management of water resources. Where it is possible to explain some properties of the system, mainly to quantify the self-cleaning capacity of the water body, thus anticipating the impacts resulting from a possible polluting discharge.

The objective of this research was to perform the modeling of water quality parameters (Biochemical Oxygen Demand (BOD); Dissolved Oxygen (DO) and Total Coliforms) of the Inhandava River - RS.

## II. METHODOLOGY

The Inhandava River microbasin includes the municipalities of Lagoa Vermelha, Caseiros, Ibiaça, Santo Expedito do Sul, Sananduva, Cacique Doble, São João da Urtiga, Paim Filho, Maximiliano de Almeida, Machadinho, São José do Ouro, Capão bonito and Tupanci do Sul (Fig. 1). The river rises in the municipalities of Lagoa Vermelha and Caseiros and flows into the Uruguay River.

Melo and Astolfi [5], monitored the water quality of the Inhandava River at 16 points along the river, and in this study only twelve points were considered. Table 1 shows the geographical coordinates of the inventoried points.

Figure 2 shows the Inhandava River microbasin delimited by the Ottocodified form.
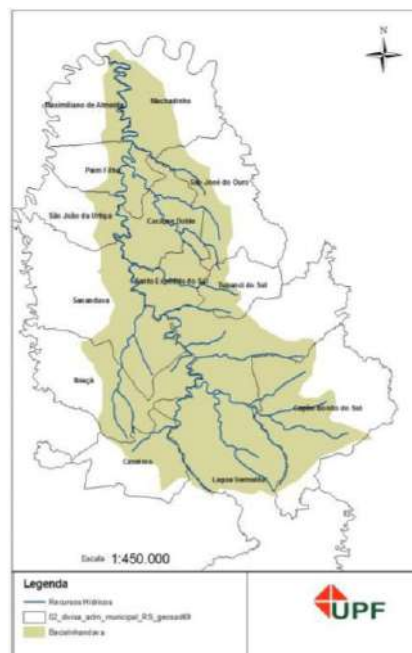


*Fig. 1: Location of the municipalities of the Inhandava River watershed.*

*Table.1: Geographic coordinates of collection points in Rio Inhandava-RS*

| Spot | Longitude | Latitude | Elevation (m) | Location (km) |
|------|-----------|----------|---------------|---------------|
| 1 | -51,3994188 | -28,1914137 | 842 | 26,7 |
| 2 | -51,4526527 | -28,1888668 | 729 | 33,6 |
| 3 | -51,5246755 | -28,1424544 | 686 | 48,3 |
| 4 | -51,6343324 | -28,0475590 | 675 | 64,6 |
| 5 | -51,6433833 | -28,1817566 | 632 | 84,3 |
| 6 | -51,6448763 | -27,9934335 | 596 | 97,3 |
| 7 | -51,7109516 | -27,9589900 | 588 | 106,3 |
| 8 | -51,7348512 | -27,9333331 | 577 | 116,9 |
| 9 | -51,7541818 | -27,8778018 | 576 | 152,0 |
| 10 | -51,7486111 | -27,7125231 | 574 | 162,7 |
| 11 | -51,7366667 | -27,6783333 | 564 | 171,7 |
| 12 | -51,7266000 | -27,6525000 | 504 | 181,7 |
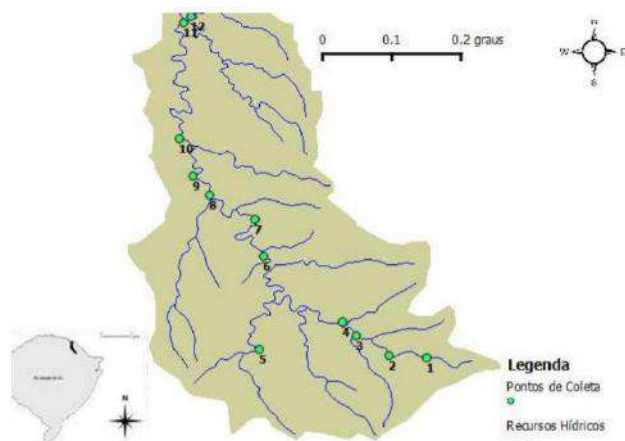
*Fig. 2: Location map of the studied points.*

In order to support the evaluation and modeling of water quality, it was necessary to determine the flow, in which values were determined only for the points 1, 7 and 10. For point 1 (km 26.7), which symbolizes the spring conditions, the flow was determined according to the conventional method (area-velocity), internationally certified by the European standard ISO 748 [6], which involves measuring velocity in several verticals (sections) of the river and in several depths for each of these.

The other points 7 (106.3 km) and 10 (162.7 km) were inventoried according to information provided by CORSAN (data referring to the water supply station for the municipality of Sananduva) and by ANA (Passo do Granzotto station), there are no other flow measurement stations along the route of the Inhandava River.

The model used for the present work was the QUAL2Kw regulated by the North American Environmental Protection Agency (U.S. - Environmental Protection Agency - EPA) [7]. The QUAL2Kw program is one of the modeling programs for surface water quality with great complexity, however its modeling of water quality is a valuable tool in Environmental Engineering, providing foreseeing and evaluating for different scenarios such as the changes in water quality of the river under study in this work.

The Qual2Kw model requires some data to be entered to perform the simulations: Coordinates and discharge coefficients in the stretches, distance between the mouth of the main river and the stretch; Altitude and slope of the stretches; Concentrations of Biochemical Oxygen Demand, Dissolved Oxygen, Water Temperature and Total Coliforms and Flow at Collection Points; Kinetic coefficients, such as the global BOD removal coefficient, re-coefficient, bacterial decay rate. Along the route, the river may receive contributions from tributaries and the

discharge of sewers, or abstractions, which may contribute to the increase or decrease in the volume of water in the source.

For the calibration of the model, it is necessary to insert monitored data, which include hydraulic data (flow) and water quality (BOD, DO, total coliforms).

## III. RESULTS

The flow is determined by the amount of water that passes through a certain section of a free conduit, in this case the river under study, for a unit of time. As shown in Figure 3, the average flow increases downstream of the river. The river channel also increases, being at first a small stream and at 162.7 km a river expressive in size and flow. With the increase in flow from 8.00 m³/s to 50.60 m³/s, the effluent loads are more dispersed, facilitating the self-cleaning of the river and consequently increasing its aeration power.
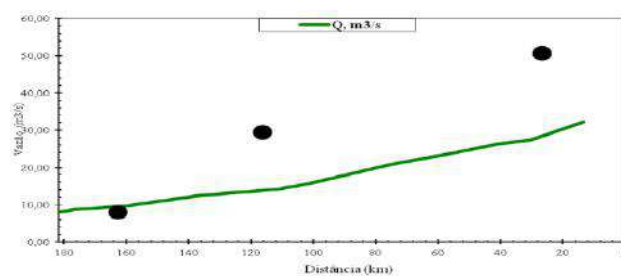


*Fig. 3: Flow simulation along the longitudinal axis of the Inhandava River*

The increase in flow rates may have a beneficial character, as a greater dilution of pollutants may occur. However, if this increase in flow occurs during periods of rain, it may also imply an increase in the loading of solids into the bed of springs, silting up rivers and streams.

The BOD shows the amount of oxygen needed to oxidize the biodegradable organic matter in the water. The greater the amount of organic matter present, the greater the amount of oxygen needed for its decomposition and at the level that the organic matter goes down, the decomposing bacteria will need small amounts of oxygen to decompose it, so the BOD will be low. The simulation of the BOD concentration for the stretch under study is shown in Figure 4.
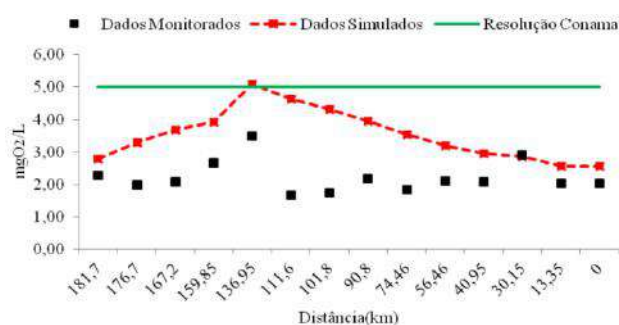
*Fig. 4: Monitored and simulated data on the Biochemical Oxygen Demand*



*Fig. 5: Simulation of Dissolved Oxygen*

In the analysis of the results of the water of the Inhandava River, the BOD varied considerably in several points, due to the diverse uses occurring in the river plains and climatological variations mainly in the pluviometric quantity. In the analysis of the BOD simulation, a reduction is observed along the simulated segment, going from 2.78 mg/L to 2.56 mg/L. This reduction may be directly related to the river's self-cleaning capacity. When there is no change in the degradation rate according to Silvino [8], possibly the reduction in BOD is due to the dilution of the organic load with the increase in the flow from the upstream to the downstream.

Dissolved oxygen (DO) is the most important parameter to express the quality of an aquatic environment, since it is fundamental for the maintenance of aerobic aquatic organisms [9] [10]. Normally, natural waters have a concentration around 8.0 mg/L at 25ºC, with the minimum concentration for maintaining aquatic biota in the range of 2.0 mg/L to 5.0 mg/L.

The concentration values of dissolved oxygen in the monitored points of the Inhandava River are above 5.0 mg/L established by Conama Resolution 357/2005, reaching high values in some samples, due to a period of river flooding, which is when the dilutions of the contaminants occur and there is a greater incorporation of oxygen by the waterfalls over the period of the river. Figure 5 expresses the values corresponding to the monitored DO data and the calibrated data in the Qual2kw model over space.

According to Vong Sperling [11], shallower and faster bodies of water tend to have a higher reaction coefficient, around 1,15 d-1 due to the ease of mixing along the depth and the greater turbulence on the surface. For the Inhandava River, a 3,0 d-1 reaeration coefficient was obtained, with a better calibration adjustment in the DO concentration.

The DO concentration is considered one of the most important variables when defining the condition of the watercourse and assessing whether it is within the limits of the class of its environment, making it a good indicator of the capacity that a water body has to promote the self-purification of organic matter discarded in its course.

The DO concentration decreases over the segment under study, varying from 8.55 mg/L to 8.47 mg/L, and the maximum concentration of this parameter did not exceed the value of 8.67 mg/L. According to Bárbara [12], the reduction in the DO concentration can be directly related to the temperature variation, knowing that these parameters are inversely proportional, the higher the temperature the lower the DO concentration in the water.

Determining the concentration of coliforms is an important indicator of the possibility of pathogenic microorganisms that are responsible for the transmission of waterborne diseases, such as typhoid fever, paratyphoid fever, bacillary dysentery and cholera.

The concentrations of total coliforms showed increases from upstream to downstream, which may be due to the presence of an urban perimeter, showing the strong influence of urban sewers in the contribution to the increase of the levels of this variable in the river. Figure 6 shows the concentration of total coliforms along the longitudinal axis of the 181, 7 km in study of the Inhandava River.
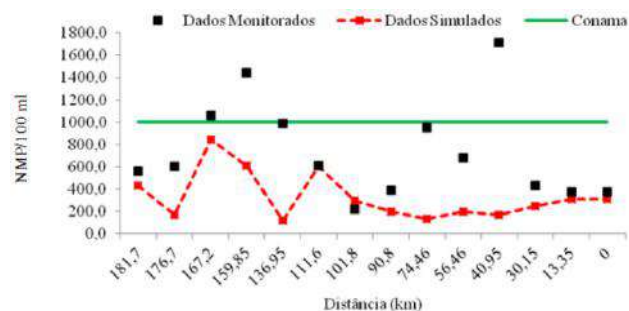
*Fig. 5: Concentration of total coliforms along the longitudinal axis of the Inhandava River*

## IV.    CONSLUSION

The water quality, from the analyzed parameters, showed variations in the results, but without any visible spatial behavior, this is due to the use of the hydrographic micro basin being mostly agricultural and livestock, being diffuse sources of pollution, where contamination by these activities depends a lot on climatic factors. The river framework based on CONAMA Resolution 357/05, for the purpose of comparisons, showed results of high parameters of Coliforms demonstrating a possible pollution by swine manure.

The flow determined at the point one was 8 m³/s, reaching 50.60 m³/s at the point ten, thus increasing downstream of the river, this increase in flow facilitates the self-purification of the medium and consequently the aeration power of the river.

With the evaluation of the quality and calibration data, it is clear that the Inhandava River does not have critical levels of pollution, since extreme levels of concentrations have not been reached, but it must be emphasized that its monitoring have relevant importance in order to make possible the diagnosis of future impacts on this water resource, which is of fundamental importance for the northern region of the state of Rio Grande do Sul.

### REFERENCES

[1] Setti, A. A., Lima, J. E. F. W., Chaves, A. G. D. M., & Pereira, I. D. C. (2001). Introdução ao gerenciamento de recursos hídricos.

[2] Albertin, L. L. (2008). Técnica de gerenciamento da qualidade hídrica superficial baseada na otimização multiobjetivo (Doctoral dissertation, Universidade de São Paulo).

[3] CONAMA (2005) - Conselho Nacional do Meio Ambiente. Resolução n° 357/05. Estabelece a classificação das águas doces, salobras e salinas do Território Nacional.

[4] KNAPIK, H. G. (2009). Reflexões sobre monitoramento, modelagem e calibração na gestão de recursos hídricos: estudo de caso da qualidade da água da Bacia do Alto Iguaçu.

[5] MELO, E F R Q; ASTOLFI, R M. (2011). Relações entre Geologia, Geomorfologia, Pedologia e Cobertura Vegetacional em Ambientes Fluviais do Rio Inhandava – RIO GRANDE DO SUL.

[6] INTERNATIONAL STANDARDS ORGANIZATION. (2007). Measurement of liquid flow in open channels - Velocity-area methods. Hydrometry - ISO-748:2007.

[7] SILVINO, A. N. D. O. (2008). Avaliação e modelagem da qualidade da água da bacia do rio Coxipó, no município de Cuiabá-MT. Cuiabá, MT.

[8] ENVIRONMENTAL PROTECTION AGENCY. (2012) Stream water quality model (QUAL2K).

[9] Maciel Jr, M. J. (2000). Zoneamento das águas: um instrumento de gestão dos recursos hídricos. Instituto Mineiro de Gestão das Aguas.

[10] Libânio, M. (2008). Fundamentos de qualidade e tratamento de água. Átomo.

[11] Von Sperling, M. (2007). Estudos e modelagem da qualidade da água de rios. DESA/UFMG.

[12] BÁRBARA, V. (2006). Uso do Modelo QUAL2E no Estudo da Qualidade da Água e da Capacidade de Autodepuração do Rio Araguari–AP (AMAZÔNIA). Goiânia, GO (Doctoral dissertation, Dissertação de Mestrado. Universidade Federal de Goiás).

# Productive Performance of Tomatoes under Fertigation Management

Pedro Henrique Máximo de Souza Carvalho[1], Jamerson Silva e Silva[2], Sérgio Oliveira Pinto de Queiroz[2], João Vitor Máximo de Souza Carvalho[3]

[1]Post-Graduate Program in Agricultural Engineering at the Federal Rural University of Pernambuco – UFRPE, Recife, Pernambuco - Brazil
[2]Department of Technology and Social Sciences - State University of Bahia - UNEB, Juazeiro, Bahia - Brazil
[3]Post-Graduate Program in Medical Physics at the University of São Paulo – USP, São Paulo - Brazil

*Abstract*— *Tomato is an important global commodity, with high socioeconomic expression in Brazil, due to consumer preference and wide availability of varieties. This work aimed to evaluate the use of solution extractors in the management of fertigation and monitoring of soil salinity, in the production of table tomato cultivars, under a protected environment. The experimental design used was in randomized blocks in a factorial scheme, with four fertigation management in the plots, and two table tomato cultivars in the subplots, repeating five times. Fruit length, fruit diameter, average fruit mass, productivity and water use efficiency were evaluated. The management of fertigation based on the replacement of the electrical conductivity of the soil solution, at levels of 10% and 25% provides tomato fruits with qualitative and quantitative characteristics similar to the conventional production system, with reduction in the consumption of fertilizers, having to cultivate nugget superior agronomic performance.*

*Keywords*— *Solanum lycopersicum; soil solution, salinity.*

## I. INTRODUCTION

The consumption of tomatoes has experienced a strong expansion in the world market in recent decades, making it an important global commodity, with a prominent place on the consumer's table, due to its vast availability of varieties (BORGUINI, 2006). According to Squariz (2017), such acceptance and diffusion are related to its nutritional richness, especially regarding the presence of vitamins, combined with its pleasant flavor and color.

Researchers have tried to develop production systems, especially regarding the quality and commercial characteristics of the final product, produced in a protected environment or not, reporting as fundamental factors on the production cycle those of a biotic nature, such as pests and diseases, or abiotic nature, such as water stress and salinity, among others (GINOUX and DAUPLÉ, 1985).

The productive system of table tomatoes requires knowledge of techniques in production processes, such as in the management of irrigation and fertigation, mainly in crops under a protected environment. Production in such environments makes cultivation out of season feasible, reduces costs and increases productivity and, when associated with new technologies such as irrigation and fertigation, provide good results (MEDEIROS et al., 2010).

The inadequate management of irrigation, the addition of fertilizers without technical control and the absence of rainfall in a protected environment can, as a consequence, cause the salinization of soils, impairing the yield of sensitive crops such as tomatoes (DIAS et a., 2005).

According to Medeiros (2010), the high concentrations of fertilizers in the irrigation water, associated with transpiration rates and the disregard of the physiology of the vegetables in such production conditions, increase the levels of salts in the root medium, and promote imbalance in water absorption. and solute for plants. Nery (2009) reports some problems caused by salinization, such as the decreased osmotic potential of the soil solution, decreasing water retention, increasing the dispersion of soil particles, decreasing the infiltration capacity and causing toxicity problems to plants. All of these factors result in decreased productivity.

According to Queiroz (2009) and Oliveira (2011), one of the practices that has been gaining prominence in the control of salinity caused by the excess of fertilizer

salts, is the constant monitoring of ions in the soil solution through electrical conductivity, due to the need to maintain the fertilizer stability. Among the equipment used for its speed of response and ease of handling, there is the porous capsule extractor, which promotes the removal of volumes of soil solution in the area occupied by the plant's roots (Silva et al., 2015).

In monitoring the soil solution, Silva (2001) confirms the efficiency of the porous capsule extractor for the management of fertigation, demonstrating accuracy in determining the ionic concentration of the soil solution and enabling the determination of potassium, nitrate, calcium and magnesium ions, with accuracy.

The porous capsule extractor technique is efficient in gauging and monitoring salinity from the soil solution, making it an alternative to manage nutrient distribution via water, effectively and at low cost, especially when related to taking of quick decisions in the field (Medeiros, 2010).

Aiming to increase efficiency, with regard to the management of nutrients in the soil solution, this work aimed to evaluate the use of soil solution extractors to aid in the management of fertigation, under production of tomato cultivars in a protected condition.

## II. MATERIAL

The work was carried out between January and April 2019 in the experimental field of the State University of Bahia, in the São Francisco Valley, municipality of Juazeiro, Bahia, under geographic coordinates 9 ° 24 'S latitude, 40 ° 30' W longitude and 368 m of altitude, in a protected environment with an area of 10 mx 24 m, a shading structure and a gray shading screen with a 40% shading percentage.

Two cherry tomato cultivars under production in the Northeast region were evaluated and which do not have data on nutrition, cv. Pepita and cv. Gota de Mel, whose sowing was carried out in polystyrene trays, in a greenhouse. Seedlings were transplanted when they reached 0.10 m in height, proceeding with cultivation in pots with a capacity of 5 liters.

The soil in the experimental area is classified as Floss Neossolo (SANTOS., et al 2013). A vertical staking system was used, with the help of strips and smooth wires, and the phytosanitary treatment was carried out weekly in order to keep the area free from pests and diseases.

A randomized block design was adopted, in a split plot scheme, with four fertigation management (Traditional method, based on the nutrient uptake of the crop; Control of the electrical conductivity of the soil solution under 10% variation limit; 25% and 50%) in the plots and two table tomato cultivars (Pepita - hereinafter called CV 1 and Gota de Mel - hereinafter called CV 2) in the subplots, repeated five times.

The elaboration of the artificial soil salinization curve consisted of tests that relate the electrical conductivity as a function of the concentration of fertilizer salts, obtained by regression analysis. The salts used, as well as their proportions, are shown in table 1.

With the relationship between the electrical conductivity of the soil solution (CEss) and the dissolved salts, in the desired proportions of fertilizers, the equation proposed by Richards (1954) was used to transform the electrical conductivity values into concentration (mg L$^{-1}$).

$$C = CEss * 640$$

Being:

C the concentration of fertilizer salts (mg L$^{-1}$);

CEss electrical conductivity of the soil solution (dS m$^{-1}$).

*Table 1. - Sources of fertilizer salts used in the preparation of the salinization curve and in fertigation management, with respective proportions of application to the soil.*

| FERTILIZERS | Solubility (g L$^{-1}$) | Saline Index (1,0 g L$^{-1}$) | Proportion (%) |
|---|---|---|---|
| Calcium nitrate | 250,00 | 82,25 | 42 |
| Potassium nitrate | 327,00 | 99,47 | 32 |
| Monoamonic Phosphate | 361,00 | 68,06 | 3 |
| Monopotassium Phosphate | 238,00 | 55,6 | 11 |
| Potassium Sulfate | 123,00 | 112,94 | 4 |
| Magnesium Sulfate | 500,00 | 91,45 | 8 |

The replacement of fertigation, based on the extraction of the solution from the soil, was only carried out when the electrical conductivity in the solution reached, on average, 10%, 25% and 50% of its initial level. The amount of fertilizer applied was adjusted so that the soil solution recovered the initial electrical conductivity level, based on the equation of the artificial salinization curve (figure 1). The traditional method, on the other hand, was carried out based on the nutrient uptake of the crop, based on Alvarenga (2004).
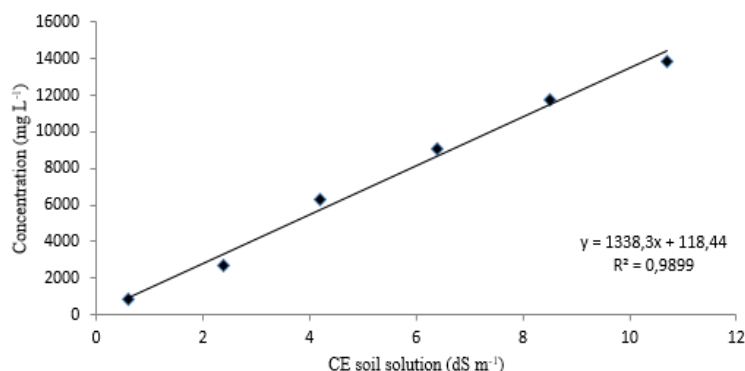


*Fig.1: Artificial salinization curve, relating the concentration of fertilizer salts and EC of the soil solution.*

The determination of daily water replenishment was based on the tensiometry method, with reference to the characteristic water curve, obtained in the laboratory (figure 2). The irrigation system was composed of three 2000 liter boxes, three 0.5 CV motor pumps, dripper tubes with 0.50 m spacing and 2 L h$^{-1}$ flow, under pressure of kgf cm$^{-2}$. The fertilizer injection occurred with the aid of a Venturi injector.
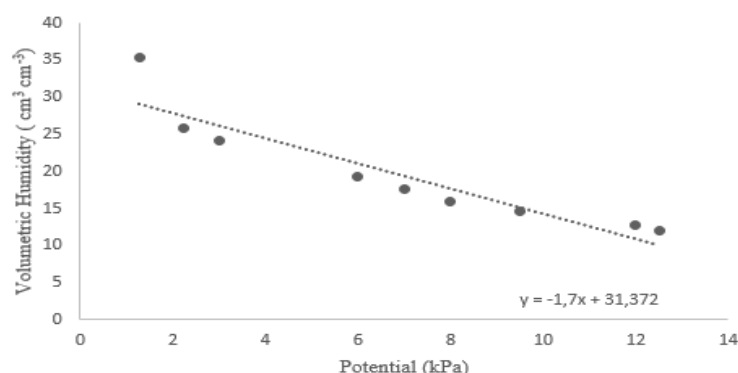


*Fig.2: Water characteristic curve of the soil used in the experiment*

*Table 2. - Chemical analysis of soil in the experimental area*

| pH | C.E | Ca$^{+2}$ | Mg$^{+2}$ | K$^+$ | Na$^+$ | SB | Al$^{+3}$ | H+Al$^{+3}$ | T | V | PST | P | Org. Mat. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H$_2$O | (dS cm$^{-1}$) | | | | (cmolc dm$^{-3}$) | | | | | (%) | (%) | (mg dm$^{-3}$) | (g kg$^{-1}$) |
| 5,7 | 0,02 | 2,62 | 1,81 | 0,16 | 0,04 | 4,63 | 0 | 0,15 | 4,78 | 96,9 | 0,83 | 58 | 5,82 |

Note: C.E - electrical conductivity, T - cation exchange capacity, V - percentage of base saturation, PST - percentage of exchangeable sodium, Org. Mat. - organic matter.

The variables analyzed were: fruit length (mm), fruit diameter (mm), average fruit mass (g), productivity (t ha-1) and water use efficiency (kg ha$^{-1}$ mm$^{-1}$).

For the evaluations, three harvests were carried out, at 50 days after transplanting (DAT), at 65 DAT, and at 77 DAT, with the harvested fruits having the same maturation stage.

The results obtained were subjected to analysis of variance, using the F test, and comparison of treatment averages with each other, adopting Tukey at 5%

probability, using the ASSISTAT version 7.6 software. (SILVA 2012)

## III.    RESULTS AND DISCUSSION

In addition to variables related to tomato crop production, during the experiment meteorological parameters obtained from an agrometeorological station installed in the area were monitored during the study period. The climatic data referring to the maximum, average and minimum temperatures (ºC) and relative humidity of the air (%) are shown in figure 3
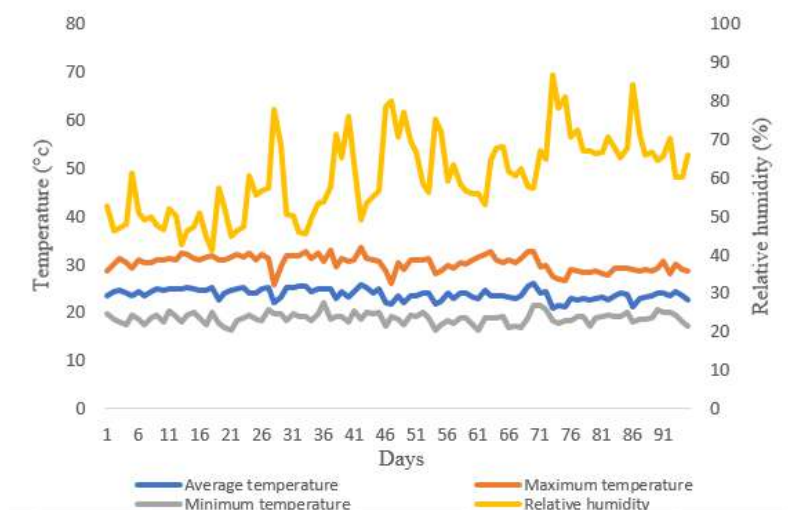


*Fig.3: Climatic data obtained over the experimental time*

During the tomato production cycle, the maximum, average and minimum air temperatures ranged between 26.4 and 34.3, 22.1 and 28.2 and 17.8 and 22.1 ºC, respectively.

The lowest values of relative humidity were observed shortly after transplanting until the beginning of flowering and, subsequently, the values increased until the end of the experiment. During the experimental period, there were no precipitations.

It was obtained, from the equation generated in the artificial soil salinization curve (Figure 1), a high correlation (R = 0.989) between the concentration of salts and the electrical conductivity of the soil solution, thus allowing to estimate the quantity of salts to be applied to the soil in order to obtain the desired electrical conductivity in the saturation extract and, with the aid of the curve and the use of soil solution extractors, it was possible to control the electrical conductivity of the soil solution.

Table 3 shows the amounts of fertilizer used throughout the experiment for each cultivar, depending on fertigation management.

*Table 3. - Quantity of fertilizers applied to the cultivars of tomato Pepita and Gomo de mel, under different limits of replacement of fertilizers based on the electrical conductivity of the soil solution.*

| Fertilizers | Absorption march | | 10% replacement | | 25% replacement | | 50% replacement | |
|---|---|---|---|---|---|---|---|---|
| | t ha$^{-1}$ | | | | | | | |
| | CV 1 | CV 2 | CV 1 | CV 2 | CV 1 | CV 2 | CV 1 | CV 2 |
| Monoamonic Phosphate | 2,925 | 2,925 | 0,772 | 0,172 | 0,328 | 0,286 | 0,140 | 0,330 |
| Monopotassium Phosphate | 7,800 | 7,800 | 2,035 | 0,447 | 0,936 | 0,754 | 0,368 | 0,872 |
| Potassium Sulfate | 2,044 | 2,044 | 0,350 | 0,086 | 0,140 | 0,130 | 0,063 | 0,165 |
| Magnesium Sulfate | 11,700 | 11,700 | 3,088 | 0,688 | 1,408 | 1,144 | 0,560 | 1,320 |
| Calcium nitrate | 4,000 | 4,000 | 1,241 | 0,388 | 0,720 | 0,594 | 0,196 | 0,872 |
| TOTAL | 28,469 | 28,469 | 7,486 | 1,781 | 3,532 | 2,908 | 1,327 | 3,559 |

Cultivar 1 demanded a greater quantity of fertilizers, when compared to cultivar 2, in the replacement limits of 10 and 25% of the initial electrical conductivity. This effect resulted in a superior performance of cultivar 1, regarding the physical variables analyzed in the present work.

Regarding productivity, treatments with conductivity replacement in 10% and 25% did not differ from the treatment with nutrition based on the absorption gait (table 4).However, such treatments reduced the amount of fertilizers applied by 73.7% and 87.5%, respectively, when compared to the treatment with nutrition based on the absorption rate (table 3). Under a

replacement limit of 50% of the electrical conductivity of the soil solution, there was a reduction in productivity compared to other treatments. This fact, related to the longer time for replacement of nutrients, in which the treatment with replacement limits of 50% was submitted. According to Andrade et al (2017) and Fayad et al. (2002), the nutritional deficit in stages of the tomato production cycle, such as in pre-flowering, flowering and fruiting, results in low productivity and lower quality fruits.

For the variable water use efficiency, the results obtained showed the same trend observed for productivity, related to the volume of water applied in irrigation and quantified by the tensiometry method.

*Table 4. - Analysis of variance and test of means of the variables productivity and efficiency in the use of water*

| SourceofVariation | Productivity | Efficiency in water use |
|---|---|---|
| Fertigation Management | 2.324 * | 2.324 * |
| Cultivars | 67.863 ** | 67.863 ** |
| M. fertirrigation x Cultivars interaction | 1.937 ns | 1.937 ns |
| CV (%) | 28.45 | 28.45 |
| AVERAGES | | |
| **Fertigation Management** | t ha$^{-1}$ | kg ha$^{-1}$ mm$^{-1}$ |
| Absorption march | 3,048 a | 7,399 a |
| 10% replacement | 3,06 a | 7,429 a |
| 25% replacement | 2,866 a | 6,956 a |
| 50% replacement | 1,096 b | 4,604 b |
| **Cultivars** | | |
| Cultivate 1 | 4,216 a | 10,234 a |
| Cultivate 2 | 1,219 b | 2,960 b |

Note: (**) and (*) at 1% and 5% probability respectively; (s) not significant; averages followed by different letters in the column, differ by 5% probability by the Tukey test.

In tomato, the length, diameter and average fruit mass are important production characteristics for the farmer, defining the choice of cultivar and the subsequent commercialization of the fruits. (ANDRADE et al., 2017)

The physical variables of length, diameter and average fruit mass were influenced by the management of fertigation, resulting in larger fruits up to treatments with a limit of replacement of the electrical conductivity of the soil solution at 25% of the initial EC. It was found that cultivar 1 showed superior performance for all physical characteristics and in all limits established for replacement of fertigation, with significant interaction in treatments

with nutrition based on the culture absorption gait and replacement of electrical conductivity at 10% and 25 % (table 5).

The average mass of tomato fruits was influenced by the different fertigation management studied. It can be seen, through Table 5, that the treatments with nutrition based on the absorption gait and with replacement at 10% and 25%, did not differ and reached the highest values 7.58, 7.03 and 7.18, respectively, with cultivar 1.

Lower performances were observed by establishing replacement management at 50% of the initial

EC, which, when imposed on cultivar 2, did not result in production. (table 5). Fact attributed to low ionic concentrations, which reflect on the decline of nutrient availability, in the soil solution, providing responses inferior to the productive potential of the crop (ANDRIOLO et al., 2015 and ROCHA et al., 2010), as observed in plants submitted to replacement management at 50% of the initial EC.

It was observed that a smaller volume of fertilizers applied until the replacement of 25% CEss, (Table 1), resulted in fruits with physical qualities similar to the conventional nutrition system, with a reduction of up to 87.5% in the application of fertilizers.

Such results are similar to those found by Kawakami et al. (2007), evaluating the physical characteristics of post harvest of tomato fruits, submitted to the replacement of the electrical conductivity of the soil solution with levels of 25%, 50% and 75%. Such authors report that it is possible, in a fertigation management program, to use as a reference limit a reduction of up to 25% of the initial electrical conductivity of the soil solution to effect a new application of fertilizers, without prejudice to productivity and physical characteristics post-harvest, thus rationalizing the use of fertilizers and reducing the production costs of cherry tomatoes.

*Table 5. - Breakdown of the interaction between fertigation management factors vs. cultivars for the variables fruit length (C.F), fruit diameter (D.F) and average fruit mass (M.M.F)*

| Fertigation management | C.F | | D.F | | M.M.F | |
|---|---|---|---|---|---|---|
| | mm | | mm | | gramas | |
| | CV 1 | CV 2 | CV 1 | CV 2 | CV 1 | CV 2 |
| Absorption march | 24,616 aA | 20,689 aB | 23,072 Aa | 19,334 aB | 7,584 aA | 4,818 aB |
| 10% replacement | 23,985 aA | 18,688 aB | 22,456 aA | 18,190 aB | 7,038 aA | 3,920 aB |
| 25% replacement | 24,006 aA | 18,752 aB | 22,711 aA | 17,403 aB | 7,182 aA | 3,829 aB |
| 50% replacement | 23,295 bA | 0,000 bB | 22,140 bA | 0,000 bB | 6,667 bA | 0,000 bB |

Note: Averages followed by the same lowercase letter in the column and the same uppercase letter in the row do not differ statistically from each other, at 5% probability, by the Tukey test.

## IV. CONCLUSIONS

Fertigation management based on the replacement of the electrical conductivity of the soil solution, at levels of 10% and 25%, provides tomato fruits with qualitative and quantitative characteristics similar to the conventional production system, with less consumption of fertilizers.

The nugget cultivar showed superior productive performance for all the evaluated productive variables.

## REFERENCES

[1] ALVARENGA, M. A. R. Tomate: produção em campo, em casa de vegetação e em hidroponia. Lavras: Editora UFLA, 2004. 400p.

[2] ANDRADE, A. R.; NORONHA, S. P.; AZEVEDO, P. R.; SILVA, P. R. A.; SANTOS, R. C.; Fertirrigação no cultivo de quatro cultivares de tomate (Lycopersicum sculentum) irrigado por gotejamento. Revista Brasileira de Tecnologia Aplicada nas Ciências Agrárias, Guarapuava, v.10, n.2, may/aug. (2017). Available in: https://revistas.unicentro.br/index.php/repaa/article/view/4706

[3] ANDRIOLO. J, L; WITTER. M; DAL.; ROSS, T; GODÓI R. S. Crescimento e desenvolvimento do tomateiro cultivado em substrato com reutilização da solução nutritiva drenada. Horticultura Brasileira. Brasília, v. 21, n. 3, jul.-set. 2003. Available in: https://www.scielo.br/scielo.php?pid=S0102-05362003000300015&script=sci_arttext

[4] BORGUINI, R. G. Avaliação do potencial antioxidante e algumas características do tomate (Lycopersicon esculentum) orgânico em comparação ao convencional. 2006. 178 p. (Doutorado em Saúde Pública) Faculdade de Saúde Pública, Universidade de São Paulo, São Paulo, 2006. (Tese)

[5] DIAS, N. S.; DUARTE, S. N.; GHEYI, H. R.; MEDEIROS, J. F.; SOARES, T. M. Manejo da fertirrigação e controle da salinidade do solo sob ambiente protegido, utilizando-se de extratores de solução do solo. Revista Brasileira de Engenharia Agrícola e Ambiental, Campina Grande, v.9, n.4, p.496-504, 2005. Available in: https://www.scielo.br/scielo.php?script=sci_arttext&pid=S1415-43662005000400009

[6] FAYAD, J. A; FONTES, P. C. R.; CARDOSO, A. A.; FINGER, F. L.; FERREIRA, F. A. Absorção de nutrientes pelo tomateiro cultivado sob condições de campo e de ambiente protegido. Horticultura brasileira Brasília, v. 20,

n.1, p. 90-94, 2002. Available in: https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0 102-05362002000100017

[7] KAWAKAMI, F. P. C.; ARAUJO, J. A. C.; IUNCK, A. V.; FACTOR, T. L.; CORTEZ, G. E. Manejo da fertirrigação em função da condutividade elétrica da solução nutritiva drenada no cultivo de tomate cereja sob ambiente protegido. Horticultura Brasileira 2007. v. 25: Suplemento-resumo.Available in:http://www.abhorticultura.com.br/eventosx/trabalhos/ev_ 1/a116_t1201_comp.pdf

[8] MEDEIROS, P. R. F. Manejo da fertirrigação em ambiente protegido visando o controle da salinidade para a cultura do tomate em solo franco-argiloso. 2010 85 p. (Doutorado em Irrigação e Drenagem) Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, 2010. (Tese) Available in: https://www.teses.usp.br/teses/disponiveis/11/11143/tde-11022011-100428/publico/Pedro_Fernandes_de_Medeiros.pdf

[9] NERY, A. R.; RODRIGUES, L. N.; SILVA, M. B. R.; FERNANDES, P. D.; CHAVES, L. H. G.; DANTAS NETO, J.; GHEYI, H. R. Crescimento do pinhão-manso irrigado com águas salinas em ambiente protegido. Revista Brasileira de Engenharia Agrícola e Ambiental, Campina Grande, v.13, p.551-558, 2009. Available in: https://www.scielo.br/scielo.php?script=sci_arttext&pid=S1 415-43662009000500007

[10] OLIVEIRA, F. A.; MEDEIROS, J. F.; DUARTE, S. N.; SILVA JÚNIOR, M. J.; CAMPELO, C. M. Calibração de extratores providos de cápsula porosa para monitoramento da salinidade e da concentração de íons. Eng. Agríc., Jaboticabal, v.31, p.520-528, 2011. Available in: https://www.scielo.br/scielo.php?pid=S0100-69162011000300012&script=sci_arttext

[11] QUEIROZ, S. O. P.; TESTEZLAF, R.; MATSURA, E. E. Metodologia para avaliação da salinidade do solo em ambiente protegido. Irriga, Botucatu, v.14, n.3, p.383-397, 2009.Available in: http://revistas.fca.unesp.br/index.php/irriga/article/view/3 426

[12] ROCHA. M, Q; PEIL. R, M, N; COGO. C, M. Rendimento do tomate cereja em função do cacho foral e da concentração de nutrientes em hidroponia. Horticultura Brasileira, Brasília, v. 28, n. 4, out.- dez. 2010. Available in: https://www.scielo.br/scielo.php?pid=S0102-05362010000400015&script=sci_arttext.

[13] SANTOS, H. G. DOS; JACOMINE, P. K. T.; ANJOS, L. H. C. DOS; OLIVEIRA, V. A. DE; LUMBRERAS, J. F.; COELHO, M. R.; ALMEIDA, J. A.; CUNHA, T. J. F.; OLIVEIRA, J. B. de. Sistema brasileiro de classificação de solos. 3.ed. rev. ampl. Brasília: Embrapa, 2013. 353p.

[14] SILVA, A. O.; KLAR, A. E.; SILVA, E. F. F. Manejo da fertirrigação e salinidade do solo no crescimento da cultura da beterraba. Eng. Agríc., Jaboticabal, v.35, n.2, p.230-241, mar./abr. 2015. Available in: https://www.scielo.br/pdf/eagri/v35n2/1809-4430-eagri-35-2-0230.pdf

[15] SILVA, F. A. S. ASSISTAT versão 7.6 beta. Campina Grande: Assistência Estatística, Departamento de Engenharia Agrícola do CTRN - Universidade Federal de Campina Grande, Campus de Campina. 2012.

[16] SILVA, M.A.G.; BOARETTO, A.E.; MURAOKA, T.; FERNANDES, H. G.; GRANJA, F.A.; SCIVITTARO, W.B. Efeito do nitrogênio e potássio na nutrição do pimentão cultivado em ambiente protegido. Revista Brasileira de Ciência do Solo, Campinas, v. 25, p. 913–922, 2001. Available in: https://www.scielo.br/pdf/rbcs/v25n4/14.pdf

[17] SQUARIZ. J, C, DE O.; RESENDE. J, T, V, DE.; TOLOMEOTTI. K, R, B. Avaliação da microsporogênese em acessos de Mini Tomate. Ambiência. Ambiência Guarapuava (PR) v.13 n.2 p. 342 - 355 Maio/Ago. 2017. Available in: https://revistas.unicentro.br/index.php/ambiencia/article/vie w/3663

# Short-term Load Forecasting using Combined Data from Several Weather Stations

Guilherme Guilhermino Neto[1], Henrique S. Hippert[2]

[1]Department of Business Management Technical Course, Federal Institute of Espírito Santo (IFES), Brazil
[2]Department of Statistics, Federal University of Juiz de Fora (UFJF), Brazil

*Abstract—In order to schedule the load generation and distribution, operators of energy markets rely on short-term load forecasts, especially those made for the next few hours. Since it is not feasible to store a large energy amount for compensating unbalances between supply and demand, what lacks or remains must be exchanged with an interconnected system, at the latest time price quotation. One of the new interests in this research field is the hierarchical load forecasting. The latest smart grid systems made possible to monitor real-time load at various levels of aggregation, from households to the whole system, which brought interest to forecasting from the whole system to a sole household. Some levels may comprise large geographical zones, on which more than one weather station may be located, and that raises a question: how to combine data from more than one weather station, and use the combination as input for load forecasting models? On this paper, we combine data from several weather stations by giving more weight to those stations closer to the centroid of the load zone. We experiment on data from a load zone in the state of New York and 11 weather stations spread throughout the state, using the combined data as input for neural networks. In our datasets, the proposed combinations lead to better results than those from neural networks that use of any of the 11 stations individually. Also, the proposed method outperforms several statistical time series benchmarks.*

*Keywords—hierachical load forecasting, load forecasting, neural networks, time series, weather variables combination.*

## I. INTRODUCTION

For many years, electrical energy markets have been structured as vertically integrated monopolies, where a single agent (usually the local government) was responsible for all generation, transmission, and distribution operations. However, in the decade of the 1980s, a worldwide process of liberalization started on these markets, with the goals of promoting efficiency gains, stimulating technical innovation and leading to efficient investment [1].

One of the most important features of today's liberalized markets is that the energy prices are determined by a formal quotation mechanism, strongly influenced by the balance between supply and demand. Because of today's technological standards, it is not feasible to store large amounts of electrical load for compensating unbalance, therefore supply and demand must be matched by selling or buying the difference [1].

Transactions of energy are made on day-ahead markets, with hourly-based prices, where clients buy or sell, in closed auctions, the amount needed for the next 24 hours

[1,2]. For this reason, hourly-based day-ahead load forecasts provide vital information for all the stakeholders of energy markets, from the system operators, who must schedule from generation to distribution, to the shareholders, whose bidding also influences the prices [1]. Hourly-based load forecasts made for the next 24 hours, often called short-term load forecasts [3] are the subject of this work.

The short-term behavior of electrical load is known to be seasonal and influenced by the weather. Usually, loads are higher during business hours within a day, and during business days within a week, patterns which are periodically repeated. Also, loads are highly correlated to weather variables, mostly the air temperature (for example, higher temperatures usually lead to the use of air-conditioning systems, raising the load levels).

Load forecasting has been a subject of great debate in the literature for decades. The first book solely devoted to the theme is a collection of papers describing methods used by the industry [4]. According to this volume, the practitioner's toolbox at that time consisted mostly of statistical

and numerical methods, such as linear regression, exponential smoothing, polynomial curve fitting and trigonometric series. These techniques have the advantages of robustness and interpretability. However, the functional form of models must be pre-defined, which can make the inclusion of the nonlinear relationships between weather and load a challenge.

Statistical and numerical methods are still used by the industry. For example, [5] describes a Box & Jenkins autoregressive model, currently used by Spanish Transmission System Operator.

The evolution of computer hardware made possible to try more computationally demanding methods, such as neural networks, support-vector machines, neural-fuzzy systems, and biological inspired metaheuristics. Because they make possible to capture more specific relationships between load and weather with no need to pre-define a functional form, such methods may reduce the average forecasting errors. However, since these relationships may be too complex, some caution must be taken to avoid overfitting or, equivalently, poor generalization for unseen data.

A broad review and critique on feedforward neural networks, still worth reading, may be found in [6]. More recently, many experiments are being reported using deep learning neural networks (which are even more computationally demanding), such as [7], whichuses pooling deep recurrent networks for household data, and [8], whichuses convolutional neural networks for Greek electrical systems load data.

There does not seem to exist a 'best' technique for load forecasting. Let us look for instance at the best results for 2012 edition of Global Energy Competition (GEFCom). GEFCom is an initiative of the Institute of Electrical and Electronics Engineers (IEEE) that invites participants from all over the world to work on solutions for energy forecasting problems. Amongst the best ranked solutions for short-term load forecasting in 2012 were linear regression, polynomial regression, gradient boosting, and neural networks [9]. This reinforces the idea that various techniques may lead to suitable results, and good predictions may depend more on the practitioner's expertise and its adequacy to the data than on the technique itself.

Despite the wide literature on how to produce load forecasts, new challenges still emerge because of the dynamic nature of energy markets. Some posed problems for the future of energy markets are, according to [2]

1. The impact on climate change on electricity demand, supply and price

2. Share, costs and subsidies to renewables in electricity production

3. The effort to make the electricity sector "smarter", at different levels of the Electricity Supply Chain, mainly distribution and usage.

All these themes are somehow related to short-term load forecasting and so motivate research on the improvement of existing techniques, the creation of new ones, the solution of new issues, and so on.

One of the main goals of the substitution of old systems by smart grids, mentioned in item (3) of the list above, is the possibility of monitoring the load at various levels of the grid, such as individual transformers, substations, cities, regions and countries. From that follows the need of forecasting not just the load for all the system anymore, but for all individual levels, and for aggregations of them; a paradigm called "hierarchical load forecasting" [10]. As the grid usually covers a vast geographical area, it is possible that, for some zones, data from more than oneweather stations will be available. When that is the case, how can we select the sources of data and combine them?

Little attention has been devoted to strategies for weather station selection until now. The most relevant works are [11] and [12]. The first introduced a heuristic for ranking Nweather stations and, then, combining the best 1 to N by using a simple average. The latter tested the same heuristics but experimented various types of weighted averages for combining the best stations.

Both papers are valuable contributions, since they brought to the table an important practical matter that was overlooked until now. However, there is still much to be developed. For example, testing the heuristic with other forecasting models (both papers only tried linear regression), incorporating to the combining process practical aspects such the localization of the weather stations and the characteristics of the weather data, and trying the proposed selection heuristic on different data.

In this study, we continue the investigations by introducing three new methods for combining weather stations: averages weighted by the distance of the weather station to the load zone, by the difference of the altitudes between the weather station and the load zone and by the intensity of the nonlinear correlation between the weather station and the load datasets. We experiment on temperature data from 11 weather stations in the state of New York, and load data from a zone of the New York Independent System Operator (NYISO).

## II.    MATERIAL

The data we used for our experiments consist of one series of electrical loads (in MW) and 11 series of dry bulb air temperature (in°C). The measurements correspond to the period from January 1, 2015 to December 31, 2018, adding up to 35,064 hourly observations. The load series, available on the NYISO's website [13], refers to a load zone of the state of New York called GENESE, which comprises the region of Rochester and surroundings. The temperature series are measurements of the actual temperature, reported from 11 weather stations spread through the state of New York. These data are available on the National Oceanic and Atmospheric Administration's (NOAA) website [14]. In Fig. 1, we see the geographical locations of the load zone and the weather stations:
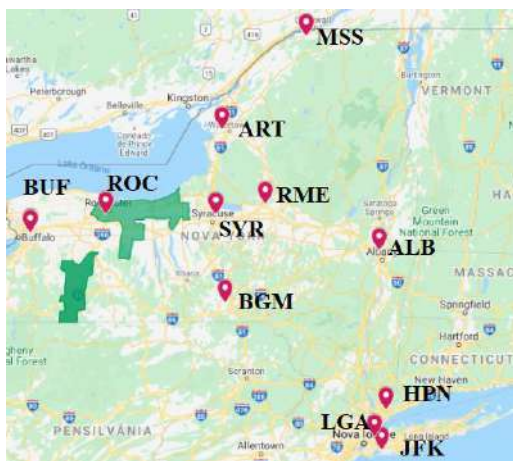


*Fig. 1: Borders for the load zone GENESE (highlighted), and locations for 11 weather stations [15].*

Despite the GENESE load zone being formed by two disjoint regions, the NYISO treats it as one, and records the loads in a single data set, which accounts for the total load for both areas.

The 11 weather stations, all located in airports, are labeled on the map by their International Air Transport Association (IATA) codes. We will use these codes to refer to the stations from now on. The NOAA provides data from 4 more weather stations (ELM, MSV, POU, SWF). We chose not to use them because their data contained a significant amount of missing values.

The two main characteristics of load series can be observed in our data: the seasonality and the influence of the weather.

In Fig. 2, we have a line plot for two typical fortnights of winter and summer loads, sampled by convenience.

The line plot suggests that two seasonal patterns occur: an intraday pattern, with higher loads in the middle of the

day; and an intraweek pattern, with lower loads on the weekends. The plotted data also indicates that the mean level of the load is higher in the winter than in the summer.
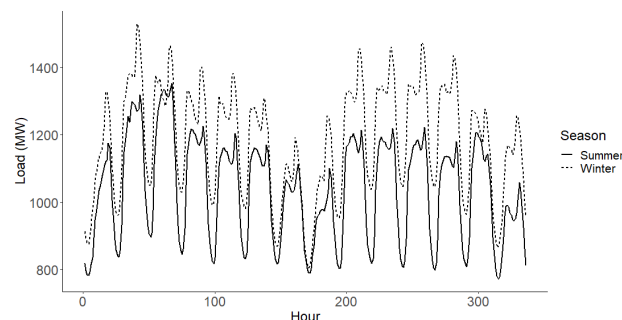


*Fig. 2: Typical loads for two fortnights in summer and winter, data for GENESE load zone; data from[13].*

In Fig. 3, the scatterplots show the relationship between load and temperature data. For the temperature, we picked the ALB station for convenience, but the pattern is quite similar for all weather stations.
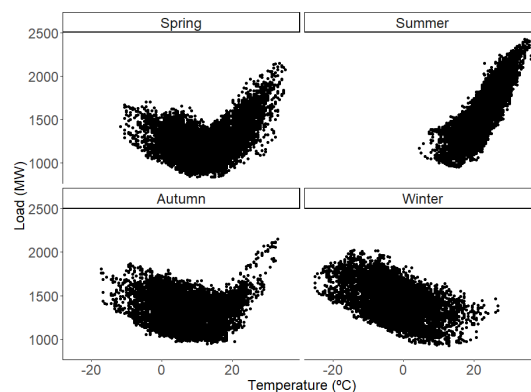


*Fig. 3: Scatterplots for loads versus temperatures, by season of the year, for GENESE load zone and ALB weather station; data from[13, 14].*

The plots suggest that, for our data, load and temperature are correlated. The highest loads generally occur as we approach the extreme temperatures, what probably happens because of the use of air heating and cooling systems in these cases. In each season, it seems there is a positive linear relationship for summer loads (the higher the temperature, the higher the load) and a negative linear correlation for winter loads (the higher the temperature, the lower the load), while a seemingly nonlinear correlation may be noted for spring and autumn loads (higher loads both associated with lower and higher temperatures).

The patterns for spring and autumn look like a composition of the two other seasons, which we think is due to

these seasons being a sort of a transition between the other two.

Almost no treatment was needed for the data. Just a few missing values for the temperature needed to be replaced by imputed values, which we have done by using polynomial interpolation.

## III. METHODS

For all the following methods, we will denote the actual and forecasted loads respectively by $y_t$ and $\hat{y}_t$, where $t$ is the instant of time. For our work, we are interested in computing, at the last hour of a day, the forecasts $\hat{y}_{t+k}$, for $k = 1, \dots 24$. In other words, at the 24th hour of a day, we forecast all the hourly loads for the following day.

### 3.1 SELECTION AND COMBINATION OF WEATHER STATIONS

#### 3.1.1 A heuristic for selection and combination

To rank and select the weather stations, we use a heuristic introduced in [11]. Let the temperature series of the $i$-th weather station be denoted by $W_i$, and $n$ be the number of weather stations. The heuristic follows the five steps enlisted in Table 1:

*Table 1. Heuristics for ranking and selecting weather-stations [11, adapted]*

| # | Step description |
|---|---|
| 1 | For $i = 1, \dots, N$ produce in-sample forecasts using the series $W_i$. Also, at each step, calculate an evaluation measure (the mean absolute percentage error, for example) for these forecasts. |
| 2 | Rank the error measures calculated in the previous step in ascending order. |
| 3 | For $k = 1, \dots, n$, generate an artificial weather station by combining the temperature series from the first $k$ stations (which can be done, for example, by using a simple average), and produce in-sample forecasts. At each step, calculate an evaluation measure for these forecasts. |
| 4 | Rank the error measures calculated in the previous step in ascending order. |
| 5 | The $k$ corresponding to the first position in the previous step's rank will be number of stations to be combined. The first $k$ stations in step 2's ranking will be the ones to be combined. |

We have made one little adjustment to this heuristic. In both steps #1 and #3, the forecasts are produced for the in-

sample data set. We think that, to assure better generalization, the evaluation for step 3 could be for the post-sample data – and that is how we proceeded in our work.

#### 3.1.2 A novel method for combining weather stations

[11] uses just a simple average for combining the weather stations. In [12], weighted averages are tested. Although we think it is reasonable to assign different weights to different stations, the methods proposed in [12] are purely algebraic and mainly based in the forecast errors (more weight is given to the stations that produce more accurate forecasts), leaving out practical issues, such as the geographical location of the station. In this work we introduce a novel method for combining weather stations, based in geographic information.

Be $d_i$ the distance from the weather station $i$ to the centroid of the load zone. The combination of the first $k$ weather stations (step #3 from Table 1) will be given by Eq. (1):

$$W_k = \sum_{i=1}^{k} \frac{d_i^{-1} W_i}{d_i^{-1}} \qquad (1)$$

For our method, the closer the station from the centroid of the load zone, the higher its weight.

The distance between the weather station location and the centroid of the load zone may be calculated by using the haversine formula [16], which results in the great-circle distance between two points on a sphere, given their longitudes and latitudes.

Being $\varphi = (\varphi_1, \varphi_2)$ and $\lambda = (\lambda_1, \lambda_2)$, respectively, the latitude and longitude coordinates, $\Delta\varphi = \varphi_2 - \varphi_1$ and $\Delta\lambda = \lambda_2 - \lambda_1$, and $R$ the radius of the Earth (approximately 6371 km), the distance $d$ between two points on a sphere by the haversine formula is given by the set of equations from Eq. (2.1) to Eq. (2.3):

$$a = \sin^2(\Delta\varphi/2) + \cos\varphi_1 \cdot \cos\varphi_2 \cdot \sin^2(\Delta\lambda/2) \qquad (2.1)$$

$$c = 2 \cdot \operatorname{atan2}\left(\sqrt{a}, \sqrt{(1-a)}\right) \qquad (2.2)$$

$$d = R \cdot c \qquad (2.3)$$

### 3.2 FORECASTING METHODS

In the following sections we describe the forecasting method we propose and the ones we use for benchmarking.

#### 3.2.1 Feed Forward Neural Networks (FFNN)

Feed forward neural networks (FFNN) are the main forecasting method in the work. The following introduction is based in [17], which the reader may look for more details.

We can define a neural network as a function composition like in Eq. (3):

$$y = f_{NN}(\mathbf{x})\left(f_3\left(f_2(f_1(\mathbf{x}))\right)\right) \qquad (3)$$

Eq. (3) is an example of a three-layer neural network. $f_2$ and $f_1$ are vector functions of the form shown in Eq. (4).

$$f_l(\mathbf{z}) \stackrel{\text{def}}{=} g_l(\mathbf{A}_l\mathbf{z} + \mathbf{b}_l) \qquad (4)$$

In Eq. (4), $l$ is the index for the layer of the network, an integer greater than or equal to 1. The function $g_l$, usually nonlinear, is called activation function. The values $\mathbf{A}_l$ and $\mathbf{b}_l$ are respectively called weights and biases of the layer $l$; these values are calculated (or "learned", as in neural networks' practitioner's language) based on the data. The learning process occurs by using a proper optimization algorithm.

Fig. 4 shows an example of a neural network in the form of a directed graph, a common visual representation:
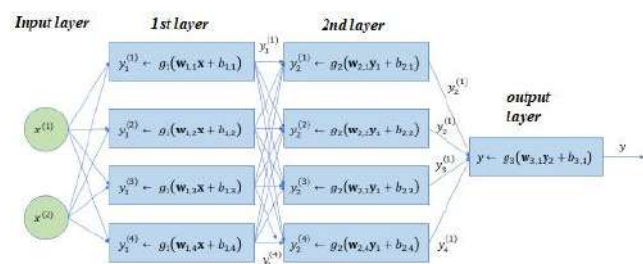


*Fig. 4: FFNN with two inputs, two hidden layers and one output. Adapted from* [17].

The architecture depicted in Fig. 4 is called feed forward, in the sense that information flows exclusively one-way (in this illustration, from left to right). The rectangles represent the units called neurons, which are organized in layers. In this example, there is an input layer, which receives a dimensional vector $\mathbf{x}$; two hidden (*i.e.* intermediate) layers that perform mathematical operations on the inputs; and an output layer, which returns a value $y$ as the result of the previous calculations.

By using the universal approximation theorem, [18] shows that a FFNN with one hidden layer and a finite number of neurons is capable of approximating continuous functions, since the activation functions $g_l$ follows some prerequisites, such as being differentiable. This capability makes FFNN attractive for load forecasting because the networks can model the complex nonlinear relationship between load and temperature with no need to specify a functional form.

To produce our forecasts, we propose a FFNN with one hidden layer and the following groups of inputs: 24 loads for day $d$; 24 loads for day $d-1$; 7 dummy variables for the days of the week; 4 dummy variable for the seasons of the year; 24 temperatures for day $d$; and 24 temperatures for day $d-1$; 24 temperatures for day $d+1$.

The first three groups model the recent trend of the load curve and, the following two, the daily and weekly seasonal factors. The last three groups model the effect of the temperature on the load.

One may note that although we use the temperatures of the day $d+1$ in our model, we do not have access to these data in practice: in fact, because the forecasts are made at the day $d$, the temperature series for the next day does not even exists at this point. In practice we would use temperature forecasts, instead of the actual temperatures. Since temperature forecasts contain errors, we also made a sensitivity analysis by injecting various levels of noise to the temperature data to see how the errors in temperature data would affect the performance of our model.

Another thing that is important to highlight is how we proceeded for the first phase of the implementation of the FFNN: the hyperparameter tuning.

We adopted the strategy suggested by [19]: start by deciding which hyper parameters we are willing to tune (which may be limited in number, according to time and computational power issues) and fix the values for the others. For all the hyper parameters that will be tuned, from the most important to the least, try a number (defined by the user) of random values for the parameter while fixing the others. Pick the value that leads to the best results, make it fixed and go to the next hyper parameter. [19] points that this random search has proven more effective than a grid search for hyper parameter tuning. In the order of importance, we have chosen to tune the following hyper parameters: learning rate, batch size, number of hidden units and number of iterations. Some other hyper parameters (and their fixed values) were: number of hidden layers (1), learning algorithm (Adam) and activation function (ReLU).

A common practice when tuning the hyper parameters of a FFNN in a limited data sample is using a resample technique such as cross-validation, with the goal to assure better generalization. One of the most common forms of cross-validation is the $k$-fold cross validation. For this method, data is first randomly shuffled, then split in $k$ groups. For each group, its data is taken as an out-of-sample (or validation) set while the rest is taken as an in-sample set. The model is fit using the in-sample data and

evaluated for the out-of-sample data. The final evaluation is done by summarizing the performance for all $k$ groups.

We must be careful, though, if there is time dependence**:** shuffling the data may cause us to use future data for fitting the model and past data for evaluating. Since usingthe future to predict the past would seem rather unfair, we should look for a more suitable strategy.

We used the strategy usually called "rolling forecasting origin". In this approach, the validation sets all consist of one observation; the related training sets will be all the observations that occurred before [20].

Fig. 5 illustrates how this procedure works: the blue dots represent the training sets and the red dots the validation sets. The diagram makes clears that no future observation is used during the training.
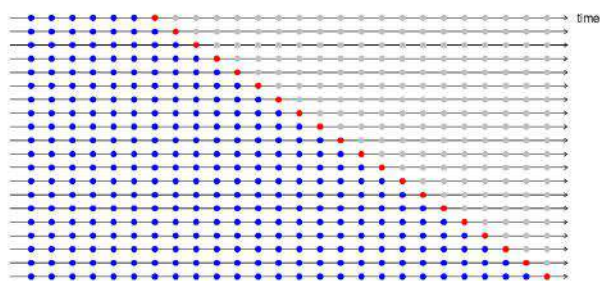


*Fig. 5: Diagram for the general rolling forecasting origin method* [20]

Although our data is limited, we still have some thousands of points. Because of that, we defined the validation sets to comprise a month of observations, instead of a single observation. Also, for each new validation set, we included six more months instead of only one - what we think that makes more sense, since our data is seasonal.

The final segmentation we used for validating the FFNN models is shown in Table 4.

*Table 3. Adapted rolling forecasting origin segmentation*

| Set | In-sample months | Validation month |
|-----|------------------|------------------|
| 1 | [1,5] | 6 |
| 2 | [1,11] | 12 |
| 3 | [1,17] | 18 |
| 4 | [1,23] | 24 |
| 5 | [1,29] | 30 |
| 6 | [1,35] | 36 |
| 7 | [1,41] | 42 |
| 8 | [1,47] | 48 |

### 3.2.2 Benchmark I: Seasonal naïve method

A naïve method, possible the simplest class of forecasting methods, considers that the forecasting equals the last observed value.

Our data is seasonal, so it is reasonable to use a variation called seasonal naïve [21]. The formulation can be read in the Eq. (6):

$$\hat{y}_t = y_{t-m} \qquad (6)$$

In Eq. (6), $m$ is the seasonal period. As the data is hourly and we have two seasonal periods, with $m = 24$ hours (intraday) and $m = 168$ hours (intraweek), we experimented two seasonal naïve forecasters.

### 3.3.3 Benchmark II: Double-seasonal exponential smoothing

A more sophisticated time series method is the extension of the classical Holt-Winters exponential smoothing, proposed by [22] to accommodate two seasonal factors. The double-seasonal exponential smoothing (also called Holt-Winters-Taylor exponential smoothing, or HWT) is given by the set Eq. (7.1) to (7.4):

$$l_t \quad = \alpha\big(y_t - d_{t-s_1} - w_{t-s_2}\big) + (1-\alpha)l_{t-1} \qquad (7.1)$$

$$d_t \quad = \delta\big(y_t - l_t - w_{t-s_2}\big) + (1-\delta)d_{t-s_1} \qquad (7.2)$$

$$w_t \quad = \omega\big(y_t - l_t - d_{t-s_1}\big) + (1-\omega)w_{t-s_2} \qquad (7.3)$$

$$\hat{y}_{t+k} \quad = l_t + d_{t-s_1+k} + w_{t-s_2+k} \qquad (7.4)$$

$$+ \phi^k\left(y_t - \big(l_{t-1} + d_{t-s_1} + w_{t-s_2}\big)\right)$$

In the Eq. (7.1) to (7.4), $l_t$ is the level; $d_t$ is the intraday seasonal factor; and $w_t$ is the intraweek seasonal factor, for instant $t$. The forecast $\hat{y}_{t+k}$ is a composition of the most recent updates of these components and a correction of the last forecast. $\alpha$, $\delta$, and $\omega$ are constants for level, intraday seasonal factor, and intraweek seasonal factor. $\phi$ is a constant for correcting the first order autocorrelation. The constants are real numbers, restricted to the interval [0,1].

Although relatively simple, this method has been proved surprisingly accurate for different time series, even shown to outperform more complex multivariate methods, as reported in [23, 24].

### 3.3.3 Benchmark III: Box & Jenkins models

A last benchmark we have tried for our data was the class of models called Box & Jenkins models [25], which are an auto-regressive formulation for time series.

An $(p, q)$ order auto-regressive (AR) moving average (MA) polynomial, denoted by $ARMA(p, q)$, is written as in Eq. (8):

$$\phi(B)y_t = \theta(B)\varepsilon_t \qquad (8)$$

, where $\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \ldots - \phi_p B^p$; $\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \ldots - \theta_q B^q$; $B^h$ is the backshift operator, which lags and observation by $h$ steps (that is, $B^h y_t = y_{t-h}$); $\varepsilon_t \sim N(0, \sigma^2)$; and $\phi$ and $\theta$ are the model's coefficients.

We can derive a seasonal formulation for this model. Denoted by $ARMA(P, Q)_s$, the $(P, Q)$ order seasonal formulation with period $s$, is written as in Eq. (9):

$$\Phi(B^s)y_t = \Theta(B^s)\varepsilon_t \qquad (9)$$

, where $\Phi(B^s) = 1 - \Phi_1 B^s - \Phi_2 B^{2s} - \ldots - \Phi_P B^{Ps}$; $\Theta(B^s) = 1 - \Theta_1 B^s - \Theta_2 B^{2s} - \ldots - \Theta_Q B^{Qs}$; and $\Phi$ and $\Theta$ are constants.

Finally, a mixed seasonal ARMA, denoted by $ARMA(p, q) \times ARMA(P, Q)_s$, a composition of both aforementioned models, is shown in Eq. (10):

$$\Phi(B^s)\phi(B)y_t = \Theta(B^s)\theta(B)\varepsilon_t \qquad (10)$$

The formulations in Eq. (8) to (10) do not directly allow us to forecast for lead times ahead of $t + 1$. To achieve our goal of forecasting for up to 24 hours ahead, we have adjusted 24 Box & Jenkins models – one for each hour of the day and used them to forecast the next hour.

3.3 EVALUATION

For evaluating the post-sample accuracy, we chose to calculate the mean absolute percentage error (MAPE), as it is a standard in the literature, and is easily interpretable.

The MAPE is given by the following equation:

$$\text{MAPE} = \frac{1}{N} \sum_{1}^{N} \left| \frac{y_t - \hat{y}_t}{y_t} \right| \times 100 \qquad (11)$$

In Eq. (11), $N$ is the number of observations in the data set.

3.4 COMPUTATIONAL RESOURCES

All the experiments were run on a 3.70GHz Intel® Core™ i7-8700K CPU, with 32 GB of RAM, and a Nvidia GeForce 1080Ti GPU with 11 MB RAM.

The implementations were written in R language [26]. We have used functions from the packages keras [27], for neural networks; forecast [28] for Box and Jenkins models; and geosphere [29] for haversine distance.

For calculating the centroid of the load zone, we have used the coordinates of the outline map made available by [30,31].

## IV. RESULTS AND DISCUSSION

We used approximately 36 months, up to 31 December, 2017, for our in-sample data. These data were used for optimizing the HWT constants, finding the Box & Jenkins models and training the FFNNs.

The data for the final year, 2018, we used for post-sample evaluation.

4.1 BENCHMARKS

First, we implemented the time series benchmark methods. We used the limited memory Broyden-Fletcher-Goldfarb-Shano (l-BFGS) optimization algorithm [32] to find the constants that minimized the in-sample mean squared error. To find the order and the model's coefficients for the Box & Jenkins models, we used the Hyndman-Kandakhar algorithm [33], which minimizes the Akaike Information Criterion (AIC), leading to more parsimonious models.

Table 2 shows the MAPE for the benchmark methods, for out-of-sample data.

*Table 2. MAPE for the benchmark methods (out-of-sample data)*

| Method | MAPE (%) |
|---|---|
| HWT | 4.15 |
| Box & Jenkins | 5.31 |
| Seasonal naïve ($m = 24$) | 6.64 |
| Seasonal naïve ($m = 168$) | 8.75 |

As we expected, the naïve forecasters perform worse than the other two methods. HWT produces more accurate forecasts than Box & Jenkins models, according to the MAPE, and is the best of the benchmarks.

In Table 3 we show the constants for the model. While the constant for the level update, $\lambda$, is close to zero, which suggests that the average level is nearly constant for all the framed time period, the constant for adjustment of the first order autocorrelation, $\phi$, pays a great role in our data. As regards the intraday and intraweek seasonal factors, their constants, $\delta$ and $\omega$ indicate that both influence the forecasts with similar strength.

*Table 3. Constants calculated for HWT method*

| $\phi$ | $\lambda$ | $\delta$ | $\omega$ |
|---|---|---|---|
| 0.99 | 0.02 | 0.14 | 0.15 |

4.2 FFNN

4.2.1 One weather station per FFNN

We started by training 11 FFNNs, all with architecture mentioned in section 3.2.1. That is: the inputs were 24 loads for day d; 24 loads for day d-1; 7 dummy variables for the days of the week; 4 dummy variable for the seasons of the year; 24 temperatures for day d; and 24 temperatures for day d-1; 24 temperatures for day d+1; and the outputs were the 24 loads for day d+1.

As we mentioned before, although we have the data for observed temperatures for day d+1, in practice we have just forecasts for those. Because we aim at testing our method for a broad range of situations, we also evaluated the networks with noise added to the data, to simulate the temperature forecast errors. The level of noise $r$ added to a temperature data point in time instant $t$ is shown in Eq. (12).

$$r_t = \text{rnorm}(0, l \times \mu_{TMP}) \qquad (12)$$

In Eq. (12), the noise is given by a random number of the gaussian distribution (rnorm), with 0 mean and a standard deviation given by a constant $l$ times the mean of the temperature series.

In short, for each weather station data set, we:

1. Train 100 FFNNs (because initial random guesses in the training phase may cause the results to vary, and running more networks we can analyze the variability)
2. Add noise to the out-of-sample data
3. Calculate the median MAPE for the predictions of the 100 FFNNs in the out-of-sample data.

We have tried this algorithm for noise levels $l = 1\%$, 2%, 3%, 4% and 5%, and also for data with no noise ($l = 0$).

The final evaluation of the post-sample accuracy was given by the median MAPE for the performance of the FFNN in all levels of noise – which we think coversthe wide range of possibilities that may come from the variability regarded to the initial guesses in the training phase, and also from the noise in the temperature data.

Table 4 show the results for 11 FFNNs, each using data from a different weather station.We can also see the distance from each weather station to the centroid of the load zone. We mentioned in section II that GENESE load zone is formed by to disjoint geographical areas. Among other possible strategies, we calculated this distance as the average of the distance to the centroids of the two areas.

*Table 4.MAPEs for FFNNs (different stations)*

| Weather station | MAPE (%) | distance ($10^5$ m) |
|---|---|---|
| ROC | 3.32 | 0.65 |
| SYR | 3.39 | 1.33 |
| BUF | 3.41 | 1.06 |
| ART | 3.63 | 1.91 |
| BGM | 3.68 | 1.56 |
| RME | 3.79 | 1.91 |
| MSS | 3.87 | 3.31 |
| ALB | 3.99 | 3.15 |
| LGA | 4.53 | 3.84 |
| JFK | 4.90 | 4.00 |
| HPN | 4.94 | 3.78 |

Table 4 seems to indicate that, the closer the station is to the centroid, the best are the FFNN results. That is made clearer by observing the scatterplot for MAPE versus distance in Fig. 6:
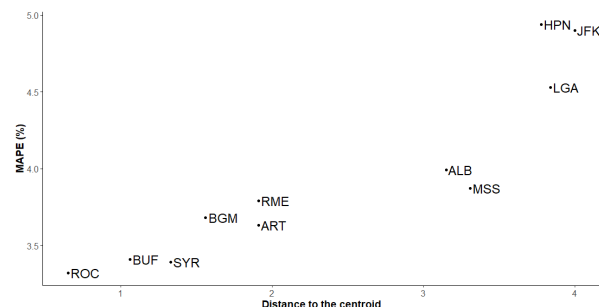


*Fig. 6: Scatterplot for MAPE versus distance, weather stations labeled (FFNN)*

The points in Fig. 6 have a Pearson's correlation coefficient of 0.91, which suggests a strong positive linear correlation (the higher the distance between the weather station and the centroid, the higher the MAPE).

We then started to combine the weather stations, from two station to 11, starting from the best (following the heuristics mentioned in 3.1), re-trained the FFNNs and computed the MAPEs for the various levels of noises.

The first combination we experimented was a simple average of the temperature data. Results are displayed in Table 5. The simple average improves the results we had previously, especially the first three stations from Table 4,

ROC, SYR and BUF, which are the closest to the load zone.

*Table 5. MAPEs for FFNNs (combination by mean)*

| No. of weather stations | MAPE (%) |
|:---:|:---:|
| 3 | 3.09 |
| 5 | 3.11 |
| 4 | 3.12 |
| 2 | 3.14 |
| 7 | 3.18 |
| 6 | 3.19 |
| 8 | 3.25 |
| 10 | 3.29 |
| 1 | 3.32 |
| 9 | 3.33 |
| 11 | 3.44 |

Finally, we experimented our proposed combination method, the weighted average by the inverse of the distance to the centroid. Results shown in Table 6point that our method improves the results even more than the combination by simple average: combining only the 2 best weather stations of the ranking in Table 2 lead to a significantly better performance.

*Table 6. MAPEs for FFNNs (weighted average by the inverse of the distance to the centroid of the load zone)*

| No. of weather stations | MAPE (%) |
|:---:|:---:|
| 2 | 2,92 |
| 5 | 2,92 |
| 3 | 2,95 |
| 4 | 2,96 |
| 9 | 3,04 |
| 6 | 3,05 |
| 7 | 3,05 |
| 8 | 3,06 |
| 11 | 3,10 |
| 10 | 3,12 |
| 1 | 3,32 |

## 4.4 A BRIEF SENSITIVITY ANALYSIS

A last analysis we would like to show is a brief sensitivity analysis to the injected noise.

In Table 7, we show the median MAPEs for the best FFNN (stations ROC and SYR, combined by the centroid method), for the various noise levels and also the MAPEs for the benchmark methods:

*Table 7. Best methods*

| Method | Noise level | | | | | |
|:---:|:---:|:---:|:---:|:---:|:---:|:---:|
| | **0** | **1%** | **2%** | **3%** | **4%** | **5%** |
| FFNN | 2.59 | 2.64 | 2.78 | 2.95 | 3.19 | 3.48 |
| HWT | 4.15 | | | | | |
| SARMA | 5.31 | | | | | |
| NF24 | 6.64 | | | | | |
| NF168 | 8.75 | | | | | |

Those results are also shown in Fig. 7.
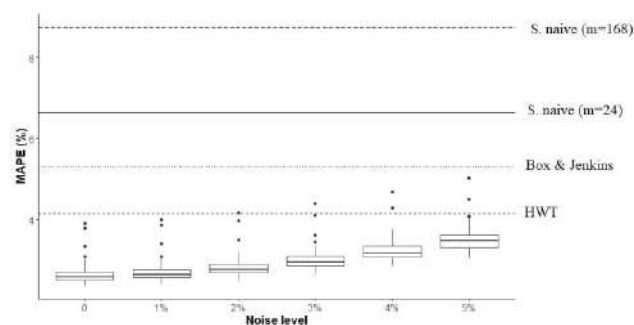


*Fig. 7: Results for the best FFNN and the benchmark methods*

Note that these results show that, even though the FFNNs are capable of producing accurate forecasts, they are not flawless. Random initial guesses in the training phase may cause variations, as we can see in Fig. 7. Even with no noiseadded, some outlier MAPEs were observed.

But not just that: as we inject more noise to the temperature data, the variability gets higher (which is clear by looking at the size of the boxes) and some few results may even be worse than those produced by an exponential smoothing method, which is much less computationally demanding.

Because of that, we recommend running FFNNs as many times as possible, in order to analyze the variability, and being careful to consider the possibility that the input data may include some noise. If that is the case, it is possible that a simpler, but more robust method, such the time series benchmarks we used, area safer bet, depending on the level of noise.

## V.  CONCLUSION

With the emerging importance of hierarchical load forecasting, the problem of selecting and combining weather stations data becomes a major concern for the field of load forecasting.

In this work, we propose a new method for combining weather station data, a weighted average where more weight is assigned the closer the weather station is to the load zone. Using data from a load zone of the NYISO and 11 temperature weather stations of the state of New York, we experimented with this method for combining the data, and usedthe combinations as input for neural networks.

For our data, the proposed combining method improves the performance of the neural networks, if compared to the use of the weather stations individually and to the combination via simple averages. The method also outperforms, in median, several time series benchmarks. For certain levels of noise in the input data, though, one must be careful since it may weaken the results at some level, as we commented in a brief sensitivity analysis.

For further work, we suggest trying the method on other datasets, tryingwith different neural network architectures and trying to combine the results from the HWT exponential smoothing with those from the neural networks, in order to see if the robustness of the time series method could improve the performance of the neural networks when there is noise in the input data.

## ACKNOWLEDGEMENTS

## REFERENCES

[1] Weron, R. (2006). *Modeling and forecasting electricity loads and prices: A statistical approach.* Chichester, UK: Wiley.

[2] Cretì, A., &Fontini, F. (2019). *Economics of electricity: markets, competition and rules*. Cambridge, UK: Cambridge University Press.

[3] Hong, T.,& Fan, S. (2016). Probabilistics electric load forecasting: A tutorial review.*International Journal of Forecasting*, 32 (3), 914-938.

[4] Bunn, D.W.,& Farmer, E.D. (1985). *Comparative models for electrical load forecasting*. Belfast, UK: Wiley.

[5] Caro, E., Juan, J.,& Cara, J. (2020). Periodically correlated models for short-term electricity load forecasting.*Applied Mathematics and Computation*, 364, 124642

[6] Hippert, H.S., Pedreira, C.E.,& Souza, R.C. (2001). Neural networks for short-term load forecasting: A review and evaluation.*IEEE Transactions on Power Systems*, 16 (1), 44-55.

[7] Shi, H., Xu, M.,& Li, R. (2018). Deep learning for household load forecasting – A novel pooling deep RNN.*IEEE Transactions on Smart Grid*, 9 (5), 5271-5280.

[8] Sideratos, G., Ikonomopoulos, A.,& Hatziagyriou, N.D. (2020). A novel fuzzy-based ensemble model for load forecasting using hybrid deep neural networks.*Electric Power Systems Research*, 178, 106025.

[9] Hong, T., Pinson, P., &Fan, S. (2014). Global Energy Forecasting Competition 2012.*International Journal of Forecasting*, 30 (2), 357-363.

[10] Ben Taieb, S., Taylor, J.W., &Hyndman, R.J. Hierarchical probabilistic forecasting of electricity demand with smart meter data.*Journal of the American Statistical Association*, to be published.

[11] Hong, T., Wang, P., &White, L. (2015). Weather station selection for electric load forecasting.*International Journal of Forecasting*, 31 (2), 286-295.

[12] Sobhani, M., Campbell, A., Sangamwar, S., Li, C., &Hong, T. (2019). Combining weather stations for electric load forecasting.*Energies*, 12 (8), 1510.

[13] New York Independent System Operator. *Real-time dashboard*. Retrieved September 23, 2020 from:https://www.nyiso.com/real-time-dashboard

[14] National Oceanic and Atmospheric Administration. *Integrated surface dataset (Global)*. Retrieved September 23, 2020 from:https://www.ncei.noaa.gov/access/search/data-search/global-hourly

[15] Google. (n.d.). [Google Maps directions to the State of New York and surroundings]. Retrieved September 23, 2020 from https://goo.gl/maps/DogN3sf4mUCMvLY58

[16] Sinnott, R.W. (1984). Virtues of the haversine. *Sky and Telescope*, 68 (2), 159.

[17] Burkov, A. (2019). Neural Networks and Deep Learning. In*The hundred-page machine learning book* (pp. 61-75). Andriy Burkov.

[18] Cyberenko, G. (1989). Approximations by superpositions of sigmoidal functions. *Mathematics of Control, Signals, and Systems*, 2 (4), 303-314.

[19] Bengio, Y. (2012). Practical recommendations for gradient-based training of deep architectures. In: *Neural networks: Tricks of the trade* (pp. 437–478). Berlin: Springer.

[20] Hyndman, R.J. (2016). *Cross-validation for time series*. Retrieved September 23, 2020 from: https://robjhyndman.com/hyndsight/tscv/

[21] Hyndman, R.J., & Athanasopoulos, G. (2018). Some simple forecasting methods. In *Forecasting: principles and practice, 2nd edition*, OTexts: Melbourne, Australia. Retrieved 23 September, 2020 from: OTexts.com/fpp2.

[22] Taylor, J.W. (2008). A comparison of univariate time series methods for forecasting intraday arrivals at a call center. *Management Science*, 54 (2), 253-265.

[23] Taylor, J.W. (2010). Triple seasonal methods for short-term load forecasting. *European Journal of Operational Research*, 204 (1), 139-152.

[24] Taylor, J.W. (2012). Short-term load forecasting with exponentially weighted methods. *IEEE Transactions on Power Systems*, 27 (1), 458-464.

[25] Box, G.E.P., Jenkins, G.M., Reinsel, G.C., & Ljung, G.M. *Time series analysis: forecasting and control.* 5th ed. Hoboken, US: 2016.

[26] R Core Team (2020). R: A Language and Environment for Statistical Computing. Vienna, Austria. Retrieved from: https://www.R-project.org

[27] Falbel. D., Allaire, J.J., Chollet, F., RStudio, Google, Tang, Y., Van Der Bijl, W., Studer, M., &Keydana, S. (2020). keras: R Interface to 'Keras'. R package version 2.3.0.0.

[28] Hyndman, R., Athanasopoulos, G., Bergmeir, C., Caceres, G., Chhay, L., O'Hara-Wild, M., Petropoulos, F., &Razbash, S. (2020). forecast: Forecasting functions for time series and linear models. R package version 8.13.

[29] Hijmans, R.J., Williams, E., & Vennes, C. (2019). geosphere: Spherical Trigonometry. R package version 1.5-10.

[30] Igava, L. *Zone B one outline*. Retrieved Sept23rd, 2020 from:https://www.arcgis.com/home/item.html?id=99fa9c4d2 2274fa7bc813e48d0ee28cd

[31] Igava, L. *Zone B two outline*. Retrieved Sept23rd, 2020 from: https://www.arcgis.com/home/item.html?id=a6054c840e904 7d9a648ed89d1c741ea

[32] Byrd, R.H., Lu, P.; Nocedal, J., & Zhu, C. (1995). A limited memory algorithm for bound constrained optimization. *SIAM Journal on Scientific and Statistical Computing*, 16 (5), 1190-1208.

[33] Hyndman, R.J., & Khandakar, Y. (2008). Automatic time series forecasting: The forecast package for R. *Journal of Statistical Software*, 27 (3), 1-22.

# Work Accidents from the Perspective of Workers: A Case Study in the Footwear Industry (Rs, Brazil)

OLIVEIRA Paulo Antonio Barros[1], RENNER Jacinta Sidegum[2]

**Abstract**— *This research aimed to understand the perception of operators, supervisors, and managers on the causes of work accidents, risk, danger, and human error. In addition, it sought to identify convergent and divergent issues among workers at different positions and functions. We used the case study method with qualitative data analysis, in a footwear company located at Vale do Paranhana (Rio Grande do Sul, Brazil). Although human error is usually considered the cause of work accidents, results showed that there are problems in both the work process and work organization. These impose an accelerated pace dictated by conveyors that does not always allow proper care in order to prevent accidents. Other causes of accidents mentioned are the lack of safety training and the configuration of machines and equipment that allow for failures, errors, incidents, and accidents.*

**Keywords**— *work accident, footwear industry, work organization, human factors.*

## I. INTRODUCTION

At the time of the research, Brazilian footwear industry comprised more than 7,200 companies, which produced around 665 million pairs of shoes a year, of which 189 million for export. This industry was, and still is, one among those that create more jobs in the country and employs more people in the state of Rio Grande do Sul (RS) (ABI CALÇADOS, 2014).

Despite the concentration of large companies in Rio Grande do Sul, Brazilian footwear production has gradually expanded to other areas in the Southeast and Northeast regions of the country, especially in the state of São Paulo (cities of Jaú, Franca, and Birigui) and in emerging states as Ceará and Bahia. Footwear production has also increased in the states of Santa Catarina (São João Batista area) and Minas Gerais (Nova Serrana area), in addition to the large-scale migration to China and India in recent years.

In view of the labor size in this industry and its expansion within Brazil, improvements and investments are expected in health, safety and quality of life, which will result in benefits for a large number of workers, since there are several risks of accidents in the footwear industry. Work accidents vary for each branch of economic activity, due to technologies used, working conditions, workforce characteristics, and safety measures adopted, among other factors (COSTELLA, 2012).

As for the definition of work accident, according to the Brazilian Accident Registration Standard (NB18), "[it] is an unforeseen and undesirable occurrence, instantaneous or not, related to work performance, which causes personal injury or results in a near or remote risk of that injury" (ABNT, 1995). In Brazil, companies consider work accidents as a phenomenon that stems from human or technical failures, expressed by unsafe acts and conditions (RIBEIRO, 1999).

Once we acknowledged the reality of the footwear industry, with regard to the number of work accidents, the main objective of this study was to understand the perspective of employees working in different areas of the company and at distinct hierarchical levels - operators, supervisors, and managers -, concerning the causes of work accidents. In addition, we also sought to understand their perception of risk, danger, and human error, as well as to identify and compare potential conflicting situations regarding risks and safety management at that company.

## II. RESEARCH METHOD

We chose to carry out a case study, with qualitative data analysis, in a firm of the footwear industry located at Vale do Paranhana, in the state of Rio Grande do Sul, Brazil. We selected employees at random for the interviews, with at least one operator representing each process stage, regardless of gender, age, or profession time. We interviewed eight workers – four operators, two

supervisors, and two managers. In order to prevent any possible constraint, participants had their anonymity ensured by signing an Informed Consent Form.

As for data collection, we developed a specific questionnaire for the interviews, which was used for the three professional categories. We conducted the interviews individually, in a room next to the production area, which facilitated participants' access. Interviews were recorded, with the participants' consent, in order to ensure full access to all information gathered.

Therefore, the main data collection instrument was the questionnaire used in the individual interviews. The initial questions regarded the personal identification of the interviewees, which allowed their profile creation. Since the study aimed to identify workers' perception of the concepts of risk, danger, accidents, and human error, we grouped the remaining questions in four categories. These were (1) workers' perception of risk in handling machines and equipment; (2) workers' perception of risk throughout the process; (3) workers' perception of personal safety and use of personal protective equipment

(PPE); and (4) workers' perception of social climate and work organization. In order to compare these perceptions with working conditions, machines whose operation was considered of highest risk were briefly examined.

## III. DATA ANALYSIS AND DISCUSSION

We describe the data in a non-literal way; however, we did not change, interfere or neglect reports that were relevant to the research.

First, we present in Table 1 the four categories of failures, according to the concept of work safety, comparing the perceptions of employees from the three hierarchical levels defined for the interviews. Next, Tables 2, 3, 4 and 5 present the risk perception, distributed among the four previously established categories: perception of risk in machines and equipment, perception of risk in the process, perception of risk in personal safety and use of PPE, and perception of risk in the social climate and work organization.

*Table.1: Interviewees' perception regarding safety concepts*

| Operators | Supervisors | Managers |
|---|---|---|
| **Risk**: distraction, conversation, bare and loose electrical wires, dealing with fire and electricity. | **Risk**: everything that puts human life at stake. | **Risk**: speed of processes and non-use of PPEs. |
| **Danger**: lack of care, electricity (3 mentions). | **Danger**: danger and risk are similar terms – the word danger draws more attention. | **Danger**: carelessness, risky machines, electricity and chemicals. |
| **Accident**: carelessness. | **Accident**: any unusual situation. | **Accident**: any abnormality or fatality. It happens due to lack of training. |
| **Human error**: distraction (2 mentions), lack of care (2 mentions). | **Human error**: it is complex; you need to examine the accident from all angles to conclude. | **Human error**: carelessness, "silly moment", distraction, lack of concentration, too many concerns. |

By analyzing interviewees' perception of the concepts related to safety at work, we observed that it was complex to define safety at the operational level. However, all respondents related the concept with facts that happen in daily work.

When comparing the three groups, they were similar about gaps in knowledge and understanding of the basic issues related to safety; regardless of the hierarchical level, nobody was able to clearly define risk, danger, accident, and human error. For example, danger always related to electricity. As for the concept of risk, there were no significant differences among the ideas mentioned by participants of different hierarchical levels; however, all of them tended to correlate risk with behavioral traits such as distraction and carelessness. Finally, managers and

supervisors defined risk as everything that puts human life at stake, and related it to the process speed. This indicates that understanding goes beyond the responsibility centered purely on the individual (perception of operators) and extends to the level of work organization (perception of managers and supervisors).

Regarding the concept of human error, there were no significant differences among the ideas provided by different groups. Despite not being defined, human error was considered a distraction, carelessness, or as a "silly moment". There is a strong predisposition of operators to take on a large load of responsibility for the accident. Sometimes, in their own perception, the work accident seems to have a single cause – negligence of the operator.

*Table 2: Interviewees' perception of risks in machinery/equipment*

| Operators | Supervisors | Managers |
|---|---|---|
| **Dangerous machines**: electric press and rocker cutting machine; lack of mechanical preventive maintenance; foot drive.<br><br>**Workaround**: witnessed by operators in other firms (3 mentions); the company's safety team does not allow workarounds.<br><br>**Dangerous equipment**: punch tool, scissors and needles. | **Dangerous machines**: belt sander and toe cap molding machine – danger is higher without preventive maintenance.<br><br>**Workaround**: witnessed on the rocker cutting machine; the operator may wish to stand out by producing more.<br><br>**Dangerous equipment**: punch tool (witnessed accidents with it) and scissors. | **Dangerous machines**: toe cap molding machine, outsole press, heel nailing machine, press and belt sander, sole pressing machine. All may be dangerous without preventive maintenance.<br><br>**Workaround**: did not witness any; understand that workarounds are due to the lack of preventive inspections of machines.<br><br>**Dangerous equipment**: risk has decreased due to technological developments. |

Regardless of hierarchical level, all interviewees understand the risks of accidents related to machinery and equipment, especially of those that represent a real risk. In the workers' perception, presses and rocker cutting are the machines that bring danger, not only because of their conformation, but also due to the compensation mechanisms – workarounds – added by operators, which, in the end, limit the machine even more in terms of safety.

Therefore, the question about adding "workarounds" to the machines is relevant, because, to the workers, it has become a common practice in most companies of the region. Respondents justified the use of this practice, although it should not occur.

A cutter's activity consists of cutting pieces of leather to make up the shoe. The operator receives razors and leather pieces, and must cut these pieces for the best possible use of the leather. He is responsible for checking the leather conditions and the orders that accompany the material. He makes the cut with a hydraulic equipment called "rocker cutting machine" and hand tools (razor and hatchet).

*Table 3: Interviewees' perception of risks in the industrial process*

| Operators | Supervisors | Managers |
|---|---|---|
| Dust – "specks" can fall; poorly sized work stations; lack of experience in performing the operation; "borrowed" staff; worker that lacks mastery of the operation and the machine. | Lack of training; repetitive effort; each new model has peculiarities (details); lack of guidance on how to perform the operation; noise exposure. | Lack of training; ignorance of the chemical composition of the products used (glues, solvents); the operators' mood (state of mind) affects safety. |

Operators noticed risks related to unsafe machine design. As for the need of training to deal with current risks, all three categories tended to value it. These aspects also appear in the social climate and work organization category.

*Table 4: Interviewees' perception of personal safety and use of PPEs*

| Operators | Supervisors | Managers |
|---|---|---|
| One operator did not receive safety training, all the others did. There is a constant demand for PPEs. Everybody wears ear protectors, and only two use cream to protect their hands. | They were informed about safety during the admission process. They wear ear protectors and hand cream as PPEs. One had a minor accident with a punch tool. For him, operators come from other companies with "vices" of not following safety measures. | They were informed about safety during the admission process. One had an accident in the belt sander, but did not get a leave; other had an accident with the heel-nailing machine, and got a 19-day leave. They see risk of accidents when people wear open shoes (because of the sharp objects and chemicals used). They wear ear protection as PPE. |

As shown in the above category, the role of basic education is evident – the prevention of occupational accidents –, which may occur through constant training, not only in the company's admission process. Michel (2000) mentions that none of the machines built, none of the chemical products obtained by synthesis, and none of the social theories formulated have fundamentally changed human nature so far. Different ways of behavior must be considered in the effort to prevent unsafe acts and should always be analyzed comprehensively.

The conditions identified in the field support workers' perception that the risk is in the machine, in poorly formulated projects. In contrast, supervisors and managers are concerned with qualification and training, therefore acting only on the human factor.

It is important to highlight the report of an operator that has worked in the sector for several years. He mentioned that the highest risk of an accident is not at the factory, but on the street, with many bicycles around and too many people in a hurry. A manager also stressed the risk of accidents due to the large numbers of pedestrians, bicycles, motorcycles, and cars in the area. In this scenario, work organization should also receive attention, which brings up relevant questions: must all companies have a lunch break at the same time? If companies provided good, safe and inexpensive public transportation, would it reduce the problem? Is there enough time for the lunch break? (Considering that, in this company, most women go home, prepare lunch, have lunch, and return to work, within one and a half hours).

*Table 5: Interviewees' perception of social climate and work organization*

| Operators | Supervisors | Managers |
|---|---|---|
| All interviewed operators reported that social climate is excellent. The relationship among the different hierarchical levels is very good, and they define the climate as familiar. One operator said that the integration is so good that it increases productivity. | One supervisor has already worked in four companies, and this is the best one in terms of social climate. Everyone is treated with equality and respect. Social climate favors the achievement of goals. | One manager made a self-assessment and said that humility and transparency with subordinates are necessary for a good social climate. All emphasized team importance and the priority given to good relationships and social climate in the company. |

When analyzing the above table, we notice that interviewees' understanding of work organization was restricted to social climate. Nevertheless, we emphasize that the concept of work organization covers the production mode, in this case the Taylorist-Fordist production system, characterized by repetitive and monotonous work, with the same task performed for months and years. Therefore, it comprises the content and variation of activities, rotation and breaks, period of adaptation to activities, task planning, selection of technologies, equipment and machines, and technical training of workers. Another issue to consider regards the need of spaces for cognitive exchange at the workplace, in order to create safer working conditions (OLIVEIRA, 2002). More than an ideological aspect of capital controlling labor, these spaces allow more effectiveness in the regulation procedures of these groups, while performing their activities.

Some managers and supervisors mentioned the need for increasing technical training, since the lack of training is common in this industry; operators learn the activities they will perform empirically, by simple observation and conversations with colleagues. This approach may leave gaps regarding task performance in a

safe and efficient way, especially when considering the speed of the process, which may bring the risk of accidents.

According to a manager, workarounds can increase the speed, making an employee stand out as "different and better". However, it is necessary to consider that performance varies from one person to another, and even in the same person at different moments. A policy that values the worker in a more comprehensive and integrated way, as an individual within a context – in this case, the footwear industry –, must be implemented not only to reduce the number of accidents, but also to decrease occupational diseases, since there is a correlation between psychosocial and organizational factors and the risk of accidents.

The perception of social climate and integration among the company's workers was clear in the three groups. They stressed several times that climate was a motivating factor, thus improving the overall performance, by comparing the company to a large family, where everyone gets along very well. Satisfaction was repeatedly mentioned and, according to the International Labor Organization (1990), regards "interactions between the work environment, job content, organizational conditions, workers' capacities, their needs, culture, and personal extra-

professional considerations that can, through personal perceptions and experiences, affect health, work performance, and job satisfaction".

## IV. CONCLUSION

This research sought to identify the perception of three groups of workers, regarding risk factors for work accidents in the footwear industry, through qualitative analysis techniques. We carried out interviews with operators, supervisors and managers as sources of data.

Interviewees' perceptions confirmed the authors' hypotheses: in most companies, when an accident or incident occurs at work, the concern to find a "culprit", thus attributing the cause of the accident to human error, leads the worker to accept this hypothesis as true over time. Victim's distraction and carelessness are often mentioned. However, even admitting the lack of training as a cause of accidents, operators have the perception that the unsafe conditions of the machines, resulting from their design or spatial arrangement, are also an important cause of accidents.

Some perceptions indicate lack of safety training and capacity building in companies of the sector. This issue involves work conception, because qualifying or training are seen as a waste of time and money in the distorted rhythm of the Taylorist system. It becomes evident that rhythm, journey, breaks, production mode, and work organization are not relevant issues now. The perception of the accident focuses mistakenly on the operator's behavior and on the design of machines and equipment. The use of workarounds to speed up the process, or as an element of individual valuation, in addition to the continuity of operations on poorly constructed machines, clearly show this reality, which in turn leads to the use of workarounds.

Finally, based on this study's findings, this subject deserves more research to clarify the real causes of work accidents, by taking into account human factors and especially work organization.

## REFERENCES

[1] COSTELLA, M. L. G. Contribuições para Aperfeiçoamento em um Método de Classificação de Tipos de Erros Humanos com Base na Investigação de Acidentes na Construção Civil. 2009. 82f. (Mestrado em Engenharia de Produção) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2009.

[2] BRANDIMILLER, Primo A. **Perícia judicial em acidentes e doenças do trabalho.** São Paulo: Editora Senac, 1996.

[3] GONÇALVES, Edwar Abreu. **Segurança e medicina do trabalho em 1200 (hum mil e duzentas ) perguntas e respostas**. São Paulo: LTR, 1996.

[4] MENDES, Renê (Org.). **Patologia do trabalho**. Rio de Janeiro: Atheneu, 1995.

[5] MICHEL, Osvaldo. **Acidentes do trabalho e doenças ocupacionais.** São Paulo: LTR, 2000.

[6] MINISTÉRIO DA SAÚDE. Assessoria de Comunicação Social, **Lei Orgânica da Saúde**, Brasília, 1990.

[7] MIRANDA, Carlos Roberto. **Introdução à saúde no trabalho**. São Paulo: Atheneu, 1998.

[8] MORAES, Anamaria; MONT'ALVÃO, Cláudia. **Ergonomia conceitos e aplicações**. Rio de Janeiro. 2AB, 1998.

[9] ODDONE, Ivar et al. **Ambiente de trabalho: a luta dos trabalhadores pela saúde**. São Paulo: Hucitec. 1986.

[10] OLIVEIRA, Paulo Antonio Barros. Trabalho coletivo: a construção de espaços de cooperação e de trocas entre trabalhadores. In JACQUES, M. G. e CODO, W. **Saúde Mental e Trabalho: leituras**. Petrópolis, RJ: Vozes, 2002.

[11] ROCHA, E. Lys; RIGOTTO, M. Raquel; BUSCHINELLI, T. P. José (Orgs.). **Isto é trabalho de gente?** Vida, doença e trabalho no Brasil. São Paulo: Vozes, 1993.

[12] RODRIGUES, Marcus Vinícius Carvalho. **Qualidade de vida no trabalho:** Evolução e análise no nível gerencial. 2. ed. Rio de Janeiro: Vozes, 1994.

[13] SEGURANÇA e medicina do trabalho**. Manuais de Legislação Atlas.** 46ª ed. São Paulo: Atlas, 2000.

# Teaching Mathematics: Low Performance in Mass Evaluations

Fábia Maria de Souza[1], Roberto Grün[2], Hélio Raymundo Ferreira Filho[3]

[1]PhD in Production Engineering, Federal University of São Carlos (UFSCAR), Professor at the State University of Pará (UEPA), Belém, PA, Brazil

[2]PhDin Social Sciences, State University of Campinas (UNICAMP), Professor at the Federal Universityof ABC (UFABC), São Paulo, SP, Brazil

[3]PhD in Management Sciences, University Pierre Mendès-France (UPMF), Professor at the State University of Pará (UEPA), Belém, PA, Brazil

*Abstract— External performance evaluation processes of students in Brazilian schools have shown low retention and/or learning of knowledge provided for in the legislation. More precisely in the area of Mathematics, some indices have decreased in the latest evaluations, such as the National High School Examination (ENEM in Portuguese) and the* Programme *for* International Student Assessment *(PISA). This reality requires deep reflection, structured on research and dialogues between peers and agents, and to do this, data must be collected. In order to understand the results of the mass evaluation processes of Brazilian education, quantitative research was carried out using secondary data collection techniques. The results indicate that the evaluation processes show an insufficiency in the students performance averages, and Mathematics is the area of knowledge with the lowest indexes, both in internal (such as ENEM) and external (such as PISA) evaluations.*

*Keywords—Evaluation, ENEM, Mathematics, PISA.*

## I.    INTRODUCTION

Education is considered the mainspring for human, social and economic development of any nation (IAQUINTO, 2014). Owing to this, the education system should aim to offer society systematized education as a strategy for progress at all these levels.

According to the International Commission on Education for the Twenty-first Century prepared for the United Nations Educational, Scientific and Cultural Organization (UNESCO) and entitled Learning: The Treasure Within, the educational process "consists of allowing each individual, without exception, to make their talents and their creative potential fructify, which implies, on the part of each one, the ability to assume their own responsibility and carry out their personal project"(UNESCO, 2010, p.10). This means that, within schools, students can develop their skills and they are used in order to ensure greater mobility, especially in the profession they choose.

The Brazilian educational system was consolidated and (re)structured in such a way as to promote the disarticulation between the country's economy and the objectives of education, which functioned according to "predilections and economic configurations: the country's

economic axis was changed, the main activities generating labor were changed and, as a consequence, the profile of the required worker was changed" (OLIVEIRA; CALDEIRA, 2016, p.197).

The Brazilian Ministry of Education (MEC) has presented proposals with this aim, as over the last 10 years, it has matured ideas and discourse to develop competences, increasing the time spent by students at school, in the perspective of improving basic education. These paths have culminated in laws but have not yet had an impact on practical implementations or on improving student performance.

Among the aforementioned laws are the Normative Interministerial Ordinance no. 17, of April 24, 2007, which addresses the student's length of stay in school (BRASIL, 2007); the High School Curriculum Reform, through the National High School Curriculum Parameters of 2007 (BRASIL, 2006); Law no. 13.005, of June 25, 2014, which approves the National Education Plan (BRASIL, 2014); and Provisional Measure no. 746, of September 22, 2016, a recent specific high school case, which institutes the Policy to Promote Implementation of Full-Time High Schools (BRASIL, 2016a).

As can be observed, there are doubts concerning the need for improvements in high school. Unfortunately, it seems that students see schools as meaningless and unattractive, not developing their educational potential, therefore their skills, a situation that can be seen in the results of the ProgrammeforInternational Student Assessment (PISA), Basic Education Development Index (IDEB in Portuguese) and the National High School Examination (ENEM in Portuguese).

In Brazil, the educational conditions for intellectual learning are obsolete, since the guidelines of a class society still prevail, which are very close to noble young people´s education from the latifundium of Imperial Brazil and the Colony. Nevertheless, considering the contrary discourse and the advances that have occurred, intellectual learning of excellence is reserved for the elite (FRIGOTTO; CIAVATTA, 2011).

The Basic Education Assessment System (SAEB in Portuguese) indices point to this lack of development of the minimum skills of 600 points, according to the international standard: less than 10% of students in public schools reach the adequate minimum education level (SCHWARTZMAN; CASTRO, 2013), and, on completing the two stages of basic education, they are unable to reach the minimum proposed education level, that is, the average student in all spheres of education (private and public) who performed well, reaching the minimum average. This means that:

- in elementary school, among ninth graders, considering public and private schools, only 14.7% reached the minimum or above average level in Mathematics, a percentage that reached 26.2% in Portuguese; considering only public schools, the percentage dropped to 10.4% in Mathematics and 22% in Portuguese;

- in high school, in the 2014 ENEM assessment, among third grade school leavers, analyzing them only in mathematics performance and considering public and private teaching, only 11% learned the minimum; analyzing only the results of public school students, this percentage fell, unfortunately, to 5.8%.

Table 1 shows the number of schools per sphere, as well as the number of students enrolled in the third grade of high school versus the number of students who took ENEM:

*Table 1 –Students who enrolled and took ENEM in 2014 by sphere of education*

| Sphere | State | Private | Federal | Municipal | General Total |
|---|---|---|---|---|---|
| Numberofschools | 8,990 (57.5%) | 6,215 (39.7%) | 326(2.1%) | 109 (0.7%) | 15,640(100%) |
| Students enrolled in the third grade of High School in 2014 | 1,024,255( 74.7%) | 304,927( 22.3%) | 31,533( 2.3%) | 9,805(0.7%) | 1,370,520( 100%) |
| Students enrolled in the third grade in 2014 and who took ENEM in 2014 | 685,173(69.6%) | 263,889( 26.8%) | 27,296( 2.8%) | 7,412(0.8%) | 983,770(100%) |

*Source: adapted from data in the 2014 ENEM spreadsheet of Brazil (2015a).*

According to data from the National InstituteforEducational Studies and Research"Anísio Teixeira" (INEP), in the 2014 ENEM, among the 8,990 state schools, which were analyzed in the research supported by this article, only 34 (0.38%) reached or exceeded the basic minimum average of 600 points, considered by PISA to be the minimum performance for a student to have significantly acquired knowledge (INEP, 2015a).

In the last IDEB (BRASIL, 2015c), the data did not change and showed little improvement and very modest growth, whereby learning rates were below five points. This indicates that the overall average of students when completing the teaching stages was:

a) in elementary education:

- private: 6.2 in 2011; 6.5 in 2013; 6.8 in 2015
- public: 3.7 in 2011; 4.1 in 2013; 4.5 in 2015

b) in high school:

- private: 5.8 in 2011; 6.0 in 2013; 6.3 in 2015
- public: 3.4 in 2011; 3.6 in 2013; 4.0 in 2015

Regarding Enem, the overall average was also not much different. However, the MEC announced on the Portal do Brasil that the results of the examination increased the average of schools in general in the "comparison between 2013 and 2014: the score of the Language and Codes test went from 508 to 528; Natural Sciences from 492 to 507; and Humanities from 537 to 565. However, there was a drop in the mathematics test score from 544 to 511"(PORTAL BRASIL, 2015).

Thus, it is clear that the situation has not evolved much over the years, which can be confirmed in the data made available by INEP in 2016 and widely published in newspapers, journals and magazines circulated widely in Brazil. Interesting examples of this mediatization are some reports from the magazine called Veja by columnist Castro (2016), who notes that "in mathematics, students only learn about 10% of what is expected". This is a comment that questions teacher training and the adoption of a single curriculum model for all high school students, contrary to the trend of developed countries, which adopt flexible curricula. Another key point to be observed is teacher training practices, which are directly reflected in the student's learning, and are therefore one of the biggest challenges in education: developing teaching practices that can be used for their needs.

Thus, the Brazilian educational field has legislation whose objectives are aimed at developing students' skills, although the performance concerning the evaluation processes, such as IDEB, PISA and ENEM demonstrate that these objectives are not being met.

## II. METHODOLOGY

The work presented in this article followed a qualitative research approach as it draws on premises that aim to analyze and interpret rooted aspects, trying to describe the complexity of human behavior (MARCONI; LAKATOS,

2010), using an analysis of secondary data collection.

The collection "is a measurement process used to collect information during a highly structured interview" (COOPER; SCHINDLER, 2016, p. 221), and the secondary data refer to information already collected, systematized, tabulated and ordered, with or without analysts. to meet the research purposes, which are available to companies or even in the public domain (RICHARDSON, 2010; COOPER. SCHINDLER, 2016).

Some tertiary data were also used, which are related to tertiary sources, which although difficult to define, can be understood as those contained in bibliographies, dictionaries, almanacs, etc. (COOPER; SCHINDLER, 2016).

This research followed some steps: first, we sought to find outINEP (2015a, b, c) and OECD (2011; 2013) databases through an analysis; then the information was summarized from the obtained elements.

## III. RESULTS

### 3.1 Teaching and performance in mass evaluations

Until mid-2017, the educational proposal for young people in basic education in Brazil consisted of policies that claim that their social agents are prepared for citizenship and work, based on developing capital resources.These resources are called competences, which are pointed out, conceptualized and classified in the National Curriculum Parameters (PCN in Portuguese), more specifically in the Introduction (BRASIL, 1997, p.47). The human capacities to be developed are cognitive, physical, affective, interpersonal and social, ethical and aesthetic, and can be analyzed in Table 1.

*Table 1 – Human capacities and knowledge developed by social agents*

| Capacity | Influence | Knowledgedevelopment |
|---|---|---|
| Cognitive | Ways of representation and communication involving problem solving | Representation codes; interfering with language learning, mathematics, spatial, temporal and graphic representation, and reading images |
| Physical | Self-knowledge and using the body to express emotions | Overcoming stereotypes of movements, in games, in moving around safely |
| Affective | Motivation and self-esteem, sensitivity and adequacy of attitudes in social life | Understandingyourselfandothers |
| Interpersonal | Understanding, living and producing with others, noticing differences between people, contrasts in temperament, | Allowing yourself to put yourself in the other's shoes and reflect on your own thoughts. Cooperation practices that incorporate participatory forms, enabling joint positions to be taken. |

| | intentions and moods | |
|---|---|---|
| Social Insertion | Noticing that you are part of a community, a class, one or more social groups and personally committing yourself to issues that you consider relevant to collective life | Necessary so that you can overcome individualism and act (in daily life or in political life) taking into account the collective dimension. Learning different forms and possibilities of social participation is essential for developing this capacity |
| Aesthetics | Producing art and appreciating different artistic productions | Allowing to produce and reproduce in different cultures and historical moments |
| Ethics | Possibility of governing your own actions and decision making based on a system of principles according to which, in different situations of life, the values and options involved are analyzed. | Developing this capacity enables us to consider and attempt to understand reasons, nuances, conditions, consequences and intentions, that is, it allows us to overcome moral rigidity, in judgment and personal performance, in interpersonal relationships and understanding social relationships |

*Source: adapted from Brasil(1997).*

Thus, a complex educational system was considered, together with the development of the students' capacities and skills, interlinking informal and formal knowledge when redimensioning knowledge necessary for citizenship and the world of work. Thus, in the last half of the 1990s, basic education in Brazil took on the challenge of implementing and developing educational policies based on the development, acquisition and apprehension of skills.

According to the main international organizations and UNESCO, the PCN and the Law of Directives and Bases of Education (LDB in Portuguese) are consistent with the acquisition and development of resources and values necessary to hold cultural capital, inherent and announced in the practice of competencies, including technical and higher education.

**3.2 The Basic Education Assessment System (SAEB)**

According to the Basic Education Census of the previous year (BRAZIL, 2015b), all Brazilian public schools with at least 20 students enrolled in the fifth or ninth grade of elementary school and in the third grade of high school participated in SAEB. According to Ministerial Decree no. 931 of March 21, 2005 (BRASIL, 2005), the system consists of two evaluation processes:

1. the National Assessment of Basic Education (ANEB), of universal character, which, when disclosed, is called SAEB (INEP, 2015c). It is done by large-scale sampling external to the public and private education systems and of biannual periodicity (BRASIL, 2005);

2. the National Evaluation of School Achievement (ANRESC), which is more extensive and detailed than ANEB and focuses on each school unit. It is known as ProvaBrasil (INEP, 2015c) and evaluates public primary schools (BRASIL, 2005).

Unfortunately, the indices are not encouraging. This can be seen in Graph 1, which presents data related to the Mathematics course provided by INEP (2016a):

*Graph 1 - Evolution of Brazil's results in SAEB (1995 to 2015) - average proficiency in Mathematics*
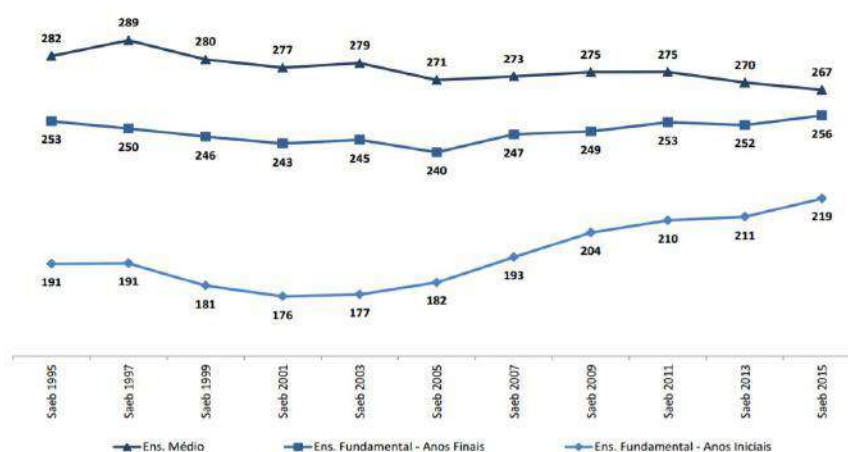
*Source: Inep(2016a).*

It can be observed that the learning rate of Brazilian children and young people is extremely low. Schwartzman and Castro (2013, p.579) point out that less than 10% of students in public schools achieve adequate minimum training, which means that when they complete the basic education stages, they are unable to reach the proposed minimum training. Another instrument that also measures basic education in Brazil is the IDEB, which does not appear to have very different data either.

**3.3 Basic Education Development Index (IDEB)**

IDEB was created by INEP in 2007 and shows the initiative of bringing together two concepts in a single indicator: the students´ peak flow and average performance assessment. IDEB data was collected and calculated in two dimensions:

1. based on data concerning the school pass rate obtained in the School Census, that is, the average pass rate reported annually by schools;

2. based on student achievement averages in the SAEB and Prova Brasil assessments in Portuguese and Mathematics - students enrolled in the fifth or ninth grade of elementary school and in the third grade of high school.

These instruments also have low levels of learning, and represent the indexes made available by INEP (2016b) with the results of the high school IDEB. The average by state of the Brazilian educational field can be seen in Table 2:

*Table 2 – IDEB: High School results and targets*

|  | IDEB Observed | | | | | | Targets | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | **2005** | **2007** | **2009** | **2011** | **2013** | **2015** | **2007** | **2009** | **2011** | **2013** | **2015** | **2021** |
| **Total** | **3.4** | **3.5** | **3.6** | **3.7** | **3.7** | **3.7** | **3.4** | **3.5** | **3.7** | **3.9** | **4.3** | **5.2** |
| **Administrative Dependence** | | | | | | | | | | | | |
| **State** | 3.0 | **3.2** | **3.4** | **3.4** | 3.4 | 3.5 | 3.1 | 3.2 | 3.3 | 3.6 | 3.9 | 4.9 |
| **Private** | 5.6 | **5.6** | 5.6 | 5.7 | 5.4 | 5.3 | 5.6 | 5.7 | 5.8 | 6.0 | 6.3 | 7.0 |
| **Public** | 3.1 | **3.2** | **3.4** | **3.4** | 3.4 | 3.5 | 3.1 | 3.2 | 3.4 | 3.6 | 4.0 | 4.9 |

Source: Inep (2016b).

A bottleneck can be clearly seen, which is reflected in the Brazilian indices with the most diverse considerations and opinions. However, this situation is more serious in some states, as can be seen in Graph 2:

*Graph 2– High School – IDEB and targets per federation unit (2015 total)*

*Source: Brasil (2016c).*

Analyzing the data in more detail, the presence of lower rates in the North and Northeast regions of Brazil can be observed, as well as higher rates in the South and Southeast regions. According to Gadotti (2014, p.12), the continuous reproduction of this dynamic coupled with the disarticulation of national education are the main reasons for negative results and inequality in educational opportunities.

Social structures should also be analyzed from this point of view, as they reflect within schools and, in most cases, the latter are passive, even because they abscond their attributions - which nevertheless contributes to the continuity of social inequalities and curtail opportunities for students. However, the teaching-learning process cannot be seen only as a final product, but also as a way in which the active and proactive subject receives a product, internalizes it and promotes feedback with their surroundings, which means that the final product needs education and is characterized as the sum of the whole (MACHADO; ALAVARSE, 2014).

Thus, evaluations are absolutely necessary knowledge, and are configured as a concrete and systematic expression of reality through the results obtained. In other words, evaluations, in general, are not just a management tool: they must be an instrument that improves democracy and qualifies public policies.

When relating the results of the Organization for Economic Cooperation and Development (OECD, 2013) and the economic development of countries, the best examples are among nations that until the mid-twentieth century were very dependent on others, but that have developed their educational fields qualitatively, investing heavily, creating and consolidating systems. These countries had a surprising trajectory, becoming great economic powers - such as in Japan, South Korea and China, countries in which young people, when evaluated in

PISA 2012, led the ranking in Mathematics.

In the PISA classification (OECD, 2013), performance rates in the area of mathematical knowledge in Brazil are low. Young people in basic education in developed countries and with advanced technologies have rates well above those in developing countries (such as the Brazilian case) or with low development.

**3.4 Programme for International Student Assessment (PISA)**

PISA was created in 2000 by the OECD, carrying out a worldwide assessment periodically and obtaining a ranking of educational performance. In Brazil, it is coordinated by INEP itself, and it is coordinated nationally in the participating countries (INEP, 2015c). Every three years, PISA evaluates performance in Reading, Mathematics and Science of students aged between 15 and 16 years enrolled in regular education (public or private) in approximately 65 countries, with a varied focus.

In 2012, the examination focused on Mathematics, which represented the second cycle of the Program. In 2000, the focus was Reading, in 2003, Mathematics, and in 2006, Science, so that in 2009, a new cycle of the program began, focusing on Reading. In 2015, Sciences were again the focus of the assessment (INEP, 2015b).

The socioeconomic disadvantages of some students may induce them to link, from one generation to the next, the cycle of few academic achievements with poor job prospects. However, this situation can be regressed by enrolling in schools that offered them regular classes, with quality in learning, a situation rarely seen in public schools (OECD, 2011).

According to the publication PISA em Foco no. 5 (OECD, 2011, p.1), in Pisa 2009 "approximately one third of students from OECD countries were identified as resilient. In fact, most students from disadvantaged backgrounds in

Korea and in the partner economies Hong Kong-China, Macau-China and Shanghai-China were considered resilient".

In the Education Ranking 2015, the first positions were held by Asian countries, such as Singapore, Hong Kong, South Korea, Japan and Taiwan, followed by European countries, such as Finland, Estonia, Switzerland and the Netherlands. At the other end are African countries, such as Ghana (last position) and South Africa (penultimate position) (OECD, 2015). Among 76 countries, Brazil is in 60th place, not far from the previous data, in 2012, when it occupied the 55th position, among the 65 participating countries, as shown in Graph 3:

*Graph 3 – Ranking of Education in 2012 in PISA, of some countries*
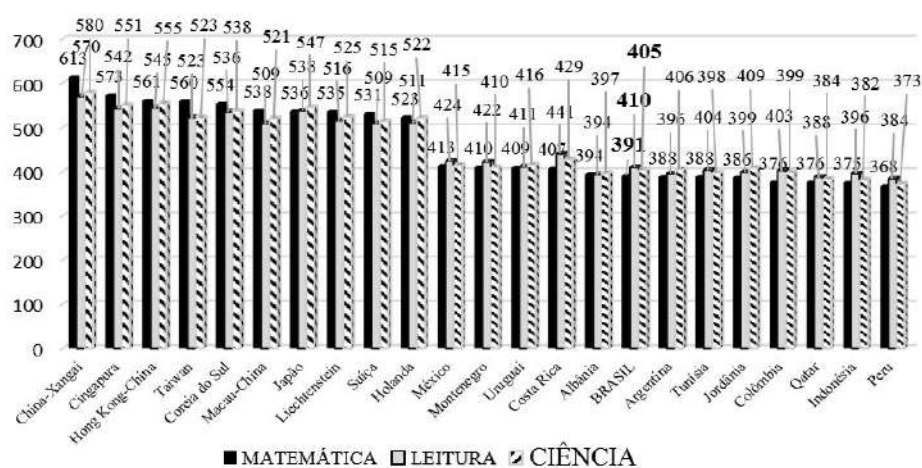


*Source: OCDE (2013).*

The difficulties or the unlikely elimination of the cycle of disadvantages in the implementation of curricula and in the educational field are well known. However, schools with concise and efficient educational practices induce and/or improve students' ability to deal with problems, overcome obstacles or withstand the pressure of situations, increasing their learning. Table 3 presents a comparison of the results in Mathematics (2003 to 2012) from PISA:

*Table 3 – Comparison of PISA Mathematics results from 2003 to 2012 editions*

| | PISA 2003 | | PISA 2006 | | PISA 2009 | | PISA 2012 | | Difference between 2003 and 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Average | Economic Status | Average | Economic StatusP | Average | Economic Status | Average | Economic Status | Average | Economic Status |
| Brazil | 356.0 | 4.8 | 369.5 | 2.9 | 385.8 | 2.4 | 391.5 | 2.1 | 35.4 | 5.4 |
| Mexico | 385.2 | 3.6 | 405.7 | 2.9 | 418.5 | 1.8 | 413.3 | 1.4 | 28.1 | 4.1 |
| Portugal | 466.0 | 3.4 | 466.2 | 3.1 | 486.9 | 2.9 | 487.1 | 3.8 | 21.0 | 5.3 |
| South Korea | 542.2 | 3.2 | 547.5 | 3.8 | 546.2 | 4.0 | 553.8 | 4.6 | 11.5 | 5.8 |
| Spain | 485.1 | 2.4 | 480.0 | 2.3 | 483.5 | 2.1 | 484.3 | 1.9 | -0.8 | 3.4 |
| USA | 482.9 | 2.9 | 474.4 | 4.0 | 487.4 | 3.6 | 481.4 | 3.6 | -1.5 | 4.9 |
| Uruguay | 422.2 | 3.3 | 426.8 | 2.6 | 426.7 | 2.6 | 409.3 | 2.8 | -12.9 | 4.5 |

| Finland | 544.3 | 19 | 548.4 | 2.3 | 540.5 | 2.2 | 518.8 | 1.9 | -25.5 | 3.0 |
| Argentina | - | - | 381.3 | 6.2 | 388.1 | 4.1 | 388.4 | 3.5 | - | - |
| Peru | - | - | - | - | 365.1 | 4.0 | 368.1 | 3.7 | - | - |
| Colombia | - | - | 370.0 | 3.8 | 380.8 | 3.2 | 376.5 | 2.9 | - | - |
| Chile | - | - | 4114 | 4.6 | 421.1 | 3.1 | 422.6 | 3.1 | - | - |

*Source: Inep (2012).*

On December 2, 2016, the financial newspaper Valor Econômico reported that Brazil, in a list of 64 countries worldwide, has the second largest number of students with low performance in basic mathematics, science and reading (GUIMARÃES; MARCHESINI, 2016). In the general data, which considers the average performance in these areas, only 2.2% of Brazilian students are among the highest scores of PISA, at levels 5 or 6, while in Japan they are 25.8% and in Finland, 21.4%. In Brazil, specifically in mathematics, the average in 2015 was 377 points, against 490 points by the OECD, which indicates that 70% of Brazilians were below level 2.

Industrial and economic development of eastern countries, such as Japan, China and South Korea, according to research, is closely linked to their cultural and ideological contexts, with interference by the State, although the government and industry are in line with each other in terms of continuously searching for development models. Brazil is one of the countries with the lowest index of students without basic knowledge of Mathematics and is one of the last placed in a ranking of competences, according to what the OECD study (2015) points out. The 2015 PISA results indicate that 67.1% of Brazilian students aged 15 and 16 are below level 2 in Mathematics (FERNANDES, 2016).

In addition, it can be observed that the mathematical apparatus allows human intellect to extract data that can be transformed into information and construct theories, developing technologies that are increasingly accurate, refined and efficient. Once again, Brazilian students´ performance, even after completing basic education demonstrated in the measured data (including the instrument that evaluates only the final stage - high school -, as in the case of ENEM), is still very low.

### 3.5 National High School Examination (ENEM)

ENEM was created in 1998 aiming to evaluate students´ performance at the end of the basic education cycle, that is, at high school. A priori, the Examination aimed to contribute only to improving the quality of this level of education, and, as of 2009, it also started to be used as a selection mechanism for entering higher education (mainly in federal universities). ENEM scores may be the only selection phase of a university, which can also combine them with its own selection processes (INEP, 2015c). Students who complete or have completed high school can participate in the exam.

According to the MEC, about 500 universities already use the exam result as a selection criterion for entering higher education, either complementing or replacing their own entrance examination (BRASIL, 2016b). ENEM is also used as a selection criterion for students who intend to apply for a scholarship at the University for All Program (ProUni) and to obtain the high school leaving qualification (BRASIL, 2016b).

Regarding INEP (2014a), the Examination aims to assess the competences and skills developed by students at the end of basic education. This evaluation process is done through an essay and objective tests that evaluate the four areas of knowledge mentioned above. Schools should use the results of this instrument to help students and teachers, as well as managers and family members, to reflect on the students' learning and their response to everyone's expectations, as it is understood that knowledge gained over 10 years has been learnt.

*Table 4 – Comparisons of the results of Brazil in ENEM from 2011 to 2015*

| Area | 2011 | 2012 | 2013 | 2014 | 2015 |
| --- | --- | --- | --- | --- | --- |

| | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum |
|---|---|---|---|---|---|---|---|---|---|---|
| Human Sciences | 793.1 | 252.6 | 874.9 | 295.6 | 793.1 | 252.6 | 862.1 | 324.8 | 850.6 | 314.3 |
| Natural Sciences | 867.2 | 265 | 864.9 | 303.1 | 867.2 | 265 | 876.4 | 330.6 | 875.2 | 334.3 |
| Languages | 795.5 | 301.2 | 817.9 | 295.2 | 795.5 | 301.2 | 814.2 | 306.2 | 825.8 | 302.6 |
| Mathematics | 953 | 321.6 | 955.2 | 277.2 | 953 | 321.6 | 973.6 | 318.5 | 1.008.3 | 280.2 |

*Source: adapted from INEP (2011; 2012; 2013; 2014a; 2015c), G1 Educação (2011; 2012a, b, c; 2013; 2014) and UOL Educação (2011; 2012; 2013; 2014).*

Regarding the results of the evaluations of Brazilian students in ENEM, converging with the instruments of previous evaluations, they show the serious deficit and great disparity between the minimum and maximum averages, as can be seen in Table 4, which shows the last four results of the evaluations of Brazilian students in the examination:

However, when analyzing the 2014 and 2015 ENEM averages made available by INEP, the high rate of very low averages is well known. The averages equal to or above 600 points were reached by a few high schools, and the ones that reached the averages are, in the vast majority, from private initiatives, some federal and very rarely state ones.The state ones are those whose evaluations reached an average of 600 or more points, and which are applicable to a university or have partnerships with the armed forces.

Graph 4 shows the general average of ENEM in 2014 and in 2015:

*Graph 4 - Averages of ENEM in 2014 and 2015*
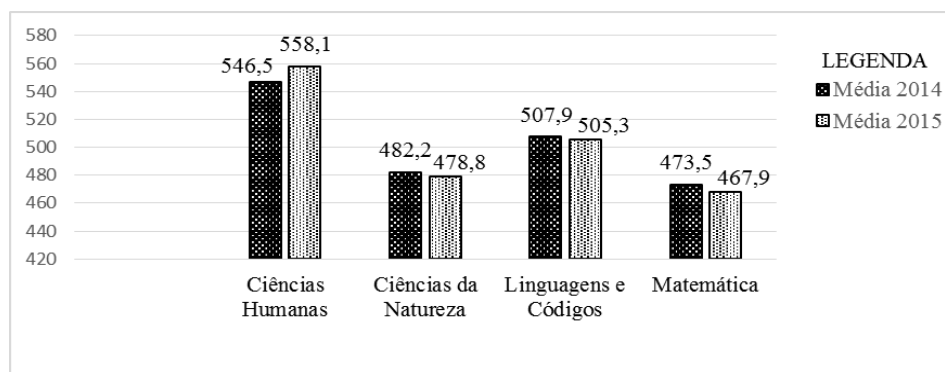


*Source: adapted from INEP data (2014, 2015c)*

## IV.    FINAL CONSIDERATIONS

Based on these statistics and the cultural situations of Education in Asian countries, the relationship of the domain in the area of Mathematics with the economic development and technology of a nation can be considered, as the basis of the development of an organization mainly consists of the performance of their professionals, and this performance is due to the competence that professionals have.

It is important to note that it also concerns the degree of importance of this science for the production of knowledge and development of competences. In a general context, all areas of knowledge are involved, without interruption. However, considering concrete data, it is understandable why Mathematics, in the educational field, has been gaining prominence in recent years.

Based on the above, Mathematics or its related areas as knowledge can be addressed, which transcends practically all other areas. The great support from technologies is also somewhat prudent, mainly because this is the area of knowledge based on logical, accurate, rigorous and formal information, and which better enables us to reach a

capacity to discern the researched essence.

It is also worth noting that the data discussed here allows us to emphasize the importance of research to change the reality of mathematics teaching in the Brazilian context: if the factors that lead to a low performance in large mass evaluations are better understood, new practices and tools for teaching and learning could be made possible.

## REFERENCES

[1] BRASIL. Lei nº 13.005, de 25 de junho de 2014. Aprova o Plano Nacional de Educação – PNE e dá outras providências.**Diário Oficial da União**, Brasília, 25 jun. 2014. Disponível em: <http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2014/lei/l13005.htm>. Acesso em: 27 abr. 2017.

[2] _____. Lei nº 13.415, de 16 de fevereiro de 2017. Altera as Leis nº 9.394, de 20 de dezembro de 1996, que estabelece as diretrizes e bases da educação nacional, e nº 11.494, de 20 de junho 2007, que regulamenta o Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação, a Consolidação das Leis do Trabalho – CLT, aprovada pelo Decreto-Lei nº 5.452, de 1º de maio de 1943, e o Decreto-Lei nº 236, de 28 de fevereiro de 1967; revoga a Lei nº 11.161, de 5 de agosto de 2005, e institui a Política de Fomento à Implementação de Escolas de Ensino Médio em Tempo Integral. **Diário Oficial da União**,Brasília, 16 fev. 2017. Disponível em: <http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/lei/L13415.htm>. Acesso em: 27 abr. 2017.

[3] _____. Medida Provisória nº 746, de 22 de setembro de 2016. Institui a Política de Fomento à Implementação de Escolas de Ensino Médio em Tempo Integral, altera a Lei nº 9.394, de 20 de dezembro de 1996, que estabelece as diretrizes e bases da educação nacional, e a Lei nº 11.494, de 20 de junho 2007, que regulamenta o Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação, e dá outras providências. **Diário Oficial da União**, Brasília, 23 set. 2016a. Disponível em: <https://goo.gl/PJ1egT>. Acesso em: 26 abr. 2017.

[4] _____. Ministério da Educação. **Avaliação internacional**. Inep participa da elaboração de itens para o Pisa de 2018. Brasília, 30 nov. 2015a. Disponível em: <http://portal.mec.gov.br/busca-geral/211-noticias/218175739/32421-inep-participa-da-elaboracao-de-itens-para-o-pisa-de-2018>. Acesso em: 3 maio 2016.

[5] _____. Ministério da Educação. **Enem – Apresentação**. Brasília: MEC, 2015b. Disponível em: <http://portal.mec.gov.br/enem-sp-2094708791>. Acesso em: 03 maio 2016.

[6] _____. Ministério da Educação. **Ideb –Apresentação**. Brasília: MEC, 2015c. Disponível em: <http://portal.mec.gov.br/secretaria-de-educacao-

basica/programas-e-acoes?id=180>. Acesso em: 3 maio 2016.

[7] _____. Ministério da Educação. Portaria Ministerial nº 931, de 21 de março de 2005. O MINISTRO DE ESTADO DA EDUCAÇÃO, no exercício das atribuições estabelecidas pelo Art. 87 § único, inciso II da Constituição Federal e atendendo... **Diário Oficial da União**, Brasília, 22 mar. 2005. Disponível em: <http://download.inep.gov.br/educacao_basica/prova_brasil_saeb/legislacao/Portaria931_NovoSaeb.pdf>. Acesso em: 26 abr. 2017.

[8] _____. Ministério da Educação. Portaria Normativa Interministerial nº 17, de 24 de abril de 2007. Institui o Programa Mais Educação, que visa fomentar a educação integral de crianças, adolescentes e jovens, por meio do apoio a atividades sócio-educativas no contraturno escolar. **Diário Oficial da União**, Brasília, 26 abr. 2007.

[9] _____. Ministério da Educação. **Resultados do Índice de Desenvolvimento da Educação Básica – IDEB 2015**. Brasília, 2016b. Disponível em: <http://download.inep.gov.br/educacao_basica/portal_ideb/documentos/2016/apresentacao_ideb_08092016.pdf>. Acesso em: 27 abr. 2017.

[10] _____. Ministério da Educação. Secretaria de Educação Básica. **Orientações Curriculares para o Ensino Médio**: Ciências da Natureza, Matemática e suas Tecnologias (vol. 2). Brasília: MEC/SEB, 2006. Disponível em: <http://portal.mec.gov.br/seb/arquivos/pdf/book_volume_02_internet.pdf>. Acesso em: 26 abr. 2017.

[11] _____. Secretaria de Educação Fundamental. **Parâmetros curriculares nacionais**: introdução aos parâmetros curriculares nacionais/Secretaria de Educação Fundamental. Brasília: MEC/SEF, 1997.

[12] CASTRO, C. de M. Ensino Médio: Aleluia! **Revista Veja**, São Paulo, ed. 2.500, 19 out. 2016. Disponível em: <http://portal.mec.gov.br/index.php?option=com_docman&view=download&alias=49911-materia-veja-ensino-medio-19102016-pdf&category_slug=outubro-2016-pdf&Itemid=30192>. Acesso em: 27 abr. 2017.

[13] COOPER, D. R.; SCHINDLER, P. S. **Métodos de Pesquisa em Administração**. 12. ed. São Paulo: Editora McGraw-Hill, 2016.

[14] FERNANDES, D. Brasil avança em conhecimento básico de matemática, mas continua atrás em ranking. **BBC Brasil**, 10 fev. 2016. Disponível em: <http://www.bbc.com/portuguese/noticias/2016/02/160209_ocde_alunos_baixa_performance_pai_df>. Acesso em: 27 abr. 2017.

[15] FRIGOTTO, G.; CIAVATTA, M. PERSPECTIVAS SOCIAIS E POLÍTICAS DA FORMAÇÃO DE NÍVEL MÉDIO: AVANÇOS E ENTRAVES NAS SUAS MODALIDADES.**EDUCAÇÃO & SOCIEDADE**, CAMPINAS, V. 32, N. 116, P. 619-638, JU./SET. 2011.

[16] G1 Educação. Apenas 10% dos alunos aprendem o ideal em matemática no ensino médio. **G1**, São Paulo, 6 mar. 2013a. Disponível em: <http://g1.globo.com/educacao/noticia/2013/03/apenas-10-

dos-alunos-aprendem-o-ideal-em-matematica-no-ensino-medio.html>. Acesso em: 27 abr. 2017.

[17] _____. Brasil evolui, mas segue nas últimas posições em ranking de educação. **G1**, São Paulo, 3 dez. 2013b. Disponível em: <http://g1.globo.com/educacao/noticia/2013/12/brasil-evolui-mas-segue-nas-ultimas-posicoes-em-ranking-de-educacao.html>. Acesso em: 20 dez. 2014.

[18] _____. Enem 2014. **G1**, São Paulo, 5 ago. 2015a. Disponível em: <http://especiais.g1.globo.com/educacao/enem/2014/enem-2014-medias-por-escola/>. Acesso em: 2 dez. 2015.

[19] _____. Lista do Enem 2015: Notas das escolas. **G1**, São Paulo, 5 out. 2016. Disponível em: <http://especiais.g1.globo.com/educacao/enem/2015/enem-2015-medias-por-escola/>. Acesso em: 8 dez. 2016.

[20] _____. MEC divulga a nota do Enem 2012. **G1**, São Paulo, 28 dez. 2012a. Disponível em: <http://g1.globo.com/educacao/noticia/2012/12/mec-divulga-nota-do-enem-2012.html>. Acesso em: 2 dez. 2015.

[21] _____. MEC divulga a nota do Enem 2012. **G1**, São Paulo, 28 dez. 2012b. Disponível em: <http://g1.globo.com/educacao/noticia/2012/12/mec-divulga-nota-do-enem-2012.html>. Acesso em: 2 dez. 2015.

[22] _____. Os resultados do Pisa 2012. **G1**, São Paulo, 2012c. Disponível em: <http://infograficos.oglobo.globo.com/educacao/os-resultados-do-pisa-2012.html>. Acesso em: 14 ago. 2014.

[23] _____.Os resultados do Pisa 2012. **G1**, São Paulo, 2012d. Disponível em: <http://infograficos.oglobo.globo.com/educacao/os-resultados-do-pisa-2012.html>. Acesso em: 14 ago. 2014.

[24] _____. Resultado do Enem 2014 por escola é divulgado pelo Inep. **G1**, São Paulo, 5 ago. 2015b. Disponível em: <http://g1.globo.com/educacao/noticia/2015/08/resultado-do-enem-2014-por-escola-e-divulgado-pelo-inep-veja-lista.html>. Acesso em: 2 dez. 2015.

[25] _____.Saem notas do Enem 2011 por escola. **G1**, São Paulo,22 nov. 2012e. Disponível em: <http://g1.globo.com/educacao/noticia/2012/11/mec-divulga-notas-do-enem-2011-por-escola.html>. Acesso em: 20 nov. 2013.

[26] GADOTTI, M. Gestão democrática com participação popular no planejamento e na organização da educação nacional. In: CONFERÊNCIA NACIONAL DE EDUCAÇÃO, 2., 2014, Brasília. **Anais...** Brasília: Conae, 2014. p. 1-25. Disponível em: <http://conae2014.mec.gov.br/images/pdf/artigogadotti_final.pdf> Acesso em: 9 ago. 2014.

[27] GUIMARÃES, L.; MARCHESINI, L. No país, 70% dos alunos não sabem o mínimo aceitável em matemática. **Jornal Valor Econômico**, 2 dez. 2016. Disponível em: <http://www.valor.com.br/brasil/4796957/no-pais-70-dos-alunos-nao-sabem-o-minimo-aceitavel-em-matematica>. Acesso em: 17 abr. 2017.

[28] IAQUINTO, K. Múltipla escolha. **Revista Conjuntura Econômica**, Rio de Janeiro, v. 68, n. 7, jul. 2014.

[29] INSTITUTO NACIONAL DE ESTUDOS E PESQUISAS EDUCACIONAIS ANÍSIO TEIXEIRA – INEP. **Enem por escola**. Brasília: MEC, 2015a. Disponível em: <http://portal.inep.gov.br/web/enem/enem-por-escola>. Acesso em: 3 maio 2016.

[30] _____. Educação Básica. **Ideb**. Brasília, 20 out. 2015b. Disponível em: <http://portal.inep.gov.br/web/guest/ideb>. Acesso em: 27 abr. 2017.

[31] _____. **Sistema de Avaliação da Educação Básica**. Edição 2015. Resultados. Brasília: MEC/Inep, 2016a. Disponível em: <http://www.agenciabrasilia.df.gov.br/wp-conteudo/uploads/2016/09/analise-proficiencia-ensino-brasileiro-ideb-2015.pdf>. Acesso em: 18 abr. 2017.

[32] _____. **IDEB – Resultados e Metas**. Brasília, 5 set. 2016b. Disponível em: <http://ideb.inep.gov.br/resultado/>. Acesso em: 27 abr. 2017.

[33] _____. **Educação Básica**. Ideb. Brasília, 20 out. 2015c. Disponível em: <http://portal.inep.gov.br/web/guest/ideb>. Acesso em: 27 abr. 2017.

[34] _____. **Relatório Nacional PISA 2012 – Resultados brasileiros**. São Paulo: Fundação Santillana, 2012.

[35] _____. **Exame Nacional do Ensino Médio – Enem**. Brasília: 2014. Disponível em: <http://portal.inep.gov.br/web/enem/sobre-o-enem>. Acesso em: 12 ago. 2014a. mimeo.

[36] MACHADO, C.; ALAVARSE, O. M. Qualidade das escolas: tensões e potencialidades das avaliações externas. **Educação & Realidade**, Porto Alegre, v. 39, n. 2, p. 413-436, abr./jun. 2014.

[37] MARCONI, M. de A.; LAKATOS, E. M. **Fundamentos de metodologia científica**: técnicas de pesquisa. 7. ed. São Paulo: Atlas, 2010.

[38] OLIVEIRA, T. B.; CALDEIRA, A. M. de A. Interdisciplinaridade escolar no ensino médio: domínios epistêmicos como possibilidade para elaboração e avaliação de um trabalho coletivo. **Acta Scientiarum**, Maringá, v. 38, n. 2, p. 193-204, abr./jun. 2016.

[39] ORGANIZAÇÃO DAS NAÇÕES UNIDOS PARA A EDUCAÇÃO, A CIÊNCIA E A CULTURA – UNESCO. **Educação**: um tesouro a descobrir. Relatório para a UNESCO da Comissão Internacional sobre Educação para o século XXI. Tradução de Guilherme Teixeira. Brasília: Unesco, 2010.

[40] ORGANIZAÇÃO PARA COOPERAÇÃO E DESENVOLVIMENTO ECONÔMICO – OCDE. Como alguns estudantes superam as dificuldades do ambiente socioeconômico? **Em Foco**, n. 5, fev. 2011. Disponível em: <http://download.inep.gov.br/acoes_internacionais/pisa/pisa_em_foco/2011/pisa_em_foco_n5.pdf>. Acesso em: 11 nov. 2015.

[41] _____. **Resultados PISA 2009**: o que os estudantes sabem e podem fazer – Desempenho dos estudantes em Leitura. OCDE, 2013. Disponível em: <https://www.oecd.org/pisa/pisaproducts/pisainfocus/PISA

%20EM%20FOCO%20N%C2%B025.pdf>. Acesso em: 15 ago. 2014.

[42] _____. **Ranking da Educação 2015**. OCDE: 2015.

[43] PORTAL DO BRASIL. **Média das escolas pelo Enem 2014 melhorou em três áreas do conhecimento**. ago. 2015. Disponível em: <http://www.brasil.gov.br/educacao/2015/08/media-das-escolas-pelo-enem-2014-melhorou-em-tres-areas-do-conhecimento>. Acesso em: 28 out. 2015.

[44] RICHARDSON, R. J. **Pesquisa social**: métodos e técnicas. 3. ed. São Paulo: Atlas, 2010.

[45] SCHWARTZMAN, S.; CASTRO, C. M. Ensino, formação profissional e a questão da mão de obra. **Ensaio**: Avaliação de Políticas Públicas em Educação, Rio de Janeiro, v. 21, n. 80, p. 563-624, jul./set. 2013.

[46] SOUZA, F. M. **Campo,** *habitus***, competências e práticas de ensino dos professores de Matemática de escolas brasileiras do ensino médio estadual com bons resultados no Enem**. 2017. 308 f. Tese (Doutorado em Engenharia de Produção) – Programa de Pós-Graduação em Engenharia de Produção, Universidade Federal de São Carlos, São Carlos, 2017.

[47] UOL educação.Inep divulga cadernos de prova do Enem 2011. **UOL**, São Paulo, 24 out. 2011. Disponível em: <https://educacao.uol.com.br/noticias/2011/10/24/inep-divulga-cadernos-de-prova-do-enem-2011.htm>. Acesso em: 2 jun. 2015.

[48] _____. Inep divulga notas médias dos candidatos no Enem 2014. **UOL**, Brasília, 13 jan. 2015. Disponível em: <https://educacao.uol.com.br/noticias/2015/01/13/inep-divulga-notas-medias-dos-candidatos-no-enem-2014.htm>. Acesso em: 2 jun. 2015.

[49] _____. Inep divulga provas do Enem 2012; exame foi realizado em novembro. **UOL**, São Paulo, 13 jun. 2013. Disponível em: <https://educacao.uol.com.br/noticias/2013/06/13/inep-divulga-provas-do-enem-2012-exame-foi-realizado-em-novembro.htm>. Acesso em: 8 out. 2015.

# The use of realistic simulation in the training of lay people in Basic Life Support: experience report

Fernando Conceição de Lima[1], Ianny Ferreira Raiol[2], Tatiane de Souza Vasconcelos[3], Aliny de Jesus Quintino[4], Kalil Orleans Silveira Pinho[5], Raissa de Sousa Marinho Pimenta[6], Rafaela Antônio de Bastos Ribeiro[7], Victor Vieira Silva[8], Artur dos Santos Soares[9], Bertho Vinícius Rocha Nylander[10], Thaís Vieira Tangerino[11], Ana Paula Silva Feio[12], Jailma Bendelaque de Sousa[13], Talyta Kelly Barata Santos[14], Beatriz Ribeiro Reis[15], Thalyta Mariany Rêgo Lopes Ueno[16], Bianca Campos Oliveira[17], Denise de Fátima Ferreira Cardoso[18], Murilo Elder Ferreira Costa[19], Marina Pinto de Souza Caldeira[20], Breno Marques Milhomem de Sousa[21], Raphaela Antunes Coelho[22], Pedro Thiago Malcher de Amorim Dias[23], Lidiane do Socorro Carvalho dos Santos[24], Andreza assundé Moraes[25], Marcos Cardoso Pacífico[26], Laydiane Martins Pinto[27], Mercês Rodrigues Cruz[28], Thainara Braga Soares[29], Ana Luisa Lemos Bezerra[30], Viviane Ferraz Ferreira de Aguiar[31], Lucia Menezes de Medeiros[32]

[1]Academic of Nursing, Metropolitan University Center of the Amazon (UNIFAMAZ), Belém, Pará, Brazil.
Email: fernandoldl58@gmail.com*
[2 ,3,13,17,24,25,28,29]Academic of Nursing, Metropolitan University Center of the Amazon (UNIFAMAZ), Belém, Pará, Brazil.
[4,5,6,7,8,9,10,11,12,20,21,22,23]Academic of Medicine, Metropolitan University Center of the Amazon (UNIFAMAZ), Belém, Pará, Brazil.
[14]Nursing, Metropolitan University Center of the Amazon (UNIFAMAZ), Belém, Pará, Brazil.
[15] Academic of Nursing, Escola Superior da Amazônia (ESAMAZ), Belém, Pará, Brazil.
[16] Nurse, Master in Parasitic Biology in the Amazon, PhD student, Stricto Sensu Postgraduate Program, Professional Doctorate in Parasitic Biology in the Amazon, State University of Para (UEPA). Professor at the State University of Amazonas (UEA), Manaus, Amazonia, Brazil.
[18,19,30]Academic of Nursing, State University of Pará (UEPA), Belém, Pará, Brazil.
[26,27]Academic of Nursing, University of the Amazon (UNAMA), Belém, Pará, Brazil.
[31] Nurse, Master in Education, Training and Management in Nursing, Professor at the Federal University of Pará (UFPA), Belém, Pará, Brazil.
[32] Nurse, Master in Health Education in the Amazon (ESA), Professor at the Metropolitan University Center of the Amazon (UNIFAMAZ), Belém, Pará, Brazil.

*Abstract—Objective: to report the experience by students of an extension project in carrying out a realistic simulation on Basic Life Support with employees of a Higher Education Institution. Method: descriptive study, type of experience report. The practice of realistic simulation was adopted in November2019 with employees of a private Higher Education Institution (HEI), in the city of Belem (PA) / Brazil. The present study emerged from the activities developed by nursing and medical students participants in an extension project of the*

*aforementioned HEI, coordinated by an advisor, nurse, master and specialist in Urgency and Emergency situations, whose objective of the group is to train the staff Institution for Basic Life Support (BLS) situations, thus making them laymen with training to act through situations like, Cardio Respiratory Arrest, Obstruction of the Airways by Foreign Body, Episodes of Seizure, Fractures, Immobilization, among other situations. Results: It was observed that training it was of paramount importance for achieving the objective of the extension project. The strategy used by researchers facilitated the socialization of knowledge for employees and consequently a response positive to what had been accomplished. Conclusion: It is concluded that the method adopted to train the employees of the Institutions, facilitated the development of skills, not only from a practical point of view, but, above all, emotional and psychological, since the trained staff were able to familiarize themselves with various situations of day by day care involving BLS situations.*

*Keywords— Nursing, Medicine, First Aid, Cardiopulmonary Resuscitation, Mentoring.*

## I. INTRODUCTION

Basic Life Support (BLS) is a process of systematized care that meets a protocol that includes a set of steps and actions that permeate the evaluation and intervention immediately in each phase and has the objective of maintaining, by basic means, the arterial blood flow to the brain and other organs noble and vital human body to provide thespontaneous cardiac recovery (CER) [1], [2].

Cardiorespiratory arrest (CPA) is conceptualized as the interruption of cardiac activity that reflects in the clinical aspects of PCR which are the loss of level of consciousness, absence of central pulse and apnea or agonized breathing [3], [4].

Furthermore, it is estimated that it is not yet possible to accurate data collection of deaths caused by PCR, through various causes such as different definitions Sudden Cardiac Death (SCD), retrospective analysis death certificates and the fragility of the notification structured in several regions [5].

A set of actions and measures is also used systematized to assist a victim of PCR, who can include assessment and intervention in an agile and immediate way that are represented by the acronyms, C - Circulation, A -airway opening, B - breathing and D – Defibrillation precocious. This sequence is recommended by the guidelines of the International Liaison Committee on Resuscitation – ILCOR and American Hearth's international scientific consensus Association (AHA) [1].

Quality CPR is known to have significant effects benefits, however, it is inferred that in a proportionality represented by three victims of CPA, only one receives properly assisting a lay person outside the hospital environment. In addition, it is estimated that approximately 200,000 cases of CRP occur annual in Brazil, with half of this value being triggered outside the hospital environment [6].

The use of realistic simulation is a strategy of teaching learning that enables communication and human relations, enabling the development of technical skills and competences [7]. In addition, realistic simulation represents an important methodology in the teaching-learning, which should be thought of as a real need [8].

In this perspective, this research is justified due to exposure to certain scenarios, such as PCR, which are not common in the various professional practice spaces. However, it is necessary to be prepared and act correct shipping to these situations. Simulated training allows training without risk of damage to the user and the opportunity to experience a real situation with greater trust and security [9].

So, the objective of this study is to report the experience by students of an extension project in carrying out a realistic simulation on Basic Life Support with employees of a Higher Education Institution.

## II. METHOD

This is a descriptive, report-type study experience. The first simulation practice was adopted realistic in November 2019 and target audiences chosen to participate in the training were the employees of a Private Higher Education Institution (IES), in the city of Belem (PA) / Brazil. It is reported that the present study emerged from the activities developed by an extension group, called Training in the care in Urgent and Emergency Situations (CASUR) of said IES, composed of students from nursing and medicine, coordinated by an advisor, nurse, master and specialist in emergency situations and Emergency, whose objective of the group is to train the of employees of the Institution for BLS situations, thus making them lay people trained to work through situations such as PCR, Obstruction of Road Areas by Foreign Body (OVACE), Seizure Episodes, Fractures, Immobilization, Trauma, among other situations.

The project came about when situations of medical emergency that needed immediate response of IES employees who were unaware of or were unable to provide first aid and need to create a safe environment through strengthening the survival chain, in this sense, medical school teachers conceived the project, primarily for academic nursing capacitors and medicine, using the "peer to peer" approach, to have the capacity to train the administrative body of the own IES in First Aid..

Thus, the following guiding question was raised: "What is the importance of using realistic simulation in formation of lay people in Basic Life Support?". It was observed as a current problem: "the need to training lay people in basic life support for urgent and emergency situations".

The extension group was created by the teacher, master and specialist in Urgency and Emergency. The entry of the discs in the project occurred through evaluation of the Lattes curriculum of the interested parties, 20 places available for the Bachelor's degree in Nursing and 20 places for the medical course, which would be occupied by students who obtained the best grades.

The selected students were trained and qualified to become instructors for a period of two months that had a seminal class load of 60 hours divided into expository-dialogued classes and practical training through realistic simulation. The students met with the teacher, coordinator of the Project, which coordinated and subsidized information important for improving skills cognitive, psychomotor, affective and attitudinal of the group to effectively meet the demands and instruct the employees from different situations and scenarios constructed clinical trials.

Realistic simulation was carried out with 20 employees, among general service assistants, concierge agents, librarians, administrative technicians, technical Information technology and security technicians work, which were divided into pairs to be instructed by an instructor student, a member of the extension and the project coordinator and IES teacher, who conducted the training.

The simulation room was chosen as the location of the action realistic in the HEI itself, used as a classroom for the students, because they have all the material necessary to facilitate and make training as reliable as possible. The organization of the content, the necessary material for training, as well as the construction of cases and scenarios lasted a month. With the creation of the simulation, the adaptation and programming of the scenarios to be applied during training.

Immediately before implementing a case, the student instructor informed employees about cynical history of the patient they would deal with. After each simulation, the HEI staff members were asked about the simulated situation, in which they could discuss, clarify doubts and improve best practices in relation to experienced situations, adapting behaviors, attitudes and posture.

This training aimed to include realistic simulation as didactic that facilitates the acquisition of knowledge, in a draped environment, where you can still commit errors and better clinical practice, in the perspective of minimize insecurities, strengthen knowledge bases, acting in a safe environment and thus minimize the problem found.

It is reinforced that the training had been done through a prior training (briefing) on the various situations already mentioned in this study, to guide employees on how to proceed in the best possible way by simulated scenario created, without intervention by the instructors, but that they were there to serve as support and support if requested.

At the end of each simulation practice, the instructor had the opportunity to perform a feed-back with the employees, summarizing the service, with a brief explanation of the key points, mistakes and successes (debriefing) favoring a critical-reflective discussion of the cases addressed.

## III.    RESULTS AND DISCUSSIONS

It was observed that the training of the instructors was paramount importance for achieving the objective of the extension, as well as for the training of lay employees to be carried out as planned. The administration of contents in an expository and dialogued, practical training and simulation as didactic instrument among the students themselves, members the extension project, was essential to highlight the importance of training laypeople for Urgency and Emergency with provision of first aid.

During training, it was observed that the majorities of participating employees in fact were unaware or never had been trained in first aid. It was found although this was the first experience of employees trained in the practice of realistic simulation, even more being focused on emergency situations and Emergency, however, it was noted that employees perceived training as a short action importance due to the environment in which they work and given also the proportion that good BLS care can provide a victim if well cared for. Valley to emphasize that the strategy used by the researchers facilitated the

socialization of knowledge for consequently a positive response to the that had been realized.

The scenario created by a simulation allows the experience, in real time, real situations, even if created, within a simulated and controlled environment, which the performance in these scenarios take place safely and allow the consolidation of knowledge, being a tool for teaching that provides the acquisition of knowledge.

The practice of realistic simulation is a useful tool effective, of utmost importance for an effective, integral action and that resolves the problems [10].

It was found, in the reports of IES officials trained as a critical point before training simulated, emotional difficulties in the face of the exposed situations due to insecurity in carrying out the procedures and lack of skill and competence in support techniques.

It should be noted that care practices can cause feelings of anxiety, stress and anguish, through the inexperience with the care process, not knowledge of care practices, unpreparedness in execution of techniques, the fear of making painful mistakes health problems. Furthermore, training contributes to the building skills and competences, which provides competence and security to the learner [11].

Training is considered to be the performance of employees, through training, went beyond the skills development to deal with situations BLS with engine and technical actions. There was greater employees' capacity for participatory interaction and motivating, with a cynical criticism about situations of urgency and unexpected emergencies.

The teaching process requires willingness from a pedagogic planning involving learning with safety, didactic and that allows the adoption of resources needed to perform a service effectively, without risks with improving practice professional [12].

In the area of health, realistic simulation is an ally, given that it is a practice that involves planning and positively influences the training of professionals, improving the teaching-learning process. Also realistic simulation as a strategy that contributes to the training of professionals in the allowing the expansion of the possibility of acquiring of knowledge [13], [14].

It is also reinforced that the use of simulation the teaching process aims to meet the needs of assumptions of planned learning. Thus, teachers act as mediators of knowledge, which facilitate the acquisition and socialization of ideas, valuing self-directed learning, in which the student is the main element. Simulation

contributes to training humanized and acting safely and with the minimum of failures [15].

In this context, it is approached that several scenarios can set a stage for the teaching process and learning and development of care, through educational strategies favored by simulation realistic, which reproduces reality in an environment interactive [16].

It appears that simulated learning is a strand that raises the self-confidence of those who learn, besides to become a promising teaching strategy for the development of assistance practice, being an educational trend that corroborates for the development and improvement of skills and habits [17].

## IV. CONCLUSION

It is concluded that the results found allow identify that the development of realistic simulation to train lay people about BLS situations, positively influence the acquisition of skills and skills to act through adverse situations to actions developed as a routine at work.

The initiative to train IES employees in first aid situations, reaffirms the extreme need to establish a survival chain providing greater security for trained people to make decisions and act correctly in front of these adverse everyday situations that will influence the victim's prognosis until seen by professionals specialized.

It is noteworthy that the use of this strategy as educational instrument can minimize errors and provide a better prognosis for the victims, besides reducing fears and insecurities in the face of these occurrences, given that meaningful learning, favors learning to learning and a critical-reflexive attitude.

The simulation experiments were able to generate positive results mediated by the interrelationship between theory and practice; also made possible a strategy different from learning by employees, through different perspectives, providing a reflection and reformulation of practice, instigating thinking and acting.

It is concluded that the method adopted to train the IES employees, facilitated the development of competences, not only from a practical point of view, but, above all, emotional and psychological, since trained staff were able to familiarize themselves with day-to-day situations involving the provision of care in BLS situations.

## REFERENCES

[1] Silva DV, Jesus AS, Lima AA, Santos MA, Alves SL. Knowledge of Nursing undergraduates about basic life

support. Revista Baiana de Enfermagem [Online].2015 Apr [cited 2020 Jul 26]; 29(2):125-134. Available from: http://dx.doi.org/10.18471/rbe.v29i2.12648

[2] Nacer DT, Barbieri AR. In-hospital cardiorespiratory arrest survival: an integrative literature review. Rev. Eletr. Enf [Online]. 2015 jul [cited 2020 Jul 26]; 17(3):8. Available from: https://www.fen.ufg.br/revista/v17/n3/pdf/v17n3a23.pdf.

[3] Nogueira MA, Maciel DO, Bernardes KC, Peres PVG, Oliveira VLG, Sá AMM. Teaching of basic life support in undergraduate nursing: an integrative review. International Journal of Current Research. 2017 [cited 2020 jul 26]; 9(8):56660-56665. Available: <http://www.journalcra.com/sites/default/files/25330.pdf>.

[4] Dallacosta FM, Dorini D, Rosa LA. Reanimação cardiopulmonar: experiência no treinamento em escolas, CATAVENTOS. 2017 [cited 2020 Jul 26].; 9(1):29-39. Available:http://revistaeletronica.unicruz.edu.br/index.php/Cataven tos/article/view/5314.

[5] Braggion-Santos MF, Volpe J, Pazin-Filho A, Maciel BC, Marin-Neto A, Schmidt A. Morte Súbita Cardíaca no Brasil: Análise dos Casos de Ribeirão Preto (2006-2010). Arquivo Brasileiros de Cardiologia. 2015 [cited 2020 jul 26]; 104(2):120-127. Available: <http://bdpi.usp.br/single.php?_id=002760556>.

[6] Nogueira MA, Santos JS, Ribeiro RA, Rodrigues MF, Jardim ACD, Camacho ENPR. "The use of realistic simulation as a basic support teaching strategy for high school students: report on extension activities in the Brazilian Amazon", International Journal of Development Research. 2019 [cited 2020 jul 26]; 09(10): 30847-30850. Available online at http://www.journalijdr.com.

[7] Ferreira CF, Carvalho JM, Carvalho FLQ. Impact of the Methodology of Realistic Simulation as Technology Applied to Education in Health Courses. III Seminar on Applied Technologies in Education and Health. 2015. Retrieved from: https://www.revistas.uneb.br/index.php/staes/article/download/1617/1099.

[8] Costa RRO, Medeiros SM, Vitor AF, Lira ALBC, Martins JCA, Araújo MS. Types and Purposes of Simulation in Undergraduate Nursing Education: an integrative review of the literature. Revista Baiana de Enfermagem. 2016 [cited 2020 jul 26]; 30(3): 1-11. Retrieved from: https://portalseer.ufba.br/index.php/enfermagem/article/download/16589/pdf_69. on 26th January 2017.

[9] Miranda FBG, Mazzo A, Pereira J, Gers A. Use of high fidelity simulation in the preparation of nurses for urgency and emergency care: scoping review. Sci. med. 2018 [cited 2020 jul 26] ; 28(1).

[10] Raiol IF, Lima FC de, Carneiro DRC, Moraes AC, Vasconcelos TS, Carvalho DNR de, et al. A simulação realística na consulta de enfermagem voltada ao idoso. Rev enferm UFPE on line. 2020 [cited 2020 jul 26]; 14:e244111 DOI: https://doi.org/10.5205/1981-8963.2020.244111.

[11] Vasconcelos FX, Silva GRF, Machado RS, Batista OMA, Nunes BMVT. Habilidades psicomotoras, administrativas e segurança autorreferida de discentes de enfermagem: estudo transversal. Online Brazilian Journal of Nursing. [Internet]. 2018. [cited 2020 Jul 26]; 17(1). http://www.objnursing.uff.br/index.php/nursing/rt/printerFriendly/5629/html_2.

[12] Oliveira SN, Prado ML, Kempfer SS, Martini JG, Caravaca-Morera JA, Bernardi MC. Experiential learning in nursing consultation education via clinical simulation with actors: action research. Nurse Educ Today. 2015 jul [cited 2020 jul 26]; 35(2):50–4. DOI: 10.1016/j.nedt.2014.12.016.

[13] Mesquita HCT, Santana BS, Magro MCS. Efeito da simulação realística combinada à teoria na autoconfiança e satisfação de profissionais de enfermagem. Escola Anna Nery. [Internet]. 2019. [cited 2020 Jul 26]; 23(1). Available: https://www.scielo.br/pdf/ean/v23n1/pt_1414-8145-ean-2301-e20180270.pdf.

[14] Martins JCA. Learning and development in simulated practice environments. Referência. 2017 [cited 2020 jul 26]; 4(12):155-62. DOI: 10.12707/RIV16074.

[15] Teixeira IND'AO, Felix JVC. Simulação como estratégia de ensino em enfermagem: revisão de literatura. Interfase Comunicação Saúde Educação. [Internet]. 2011. Out-Dez. [Cited 2020 Jul 26]; 15(39): 1173-83. Available: https://www.scielosp.org/pdf/icse/2011.v15n39/11731184/pt.

[16] Brasil GC, Ribeiro LM, Mazzo A, Almeida RGS, Martins JCA, Fonseca LMM. Use of the design and self-confidence scales in the assessment of maternal-childrealistic simulation. Rev Enf Ref. 2018 [cited 2020 jul 26]; 4(19): 117-25. https://doi.org/10.12707/RIV18025.

[17] Nascimento MS, Magro MCS. Realistic simulation: method of improving knowledge and self-confidence of nursing students in the administration of medication. REME Rev Min Enferm. 2018 Jul [cited 2020 jul 26]; 22:1-5. DOI: 10.5935/14152762.20180024.

# Brain Machine Interface (BMI) for Spinal Injuries

## Machel M. A. Allen

*Abstract*— *Brain-to-machine-interface (BMI) that facilitates the healing of Spinal Injuries. The Product is designed to facilitate the healing of scar tissues along the vertebrae column. This works perfectly for persons having a handicap that hinders motor skills. The BMI performs this operation by generating a series of electro-magnetic propagations throughout the vertebrae column. It will also be designed to target specific areas of extreme abrasion(s) that affect proper blood flow to facilitate the easy flow of blood (as before injury), so that patient(s) once again would experience the use of their limbs. The device will be engineered as such to cause the brain, where necessary, to (possibly) adjust its own internal frequencies (in Hz) and pitch (in $W \, s/cm^2$) to aid in this process. It will be disclosed that through the adjustment of frequencies (in Hz) and energy density (in W s/cm2) scar tissues can be corrected.*

*Keywords*— *Brain Machine Interface, Spinal Injuries, Transfer learning, machine learning.*

## I. INTRODUCTION

Physics-Based Transfer Learning is where one trains a model to perform a task and then uses the information/knowledge acquired in the completion of another task. It deeply involves the transferal of information from one experience and applying such to another situation under a similar heading. This greatly will improve efficiency of a learning agent.

> Transfer learning (TL) is a research problem in machine learning (ML) that focuses on…reusing or transferring information from previously learned tasks for the learning of new tasks…[3][4]

> Dopamine is a neuromodulator responsible for playing a crucial roles learning, motor control and memory along with addictive behaviour development. Most dopaminergic neurons are based in two nuclei, substantia nigra compacta and the ventral tegmental area. Exciting of these neurons in animal learning has been well characterized in mammals. Schultz and colleagues examined the live activities of dopaminergic neurons in certain tasks for training. In the study conducted, the activity of dopaminergic neurons seems to display internal expectations and outcomes for anticipation of failure. Hence, the dopamine system gives information with respect to environmental stimuli for information capture and synthesis.

## II. THE HUMAN BRAIN: NEURO-TRANSMITTANCE

Dopamine, serotonin, or acetylcholine are critical in the brain's state-dependent modulation. These neurotransmitters/ neuromodulators are conjured and dispatched from specialized neurons (small in number) located in forebrain, mid-brain and brain-stem of the brain. Synaptic contacts with varied areas of the brain are made with long-range neuro-transmitting connections. Neuromodulators dispatched from synaptic terminals are able to travel over 10 μm and acts on receptors distanced from release sites. Neuromodulators released from synaptic terminals are also capable of diffusing over substantial distances (>10 μm) (volume transmission; Venton et al., 2003; Zoli et al., 1998). [1] The information from neuromodulation/ neuro-transmitting neurons are propagated to large area(s) of the brain at the apparent cost of spatial selectivity. As such, activity changes in a small number of neurons can exert a broadcast influence on many brain areas, coordinating a functional change across areas (Hasselmo, 1995). [1]

> The activities of the brain are recognized as varied frequencies of multiple oscillations in electroencephalograms. There have been studies linking brain functions with specific oscillatory activities. These oscillatory activities are not just epiphenomena, but the brain appears to utilize them for information coding (Engel et al., 2001; Varela et al., 2001). [1][6] Selecting activities locked in phases and information binding in the

cortex of the brain, are typical examples. Brain oscillations is vital in the regulation of information traffic. Therefore, it is necessary to assess neural network and the manner in which they respond to frequency stimulation.

The proportion of the postsynaptic response effected as a result of presynaptic excitation is internally dependent on stimulation frequency in monosynaptic transmission. The magnitude of the postsynaptic response evoked by presynaptic stimulation is intrinsically dependent on stimulation frequency (Markram et al., 1998). [1] In the delivery of several stimuli within close

periods of time, the size of postsynaptic nerves increases in size, a condition called paired-pulse depression. Both presynaptic and postsynaptic mechanisms have been implicated in these processes. [1] Changes in neurotransmitter provides possibility of readily dischargeable reservoirs of synaptic vesicles. Postsynaptic receptor desensitization (Koike-Tani et al., 2008). [1] Frequency-dependent modulation of synaptic transmission has been proven to be brought into effect by the mobility of postsynaptic receptors.
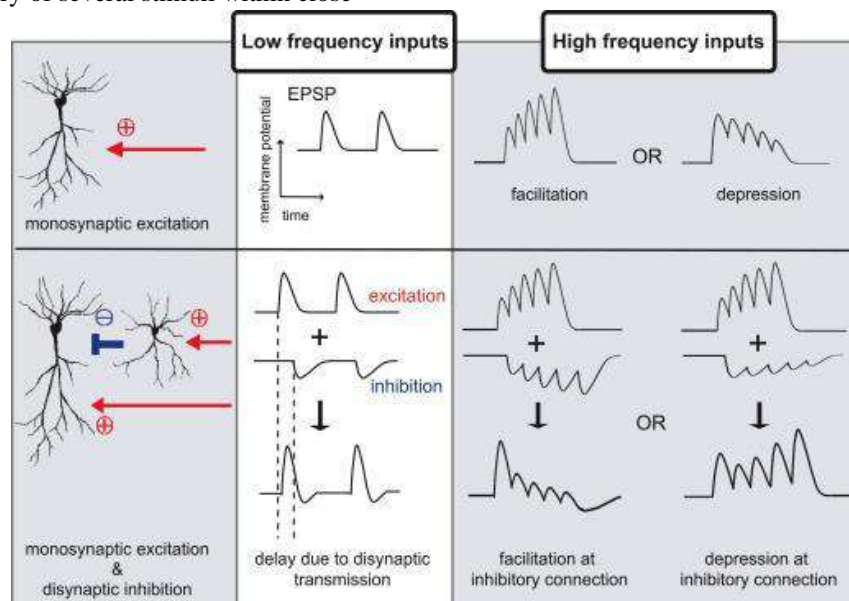


*Fig.1.1: Frequency Stimulation of Synaptic Nerves*

(Erin M. Schuman, 2008)

## III. THE PRODUCT: GAASSI CHIP

Given the scientific data/information, the design of the BMI is such that human safety is paramount while fulfilling its objective(s).
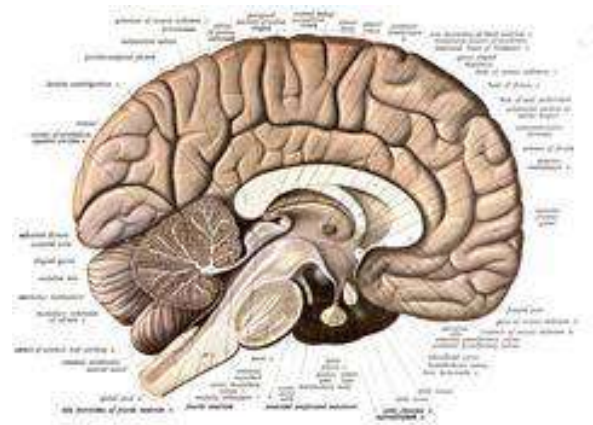


*Fig.1.2: Brain Midsection*

The BMI is designed as such that there will be an implantation of a micro-processing electrode in the midsection of the brain (just at the surface (can be on either hemisphere)) to enhance its capability to transmit signal input to and receive signal output from the brain. The chip with its electrodes will be placed just above the area of the medulla oblongata and the hippocampus. The frequency transmission is said to be greatest in this region because the neurons transmits as far as 5 micrometers.

This chip will have electrodes made of Gallium Arsenide (GaAs) and Silicon (Si) (commercial type) with a length of 1mm or less (size depends on brain density of the subject) and the diameter of the same. The electrodes will consist 90% GaAs and 10% Silicon, however, this may vary depending on the situation. The reason for choice of those materials are that they facilitate high bandwidth of frequency and watt dispensation. Also, evidential research has proven that photons/phonons are very high in these materials.

This is significant as it allows for scalability and improves bandwidth through the increase of wavelengths. It must be noted also that commercial silicon has traces of Germanium, Gallium and Arsenic. These greatly help with bandwidth dispensation and power (in W s/cm2).

This GaAsSi chip will be comprised of GaAs covered in silicon with a golden crystal in the core of the chip. The diameter of this golden crystal may be anywhere in the range of 0.5 mm to 2mm diameter. At no point will the GaAs come in contact with a human cell due to its toxicity. The silicon covering inclusive of the electrodes will be approximately 1mm thick (may be more or less depending on the situation).

These become effective as it will facilitate greater throughput in conversion from binary to analog and vice versa because there will be greater capabilities to create/draw data buses in nanometric context on the circuit while matching wavelengths will exist on the analog side of the device.

From what studies show, we will be able to acquire a bandwidth of 1nHz (Nano-Hertz) from these electrodes and also able to achieve more. This fully surpasses the 10 Micro-Hertz threshold for general neuro-communication.

When the signal from the computer reaches the chip, it makes contact with the Golden crystal which becomes electrically charged. The electrically charged atoms (electrons in particular) make contact with the electrons of the GaAs through a dipole moment creating an electric field which then makes contact with electrons of the Silicon forming one field and hence one electro-magnetic field through the magnetism which takes place once the atoms of the chip combine and the chip is placed in operation. This synergy gives the chip the power (in W s/cm2) to emit at varied wattage (up to 1000 W s/cm2 and possibly greater) and frequencies (up to 1018 Hz and possibly more).

Gallium Arsenide at 300 Kelvin has an electron mobility of 9000 cm2 (Volts per second or V.s) to 10000 cm2 (Volts per second or V.s), a band gap of 1.441 eV and an electron thermal velocity of 4.4 x 105 meters per second (m/s). This makes GaAs faster than 299, 792, 458 meter per second, the very speed of light.

Below are tables displaying the electrical properties of the materials (at 300 Kelvin) of the GaAsSi chip:

*Table: Gallium Arsenide*

| PROPERTIES | MEASURMENT |
|---|---|
| Breakdown Field | $\approx 4 \times 10^5$ V/cm |
| Mobility Electrons | $\leq 8500$ cm$^2$ V$^{-1}$ s$^{-1}$ |
| Mobility Holes | $\leq 400$ cm$^2$ V$^{-1}$ s$^{-1}$ |
| Diffusion Coefficient Electrons | $\leq 200$ cm$^2$/s |
| Diffusion Coefficient Holes | $\leq 10$ cm$^2$/s |
| Electron Thermal Velocity | $4.4 \times 10^5$ m/s |
| Hole Thermal Velocity | $1.8 \times 10^5$ m/s |

*Table: Silicon*

| PROPERTIES | MEASURMENT |
|---|---|
| Breakdown Field | $\approx 3 \times 10^5$ V/cm |
| Mobility Electrons | $\leq 1400$ cm$^2$ V$^{-1}$ s$^{-1}$ |
| Mobility Holes | $\leq 450$ cm$^2$ V$^{-1}$ s$^{-1}$ |
| Diffusion Coefficient Electrons | $\leq 36$ cm$^2$/s |
| Diffusion Coefficient Holes | $\leq 12$ cm$^2$/s |
| Electron Thermal Velocity | $2.3 \times 10^5$ m/s |
| Hole Thermal Velocity | $1.65 \times 10^5$ m/s |

*Table: Germanium*

| PROPERTIES | MEASURMENT |
|---|---|
| Breakdown Field | $\approx 10^5$ V cm$^{-1}$ |
| Mobility Electrons | $\leq 3900$ cm$^2$ V$^{-1}$ s$^{-1}$ |
| Mobility Holes | $\leq 1900$ cm$^2$ V$^{-1}$ s$^{-1}$ |

| Diffusion Coefficient Electrons | $\leq 100$ cm$^2$s$^{-1}$ |
|---|---|
| Diffusion Coefficient Holes | $\leq 50$ cm$^2$s$^{-1}$ |
| Electron Thermal Velocity | $3.1 \times 10^5$ m s$^{-1}$ |
| Hole Thermal Velocity | $1.9 \times 10^5$ m s$^{-1}$ |

*Table: Gold*

| PROPERTIES | MEASURMENT |
|---|---|
| Breakdown Field | $\approx 10^3$ V/cm |
| Mobility Electrons | 30-50 cm$^2$/V.s |
| Mobility Holes | $\approx 100$ cm$^2$/V.s |
| Diffusion Coefficient Electrons | $\approx 8.4 \times 10^{-15}$ cm$^2$/s$\pm 2.5 \times 10^{-15}$ cm$^2$/sec (estimated error) |
| Diffusion Coefficient Holes | $\approx 8.4 \times 10^{-15}$ cm$^2$/s$\pm 2.5 \times 10^{-15}$ cm$^2$/sec (estimated error) |
| Electron Thermal Velocity | |
| Hole Thermal Velocity | |

Figure 2.1 below displays an atom with its nucleus and electron:
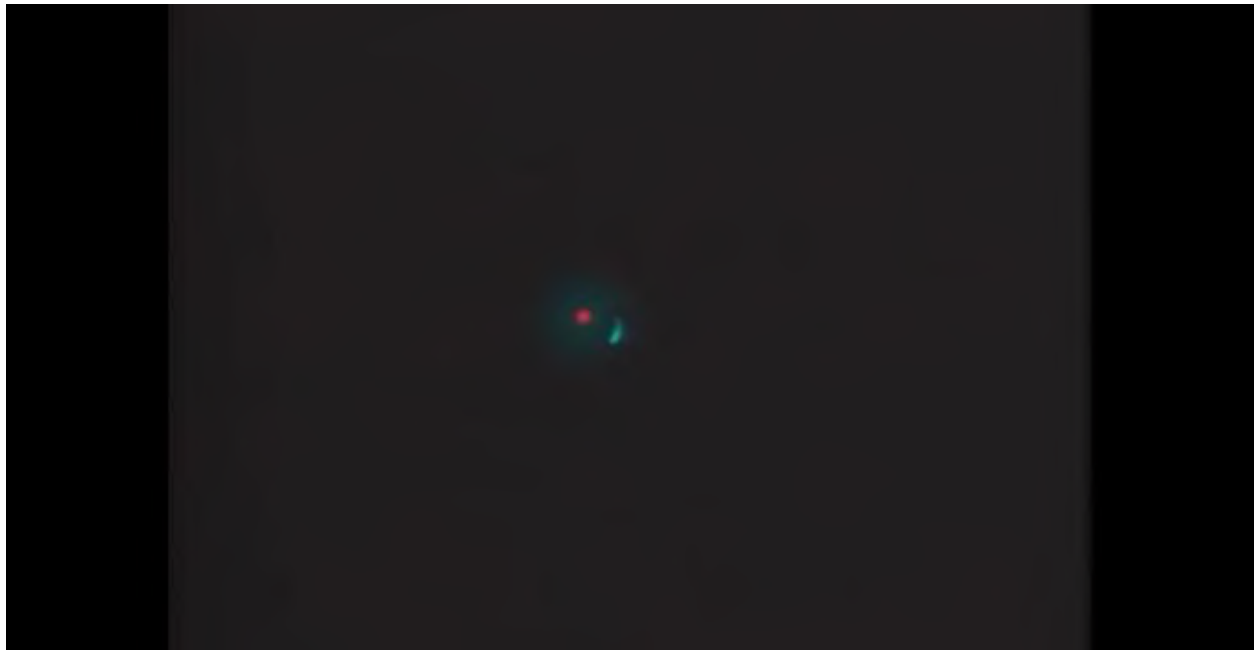


*Fig.2.1: Atom with its electron*

Figure 2.2 below displays the atom when combined with other atoms showing how electrons move between and among other atoms representing the electric field shared:

*Fig.2.2: Electron Sharing*

Figure 2.3 below displays the electro-magnetic field created between two atoms after a dipole moment has occurred and magnetism as a result of such:
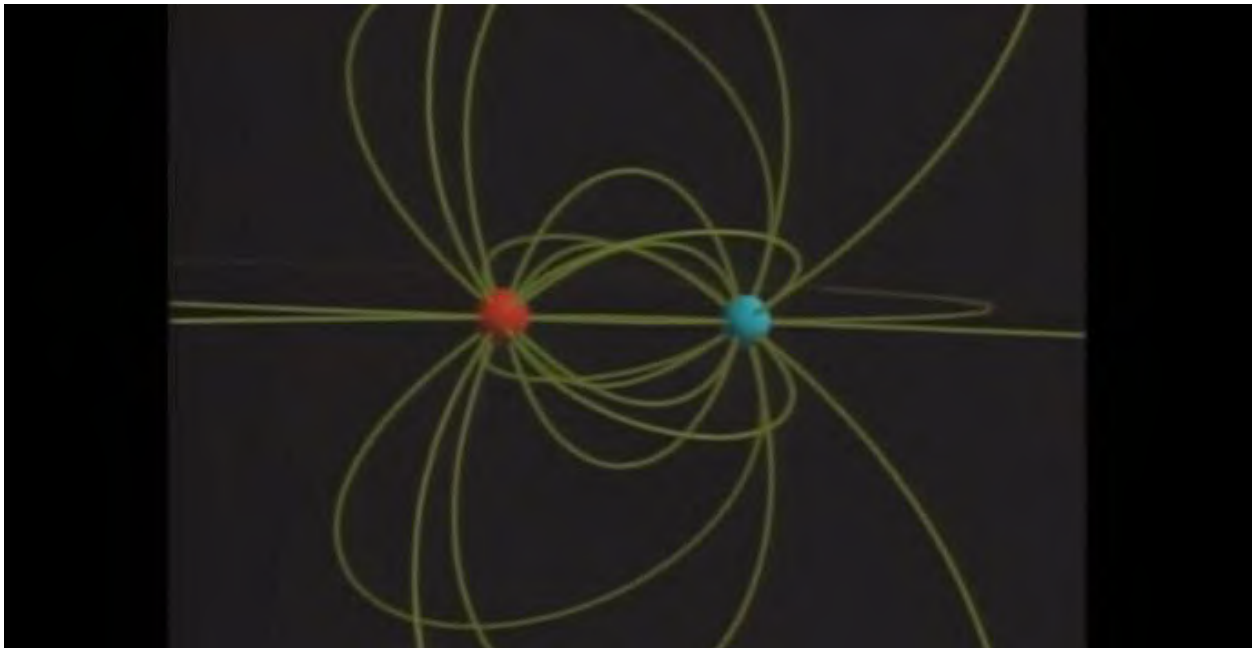


*Fig.2.3: Electro-Magnetism*

Notice the bond between the atomic particles and as several lines make contact, an electro-magnetic wave produces.

The synergy of the photons (light)/phonons (sound) created by the moving electrons and holes (absence of electrons) of the atomic particles of the respective materials will generate (once photons are on the same frequency) a superimposed frequency/wavelength and hence electro-magnetic propagation.

## IV. THE SPINAL VERTEBRAE COLUMN
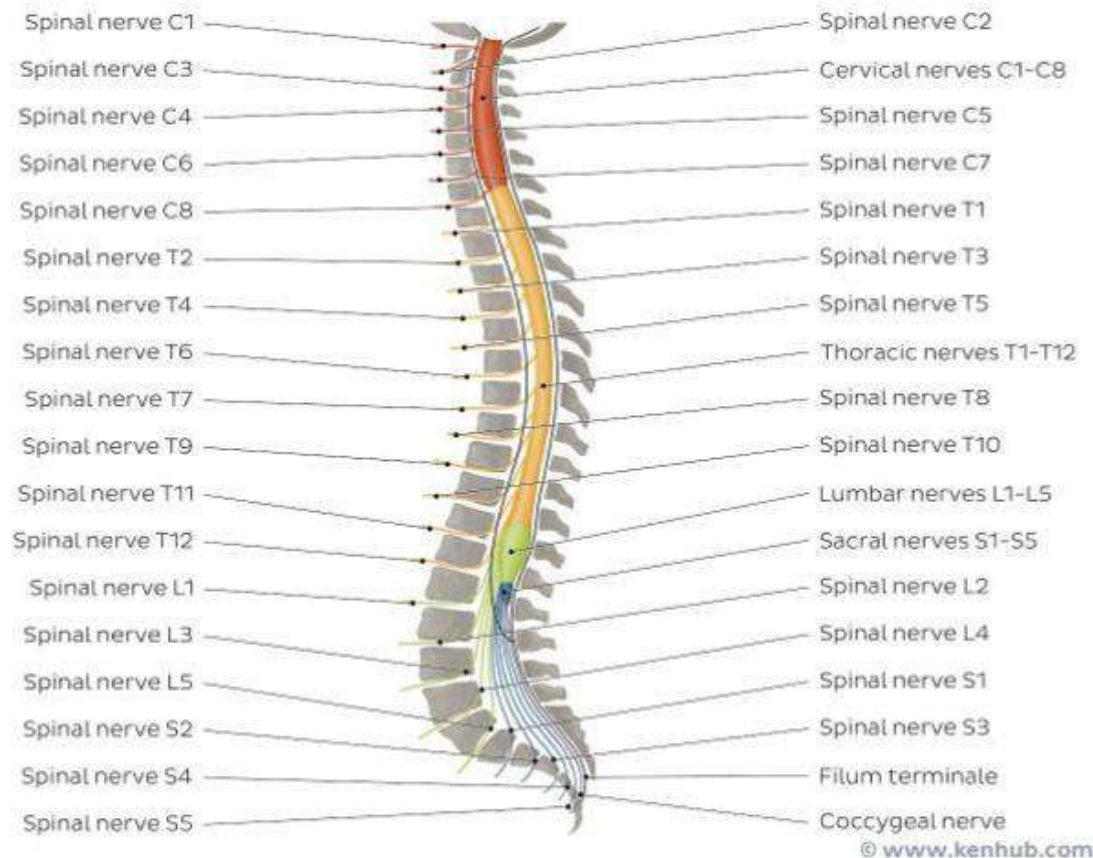


*Fig.3.1: Vertebrae Column*

The Spinal Cord is long, thin structure made up of nervous tissue. This runs from the medulla oblongata consisting of the hippocampus and runs downward to the lumbar region. It encases the cerebrospinal fluid. The brain and Spine is what makes up the Central Nervous System (CNS). The vertebral column is the bony structure which protects the spinal cord. It is approximately 45 cm (18 in) and around 43 cm (17 in) for women. The diameter ranges from 13 mm (1/2 in) in the cervical region and lumbar area and 6.4 mm (1/4 in) in stochastic region.

The Spine function is fundamentally responsible for the transmission of nerve signals from the motor cortex to the rest of the body. As well, carrying brain signals from the sensory afferent fibers to sensory cortex. Motor instructions are controlled by these circuit-paths.

The main component of the Nervous System are the Nervous/Neural Tissue. Body operations are managed by the nervous system. The sending and receiving of nervous impulses and neuroglia or glial cells (Schwann cells) are done by nerve cells/neurons. The glia assists with the propagation of nerve impulses and provide nutrients to the the neurons.

Nervous tissue is made of several types of neurons, which has axon. An axon is the stem-like part of the cell that sends nerve impulse to the next cell. Major groups of axons make up nerves in the Peripheral Nervous System (PNS) and connecting fibers of the nuclei of the Central Nervous System (CNS).

Neurons are cells with specialized features and possess a large soma/cell body with dendrites and an axon (both are forms of cell projections). Dendrites are projections branching that are thin that receive electrochemical signaling (neurotransmitters) to create a change in the voltage in the cell. Axons carry action potentials away from cell body toward the next neuron. They are long projections. The bulb-like end of the axon (axon terminal) is seperated from the dendrite of the neuron following by the synaptic cleft. When nerve impulse travels to the axon terminal, the neurotransmitters are sent across the synapse where it is received by the post-synaptic receptors continuing the communication.

Following harm to a peripheral nerve, the damaged axons declines in quality. In a few weeks, they regenerate and from thence recovered by myelin (insulating sheath which envelops the axon). This myelin enables rapid transmission of electrical pulses. However, the Schwann or glial cells do not regenerate the myelin sheath completely. Hence, the function of damaged nerves often remain impaired and certain muscles paralyzed in affected patients.

It has been proven that the growth factor neuregulin1 supports nerve repair and the redevelopment of the myelin layer.This protein is created by neurons and stationed on axons where it operates as an important signal for the development of Schwann or glial cells and myelin formation. In lieu of the rapid degeneration of axons after injury, the Schwann cells remaining lose communication with axons. Hence, there is a lack of neuregulin1 signal of the nervous fibres.

Synthesizing the neuregulin1 protein until axons are fully grown, has been shown to develop the Schwann cells and regenerate the myelin sheath after injury. From thence the neuroglia cell will contribute to the repair of the myelinated axons.

However there is another problem, the scar tissues that develop in the healing process post operation.

## V. GAASSI CHIP APPLICATION

Once surgeons have performed the operation, the GaAsSi Chip(s) will be placed above and/or below the affected area (separate from the implantation in the brain), along the vertebrae column.The purpose of this implantation is to stimulate the area affected with electro-magnetic propagation.The electrodes, which may vary in size in this situation, will be placed appropriately so as to effect proper therapy. This is in an attempt to heal the scar tissues that arise.

In a study done by Perea Clinic Ltd London, frequencies in the region of 0.8MHz to 1MHz has been known to heal scar tissues.

It involves the use of a round-headed wand (probe) that…produces a wave that vibrates at about 0.8 to 1.0 Mhz…produces a vibration of the local tissue. [15]

However, in a study done by scientists from Germany suggests frequencies in the region of 510kHz to 4.36MHz.

Here, the responses of …neural stem cells were investigated to…combination treatments between 510 kHz–3 W s/$cm^2$ and 4.36 MHz–25 W s/$cm^2$…showed enlarged neurospheres…Differentiation was not impaired…[17]

From the studies above, it appears frequencies in the region of 510kHz to 4.36MHz have the bandwidth and propagation to treat these scar tissues. A further study shows that increasing the wattage to 600 W s/$cm^2$ has been proven in mice

to remove the malignant cells that cause scar tissues to develop.

The GaAsSi chip will have the potency to generate wattages up to 1000 W s/cm$^2$ and greater. This will have the capability to prevent and remove the malignant cells forming scar tissues and improve bloodflow giving the brain passage to communicate with parts of the body previously unreachable due to injury. However, caution has to be taken because wattages of these amounts can greatly displace neurons (beyond their determination point).

Once the Medical Doctor applies 600 W s/cm$^2$ (or so) to the area affected, he/she will have to monitor the area consistently using the appropriate frequencies to make certain the patient is not over-doped with radiation. When the malignant cells have been fully removed and/or the area properly sustained then the Medical Doctor (MD) can cease the radiation.

The chip implant in the brain is necessary to teach the brain to improve its own internal frequencies and wattage to exceed the appropriate thresholds to make proper communication down the spinal column. The brain does this by using its own internal metals (iron, copper, magnesium, zinc, etc.) and nutrients responsible for hemoglobin to generate frequencies which will then be propagated down the vertebrae column. This is once a proper operation has been done and the proper treatment(s) given to the patient.

This will especially be beneficial during therapy and helping patient to gain motility in limbs previously unreachable due to injury. Proper therapy should be given to patient to help train patient to use limbs once again.

The GaAsSi chips will be able to speak wired and wirelessly with each other (inclusive of chips implanted in the brain) and with external computer. The user of the machine/computer, according to preference, will be able to synchronize and desynchronize the GaAsSi chip(s) in its functions and operations.

Sample Analog to Digital Conversion:
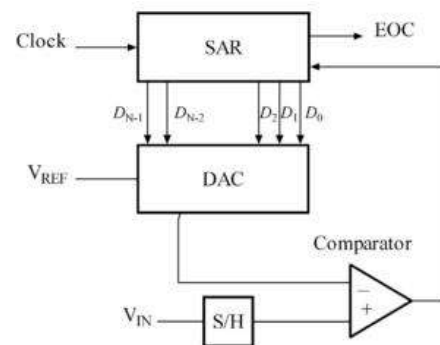


Successive-approximation ADC block diagram

*Fig.4.1: Analog to Digital Conversion*

**Key**

DAC = digital-to-analog converter

EOC = end of conversion

SAR = successive approximation register

S/H = sample and hold circuit

$V_{in}$ = input voltage

$V_{ref}$ = reference voltage

SAMPLE PROGRAM/CODE (in C++)

```
#include <library ieee>
#include <ieee.std_logic_1164.all>
#include <ieee.numeric_std.all>
#include <iostream.h>

void main{
int ADC_8_bit {
```

```
float analog_in;
  port (analog_in(float a >= -15.0 && a =< +15.0)
digital_out: out std_logic_vector(int b > 7 && b=< 0)


} return 0;


ADC_8_bit =constconversion_time (float time = 25 ns);


  signal instantly_digitized_signal :std_logic_vector(b > 7 && b=< 0);
  signal delayed_digitized_signal :std_logic_vector( b > 7 && b=< 0--);


  int ADC_8b_10v_bipolar (
analog_in (a>= -15.0 && a=<+15.0)
  ) return std_logic_vector =
const intmax_abs_digital_value= 128;
const float max_in_signal= 10.0;
    float analog_signal;
    float analog_abs;
   float analog_limited;
    int digitized_signal;
    int digital_out: std_logic_vector(b > 7 && b=< 0);
  {
analog_signal= (analog_in);
   if (analog_signal< 0.0) {  intip< 0;
digitized_signal= int(analog_signal * 12.8);
     if (digitized_signal< -(max_abs_digital_value)) {
digitized_signal = -(max_abs_digital_value);
     }
}
   else {
digitized_signal = analog_signal * 12.8;
if (digitized_signal> (max_abs_digital_value - 1)) {
digitized_signal= max_abs_digital_value - 1;
     }
     }
digital_out= std_logic_vector(to_signed(digitized_signal, digital_out_length));
```

```
    return digital_out;

  } ADC_8b_10v_bipolar;


{


instantly_digitized_signal<=

std_logic_vector (ADC_8b_10v_bipolar (analog_in));


while (instantly_digitized_signal>= conversion_time){


delayed_digitized_signal<= instantly_digitized_signal;


digital_out<= delayed_digitized_signal;


}
}
cout.flush();

}
```

There will be a hard (burnt-in) and soft address to facilitate security concerns. Therefore, the internal chips will only communicate with each other and a specific computer(s) unless they are officially programmed otherwise. With respect to data communication, 5G (and higher) data communication will be required to guarantee proper sync between internal chips and external computer(s).

## VI. THE GAASSI ARCHITECTURE

The GaAsSi Chip consists of Stimulation, Electrode Diagnostics, Power Management, Analog Amplifiers, Analog-to-Digital Converters, Processing Logic, 5G (and higher) Radio Frequency (RF) Transceiver and/Sensor Feedback. This connects to a Data Transfer Coil, which connects to a computer terminal. The Cable Connectors will be placed just under the epidermis.

The Manufacturer (or Authorized Personnel) would have the right based on user request to remotely troubleshoot any technical issues that may develop during use of the chip (where necessary), or user could go in for in-person adjustments to the chip (of course upon certification and assistance from a MD). However, the GaAsSi Chip(s) would be programmed as such to automatically raise a flag in the event of any technical issues that may develop during its use.

The GaAsSi Chip Implantation consists of twelve (12) Application-Specific-Integrated Circuits (ASICs) each containing 500 to 1000 electrodes. This results in 6, 000 to 12, 000 individually programmable amplifiers and 6,000 to 12,000 channels overall. This will enhance better reception of analog signals to the brain and transmission of signals thereto. The Language of choice is C++. Overall, there will be four (4) Chip Implantations in the brain and as a result 24,000 to 48,000

electrodes from the Sensors to the External Computer.

## 7.1 STIMULATION:

Brain stimulation therapies can play a role in treating certain mental disorders…therapies involve activating or inhibiting the brain directly with electricity. [5] The electricity is applied through electrodes inserted in the head or placed on the scalp of the subject. It is possible also for electricity to be induced through the use of magnetic propagations to the head. This is beneficial because it has been proven to help persons with neurological disorders.

From the Scientific Data/Information presented under "THE HUMAN BRAIN: NEURO-TRANSMITTANCE", the synaptic nerves respond to different frequency levels. Hence, the Stimulation Engine would be so designed that 6 ASICs (with their respective electrodes) would be placed among monosynaptic nerves and 6 ASICs (with their respective electrodes) would be placed among disynaptic nerves. Generally, a 50/50 rule relatively.

When the sensors detect a lapse in communication from the synaptic nerves the Chip will detect such lapses and is automatically configured to generate the appropriate frequencies to stimulate such nerves. From research disynaptic nerves responds best to frequencies in the range of 50 to 200 Hertz, while monosynaptic nerves respond best to frequencies in the range of 10 microhertz and lower.

In disynaptic nerve communications lapse, the Stimulation Engine will generate 50 to 200 Hertz to stimulate activity. It will do this over a 30 second to 2 minutes period. It will automatically increase by the tens until positive responses are detected. While in monosynaptic nerve communications lapse, the Stimulation Engine will generate in the range from 10 microhertz to10 nanohertz to stimulate activity. The Stimulation Engine in this situation will do continuous (non-time specific) frequency propagation until positive responses are detected. However, Medical Doctors will have the option to perform these functions manually

or to configure the device according to preference.

The generally advisable amount is ten (10) seconds per frequency (Hz) testing, before increasing or decreasing frequency variable, when stimulating nerves. The electrodes read electrical pulses between axons and also stimulates dendrites and neurons. However, this will not affect neuro-transmission due to the dipole moment between axons. [This applies to both CNS and PNS]

The reason for the above approach, is that research has shown that monosynaptic nerves respond best to low continuous frequencies and disynaptic nerves respond best to short periods of high frequencies. Even though low frequency monosynaptic nerve(s) stimulation does trigger disynaptic nerve(s), the disynaptic nerves themselves respond to higher frequencies.

General Formula:

$$S_{AM} = -0.5[\cos(2\pi(f_c + f_m)t) + \cos(2\pi(f_c - f_m)t)], \quad (1)$$

$$S_{FM} = \sin(2\pi f_c t + M \sin(2\pi f_m t)) \quad (2)$$

Where AM is Amplitude Modulation, FM is Frequency Modulation, $f_c$ is Carrier Frequency, $f_m$ is Message Frequency, t is period (in time) and M is Modulated Signal.

## 7.2 AMPLIFIERS AND ANALOG-TO-DIGITAL CONVERTERS:

An electronic amplifier is an electronic system that increases voltages. The system's power supply provides the energy required for amplification. A perfect amplifier does not interfere with the input signal. The output is an exact reproduction of the input signal but of increased pitch. It is a live quadripole based on active component(s), for example, transistor and operational amplifier.

Electronic amplifiers are implemented in most electronic circuits. They are able to give rise to electrical signals, in the case of a sensor's output, to a level of voltage that can be used by

the rest of a given system. They can also improve the maximum power that a system has available and can provide to power to a charge such as a speaker and radio antenna.

Pixel Aspect Ratio (PAR) is a mathematical ratio that defines the proportionality of the width of a pixel in comparison to the height of that pixel.

The Display Aspect Ratio (DAR) is the ratio of the height of an image*;* for TV, DAR was traditionally a four-to-three ratio, 4:3 (full screen) and a sixteen-to-nine ratio, 16:9 (widescreen) the present standard for High Definition TV. With the Storage Aspect Ratio (SAR) for Digital Imagery, there is a difference, that is, the ratio of pixel dimensions. When the image is displayed with pixels of equal width and height, then ratios are said to agree, otherwise they disagree.

The Pixel Aspect Ratio (PAR) is related by the identity:

$$SAR \times PAR = DAR \qquad (3)$$

The square pixels are 1:1.

Rearranging yields:

$$PAR = DAR/SAR \qquad (4)$$

A $680 \times 520$ Video Graphics Adapter image has a SAR of 680/520 equaling a four-to-three ratio, and if previewed on a four-to-three ratio display (DAR = 4:3) has square pixels, hence a PAR of an one-to-one ratio. On the contrary, a $744 \times 600$ D-1 Phase Alternate Line has a SAR of 744/600 equaling a five-to-four ratio, but is displayed as a DAR equaling a four-to-three ratio.

There is no SAR or PAR in analog images, but in digital conversion of analog images, the digitized form has pixels.

### 7.2.1 The Application of Laplace And Fourier Transform

### 7.2.1.1 Laplace Transform

The essential component of the Laplace transform takes the differentiation of components and multiplies them by:

for s = (σ,ω)                                    (5)

L(*f '*)(s) = sL(*f*)(s) - *f*(0)

Given the differentiation of product rule: (uv)' = u'v + v'u, integrating both sides gives          (6)

$$u(b)v(b) - u(a)v(a) = \int_a^b (uv)' = \int_a^b u'v + \int_a^b uv'$$

Therefore, the u=$e^{-\sigma t}$(cos(ωt), -sin(ωt)), and dv = *f* ', there is u'=(-σ,-ω)u, and v=*f*, and          (7)

$$0\,f(\infty) - 1\,f(0) = (-\sigma, -\omega)\int_0^\infty f(t)\,e^{-\sigma t}\,(\cos(\omega t),\,-\sin(\omega t)) + \int_0^\infty f'(t)e^{-\sigma t}(\cos(\omega t), \qquad -\sin(\omega t)) \text{Type equation here.}$$

so that

L(*f '*)(s) = sL(*f*)(s) - *f*(0)

The important matters here are that the differentiation of the product rule and the situation that differentiating lowered oscillation(s) results in multiplication of that/those oscillation(s) by a constant value.

### 7.2.1.2 Fourier Transform

Periodic functions can be approximated by Fourier series. This result is likely to be broadened to express any procedure as an integral of sine and cosine components. Let *f* be a function and define $f_T$ to be the periodic extension of *f* on the interval -T/2 to T/2, that is, $f_T = f$ on the interval -T/2 to T/2 and $f_T$ is periodic with period T. Then $f_T$ is an estimated value of a Fourier series. The Fourier series utilizes multiples of frequencies that are based on frequency 1/T cycles per second. As T goes up in numerical value, $f_T$ value goes to *f*, so the spacing in between the approximated frequencies, that is 1/T, decreases. In the limit, a replacement of the summation of the integral series is necessary. The Fourier Integral Theorem is where the integral equals *f*. The variables of the sine and cosine individual composites are stated by the Fourier transform.

Fourier cosine transform and the Fourier sine transform derives the Fourier Transform. The Fourier cosine transform series *f* is explained by any frequency deemed realistic by λ cycles per second is          (8)

$$A_f(\lambda) = 2 \int_{-\infty}^{\infty} f(t)\cos(2\pi\lambda t)$$

and the Fourier transform of the value *f* is discussed as          (9)

$$B_f(\lambda) = 2 \int_{-\infty}^{\infty} f(t)\sin(2\pi\lambda t)$$

The Fourier Integral Theorem (FIT) explains that
(10)

$$f(\text{x}) = \int_0^\infty A_f(\lambda) \cos(2\pi \lambda x)d \lambda + \int_0^\infty B_f(\lambda) \sin(2\pi\lambda x) \, d\lambda$$

It is assumed $f(\text{x}) = 0$ for $x < -T_0/2$ and $x > T_0/2$. It is believed $f$ the transform of sine is 0. The values of the Fourier series for $f_T$ (were $f_T$ matches $f$ for $-T/2 < t < T/2$, and relates to be congruent with specific periods of time (T), which are then
(11)

$$A_j = A(j/T)= 2/T \int_{-T/2}^{T/2} f(\text{t}) \cos(2\pi \, jt/T) = 2/$$
$$T \int_{-\infty}^{\infty} f(\text{t}) \cos(2\pi jt/T)= A_f(j/T)/T \text{ for } j = 0,1,2...$$

It is estimated that FIT integral by splitting the range of waves into intervals of size h=1/T and adding with
(12)

$$\int_0^\infty A_f(\lambda) \, cos(2\pi \, \lambda x)d \, \lambda <\text{- } (1/\text{T}) \sum_{j=0}^{n} TA \left(\frac{j}{T}\right) \cos \left(\frac{2\pi jx}{T}\right) = \sum_{j=0}^{n} A \left(\frac{j}{T}\right) \cos (\frac{2\pi jx}{T})= S_n(f_T,\text{x})$$

### 7.2.1.3 Explanation

In simple terms, Laplace and Fourier Transform are used in conjunction with each other to mitigate against the Nyquist Effect and bring sinusoidal (and other types of) waves to its pure form. Signals are amplified using Laplace Transform and hence exceeding the threshold to overcome noise/attenuation on a channel(s). Fourier Transform is then used to sub-divide sinusoidal waves (and also other types of waves) into periods of time. Here signals are looked at introspectively to remove any other electromagnetic interference and extract data for digitization and hence conveying an accurate representation of analog data in binary form.

> The processing of the analog waves occurs 100 picohertz. The Microprocessor Implantation accepts 80, 000 samples per second (80 milliseconds or 80 Megabits per second) and process them using 16 Core Computers. This Operation overall happens so fast that the brain will not recognize.

The Nyquist Theorem is a principle in the digitization of analog signals. For analog-to-digital conversion (ADC) to result in a faithful reproduction of the signal, the analog waveform must be taken frequently. The Nyquist Effect is when signals become halved when they exceed a certain threshold(s) (that a given system is unable to keep up with).

Any analog signal has several frequency elements. An example, the sine wave where all energy is concentrated at one frequency. Analog signals have complex waveforms with varied frequency elements. The highest frequency measurement dictates the bandwidth for that analog signal. Frequency is proportional to bandwidth, if all other considerations remain the same.

The Nyquist Theorem for a given analog signal $f_{\max}$ is at least $2f_{\max}$. The sampling converter from continuous to non-continuous signal is actuated by a clock (or pulse generating device). If the sampling rate is less than $2f_{\max}$, the highest frequency components are not guaranteed be correctly represented in the digitized output. When such a digital signal is converted back to analog form by a digital-to-analog converter, it does not return to its original analog signal or even near so. This undesirable condition is an aliasing/distortion.

The Nyquist–Shannon sampling theorem serves as a fundamental bridge between continuous-time signals and discrete-time signals. It establishes an appropriate situation for a sample rate that permits a discrete sequence of samples to capture all the information from a continuous-time signal of bounded/limited bandwidth.

The theorem is applicable to a class of mathematical functions having a Fourier transform that is zero outside of a certain region of frequencies. It is anticipated that when a continuous function reduces to a discrete sequence, it returns to a continuous function, the fidelity of the result depends on the sample rate of the original signals.

The theorem for experimentation (or sampling) is designed so that no information is lost and that

the actual fidelity for the class' hierarchy to certain bandwidth is band-limited. It shows the sampling as an expression of the bandwidth for specific hierarchy of function(s). The theorem is effectively a formula for the reconstruction of the original continuous-time or analog function from collected waveforms.

Perfect reconstruction is probable even when the sample-rate criterion is not satisfied, given other limitations on the signal are established. In some situations, where the sample-rate criterion is not met, using additional constraints allows for estimated reconstitution. The fidelity of these reconstitutions can be verified and quantified with Bochner's theorem.

## 7.3 FREQUENCY (RF) TRANSCEIVER:

With carrier aggregation (CA) and advanced-MIMO techniques, the New Radio (NR) devices can attain up to several Gb/s peak data-rate. The demand of high bandwidth has created a need for exploring high-frequency spectrum over 3GHz, while sustaining legacy Long Term Evolution (LTE) bands for LTE-NR dual connectivity (EN-DC). Since User Equipment (UE) requires small form-factor and low power consumption, a single-chip RF transceiver is essential to cover both NR and legacy protocols, simultaneously. This integrated CMOS (complementary metal-oxide-semiconductor) Radio Frequency Integrated Card (RFIC) that supports multimode and multiband applications including all the legacy 2G, 3G, 4G and stand-alone/non-stand-alone sub-6GHz 5G NR features.

According to the Third Generation Party Project (3GPP) (release 15) standards, 5G NR (New Radio) is able to operate in two frequency bands, that is, FR1 and FR2. A transceiver (TRx) operating in Time Division Duplex (TDD) mode at 3.5 GHz (FR1 band) is chosen for analysis. A band pass filter is a very essential component in wireless transceiver (TRx) systems. The system specification and Radio standards requirement are stated in detail by the Filter's specification. Filters play a major role in making the system more immune to unwanted radio signals, improving the selectivity of the receiver and rejecting spurious harmonic noise generated within the system.

The Tx chain contains a cascade of driver amplifier that conditions the input signal, a Band Pass Filter (BPF) operating at the desired frequency band, and a power amplifier (PA) to improve the pitch of signals to a required level for the antenna to transmit. The Rx chain consists of a low-noise amplifier (LNA) to increase the signal power to an appropriate level for detection with the Band Pass Filter as a digital attenuator for adjusting the gain of the system and also an amplifier (AMP) for processing the signals. The antenna is joined to the Tx and the Rx chain through a single pole double throw (SPDT) RF switch. In conjunction, a directional coupler (DC) can be placed after the antenna for supervision and standardization purposes.
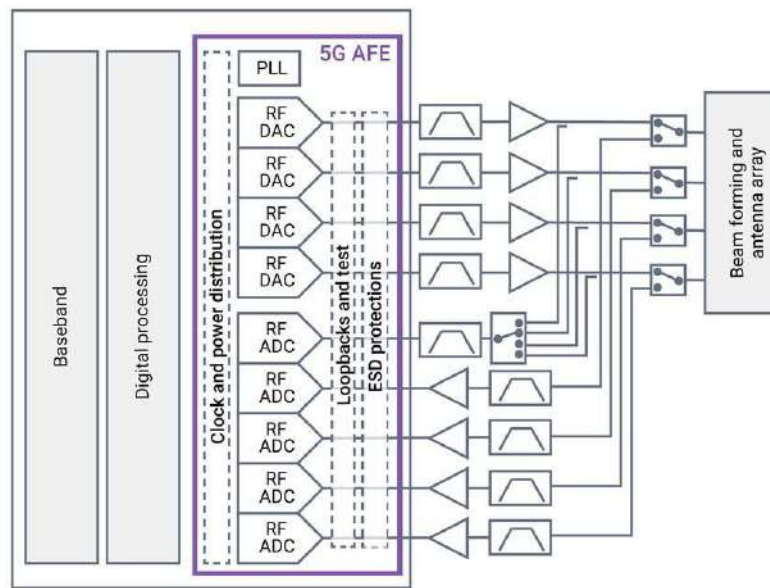
*Fig.5.1: 5G RF Transceiver Architecture*

## 7.4 ELECTRODE DIAGNOSTIC:

The medical electrode passes ionic current's energy to the (human) body as electrical current that can be made higher pitched, researched and used for medical purposes.

Medical electrodes allow for fundamental verification of internal ionic current. This yields a radical test for varied nervous, muscular, ocular, cardiac, and other illnesses that would have otherwise required surgery to establish. Muscular examinations may disclose evidence of diminished muscle fiber(s) and reveal muscle disorders and neurologically-based illnesses along with discovering whether or not muscles are weak. The electrodes are inexpensive, easy to control, can be disposable or sterilizable and very unique in the task they perform. The main purpose of the electrode is to create proper electrical communication between the patient and the apparatus used to measure and/or record activity.

## 7.5 PROCESSING LOGIC:

This coordinates all the activities of the Chip(s). Processing Logic is a ruggedized computer used for industrial automation. These controllers provide automation of a specific function/process and as well a complete manufacturing operation.

The Processing Logic receives information from connected sensors or input devices, processes the data, and triggers outputs based on pre-programmed parameters. Depending on the inputs and outputs, a Processing Logic can monitor and record run-time data such as machine productivity or operating temperature, automatically start and stop processes, generate alarms if a machine malfunctions, and more. Processing Logics are a flexible and robust control solution and are adaptable to any application.

## 7.6 POWER MANAGEMENT:

The Power Management System is designed according to Advanced Configuration and Power Interface (ACPI). ACPI is open standard that Operating Systems use to discover and configure hardware components to perform power management operations such as putting unused components to sleep and perform status monitoring.

The Power Management System is used to: reduce overall energy consumption,

prolong battery life for portable and embedded systems, reduce cooling requirements, reduce noise and reduce operating costs for energy and cooling.

Lower power use means lower heat dissipation (leading systems stability) and less energy use and that reduce costs and reduce negative impacts on people and the environment.

7.7 SENSOR FEEDBACK:

Sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. [12]

The Sensor(s) relating to the GaAsSi chips are used for interfacing with the Electrodes causing the external device to speak with the chips and vice versa.

*Table: Specifications of GAASSI Implantation*

| Channels | 24, 000 to 48, 000 |
|---|---|
| Root Mean Square Noise | 7.2 microvolts |
| Amplifier/Analog-Digital-Converter Power | 3.3 microwatts |
| Spike Detection | 2,000 nanoseconds |
| Stimulation Resolution | 0.2 microamperes and 3.0455 microseconds |
| Die Size | 4 x 5 mm |

## VII. CONCLUSION

Artificial Intelligence (AI) relates to the intelligence demonstrated by machines, in converse to that displayed by human beings. Any machine/device having the capabilities to recognize its surroundings and perform tasks to increase its chance(s) of successfully achieving its goals. AI describes machines ability to emulate cognitive actions that humans associate with the human mind in particular learning and problem solving.

The brain exhibits localization of functional areas, in that each brain region has a specific role, in sense. Most animal behaviour demands the collaborative and motor control areas of the brain and the activities of sensors. As the brain sensors undergo modification, the communication among brain areas adjusts depending on circumstances. When a new person is met, memorization of his or her face (encoding information) takes place, however when seeing the person again his or her face becomes recognizable and several events are associated with this person hence information retrieval. With the respective synaptic transmission between neurons, information processing is brought into effect. It is important to grasp that synaptic modulation can change communication among brain domains.

## REFERENCES

[1] Beatriz Alvarez-Castelo; Tom Dieck, Susanne; M. Fuso, Claudia; Donlin-Asp, Paul; D. Perez, Julio; M. Schuman, Erin (2008).The switch-like expression of heme-regulated kinase 1 mediates neuronal proteostasis following proteasome inhibition. Max Planck Institute for Brain Research, Germany (eLife Sciences Publications ISSN: 2050-084X) Retrieved from: https://elifesciences.org/articles/52714

[2] Tim Pagden, Analog to Digital Converter Model. 2 February 1996. Retrieved from: https://www.doulos.com/knowhow/vhdl_designers_guide/models/analogtodigital_converter_model/

[3] Computer Methods in Applied Mechanics and Engineering, Volume 353, 15 August 2019, Pages 448-466.

[4] Poole, David; Mackworth, Alan; Goebel, Randy (1998). *Computational Intelligence: A Logical Approach*. New York: Oxford University Press. ISBN 978-0-19-510270-3.

[5] Russell, Stuart J.; Norvig, Peter (2009). *Artificial Intelligence: A Modern Approach* (3rd ed.). Upper Saddle River, New Jersey: Prentice Hall. ISBN 978-0-13-604259-4.

[6] U.S. Department of Health and Human Services, National Institutes of Health, National Institute of Mental Health. (2016). NIMH Strategic Plan for Research (NIH Publication No. 02-2650). Retrieved from: https://www.nimh.nih.gov/health/topics/brain-stimulation-therapies/brain-stimulation-therapies.shtml

[7] Henri Lilen, A (brief) history of electronics, Vuibert, 2003, 640 pp. (ISBN 2711753360 and 978-2711753369), chapter 4: "Lee De Forest invents the Audion or tube triode."

[8] International Telecommunication Union - Radiocommunication Sector (ITU-R) (January 2007). "Recommendation BT.601-6: Studio encoding parameters of

digital television for standard 4:3 and wide screen 16:9 aspect ratios". *ITU Online Bookstore*. Retrieved October 1, 2008.

[9] Nemirovsky, Jonathan; Shimron, Efrat (2015). "Utilizing Bochners Theorem for Constrained Evaluation of Missing Fourier Data". arXiv:1506.03300 [physics.med-ph].

[10] Shannon, Claude E. (January 1949). "Communication in the presence of noise". *Proceedings of the Institute of Radio Engineers*. **37** (1): 10–21.

[11] Berkeley Science Books, CWT Volume 4 – Good Vibrations, Fourier Analysis and the Laplace Transform, (2013): berkeleyscience.com/synopsis4.htm

[12] L.Punitha*, Sathya Priya Sugumar, and P.H. Rao, Senior Member IEEE SAMEER- Centre for Electromagnetics, Chennai, Analysis of RF transceiver for 5G application, (2019), www.ursi.org/proceedings/procAP19/papers2019/PID5638325.pdf

[13] Bennett, S. (1993). *A History of Control Engineering 1930–1955*. London: Peter Peregrinus Ltd. on behalf of the Institution of Electrical Engineers. ISBN 978-0-86341-280-6The source states "controls" rather than "sensors", so its applicability is assumed. Many units are derived from the basic measurements to which it refers, such as a liquid's level measured by a differential pressure sensor.

[14] Ruth M Stassart, Robert Fledrich, ViktorijaVelanac, Bastian G Brinkmann, Markus H Schwab, Dies Meijer, Michael W Sereda, Klaus-Armin Nave. **A role for Schwann cell–derived neuregulin-1 in remyelination**. *Nature Neuroscience*, 2012; 16 (1): 48 DOI: 10.1038/nn.3281

[15] YanethPerea. Why it is important to deal with scar tissue. 5 August 2015. Retrieved from: https://pereaclinic.com/deal-with-scar-tissue/

[16] A.V. Alexandrov, C.A. Molina, *et al*. **Ultrasound-enhanced systemic thrombolysis for acute ischemic stroke** N. Engl. J. Med., 351 (21) (2004), pp. 2170-2178

[17] E.S. Ang Jr., V. Gluncic, *et al.***Prenatal exposure to ultrasound waves impacts neuronal migration in mice** Proc. Natl. Acad. Sci. U.S.A., 103 (34) (2006), pp. 12903-12910

[18] S. Atar, U. Rosenschein. **Perspectives on the role of ultrasonic devices in thrombolysis** J. Thromb. Thrombolysis, 17 (2) (2004), pp. 107-114

[19] M.H. Chen, J.S. Sun, *et al.* **Low-intensity pulsed ultrasound stimulates matrix metabolism of human annulus fibrosus cells mediated by transforming growth factor beta1 and extracellular signal-regulated kinase pathway**. Connect. Tissue Res., 56 (3) (2015), pp. 219-227

[20] Pictures on Electromagnetics from Caltech.

# Chemical and Structural Evaluation of Internal Fixation Materials for Facial Fractures

Francisnele Maria de Aquino Fraporti Tomáz[1], Helder Fernandes de Oliveira[2,*], Andreza Maria Fábio Aranha[1], Cyntia Rodrigues de Araújo Estrela[1], Alexandre Meireles Borba[1], Carlos Estrela[3], Orlando Aguirre Guedes[2]

[1]Department of Oral Sciences, University of Cuiabá, Cuiabá, Mato Grosso, Brazil.
[2]Departament of Endodontics, University of Anápolis, Anápolis, Goiás, Brazil.
[3]Departament of Stomatologic Sciences, Federal University of Goiás, Goiânia, Goiás, Brazil.
*Corresponding author

*Abstract— Oral and maxillofacial injuries often result in fractures tofacial bones. The treatment of facial fractures involves the use of plates and screws for internal fixation. This study was aimedatanalyzing the surface morphology and chemical constitution of internal fixation materials used to treatfacial fractures through scanning electron microscopy (SEM) and energy-dispersive X-ray (EDX) analysis. Twenty-seven plates and 21 screws were distributed in six experimental groups: Group 1- Toride®; Group 2- Engimplan®; Group 3- MDT®; Group 4- Promm®; Group 5- Osteomed®andGroup 6- Stryker®. The samples underwent SEM, andthe external surface morphology was analyzed qualitatively in images obtained with a magnification of 30-1000X. The surface was described according to its regularity (regular or irregular) and concerning the presence of defects (scratches, corrosion, metal fragments, metal deformation or protuberance [burrs]). Constitutive analysis was made through EDX. The chemical elements were quantified and presented asatomic weight percentages (%p). All the plates presented external surfaces with irregular aspects. Defects were not observed only in Osteomed® and Stryker® plates. The main components found in the plates were titanium (Ti), silicon (Si) and aluminum (Al). The element phosphorous (P) was found only in Stryker® plates. The screws presented regular surfaces and defects onthe head and threads. Most of the screws presented Ti and Al peaks. Traces of vanadium (V) were identified in the Stryker® and Toride® screws. The Promm® screws were made of Ti. The analyzed plates and screws presented surfaces with different aspects and defects. Some of the chemical elements found in the plates and screws were not described by their manufactures.*

*Keywords— Internal fracture fixation, Scanning electron microscopy, Energy-dispersive X-ray spectrometry.*

## I. INTRODUCTION

Trauma involving the maxillofacial complex represents a significant problem in public health[1].Studies have reported a considerable increase in the incidence of these lesions, with a substantial threat to the quality of life of children, adolescents, adults, and the elderly[2-4].

Oral and maxillofacial injuries often damage soft tissues, teeth, and facial bones[2-4]. The mandible is the bone most commonly involved in facial fractures[5] and internal fixation, an association between plates and screws, is the therapeutic modality usually indicated for resolution of these injuries[6].

Since its introduction in maxillofacial surgery and traumatology, internal fixation plates and screws have been the subject of numerous studies that have focused on the analysis of their physical-chemical and biological properties[7-9]. The interaction of the surgical material with the soft and hard tissues that surround it is strongly influenced by the characteristics of its surface and by its chemical composition[6]. The rigorous quality during manufacturing of plates and screws has been widely discussed[10].Defects on the surface of first-use materials may promote fractures during the installation phase[11]. Furthermore, preexisting irregularities on the external surface may lead to the failure of the surgical treatment[12].

Plates and screws used for internal fixation are manufactured from different titanium (Ti) alloys[13]. The use of this metal has enabled the development of materials

with excellent physical and mechanical properties[5], in addition to adequate biocompatibility[14,15]. However, metallic particles can be released during the handling of these materials and can be lodged in neighboring tissues[9,16]. There are reports in the literature of tissue pigmentation from Ti mini-plates[9,10].

The chemical composition of the material used in the internal fixation, as distributed at the level of its surface structure, can characterize different properties since this surface allows interaction between the material and the tissues with it has contact[7].Biocompatibility can be directly affected by the chemical composition of the material, since the presence of compounds that irritate the tissues reduces the tissue tolerance tothe material[7].In this way, knowledge of the chemical composition of the internal fixation materials can favor understanding of their biological and physical-chemical properties[13].A limited amount of information is available about the chemical constitution and the characteristics of the external surfaces of plates and screws before their surgical use. Thus, the present study aimed to evaluate the morphology of the external surface and the chemical constitution of plates and screws used to fix facial fractures.

## II. METHOD

Tested materials

The present experiment was an *in vitro* study whose sample consisted of 27 plates and 21 screws from six 2.0 mm internal fixation systems.The tested materials were distributed in six groups, according to their origin: Group 1 - Toride® (Tóride Ind.,e Com., Ltda., Mogi Mirim, SP, Brazil); Group 2 - Engimplan® (Engimplan Eng.,de Implantes Ind.,eCom. Rio Claro, SP, Brazil); Group 3 - MDT® (MDT Ind.,e Com.,de Implantes SA, Rio Claro, SP, Brazil); Group 4 - Promm® (Promm Materials

Surgical, Porto Alegre, RS, Brazil); Group 5 - Osteomed® (OsteoMed, Dallas, TX, USA); and Group 6 - Stryker® (Stryker Corp., Brazil, São Paulo, SP, Brazil).The model and chemical composition of the evaluated materials, according to their manufacturers, are shown in Table I.

Scanning electron microscopy (SEM) and energy dispersive x-ray (EDX)

Samples were washed in a dental ultrasonic vat with isopropyl alcohol. Then, they were fixed in stubs, taken directly to the scanning electron microscope (MEV JSM-6610; Jeol Ltda., Tokyo, Japan), which was setat avoltage of 5 to 10 kV and a working distance of 15 mm, and were examined without any preparation or manipulation.The morphology of the external surface was analyzed qualitatively in images obtained with a magnification of 30-1000X.The surface was described according to its regularity (regular or irregular) and concerning the presence of defects (scratches, corrosion, metal fragments, metal deformation or protuberance [burrs])[12,14].To determine the defects, a systematic examination of the flat surface, and the screw holes in the plates and the head, and the screw threads was performed. The constituent analysis was performed by energy-dispersive X-ray (EDX) using NSS Spectral Analysis System 2.3 software (Thermo Fisher Scientific Inc., Suwanee, GA, USA).Measurements were made using an acceleration voltage of 25 kV, a beam current of 110 mA, $10^{-6}$Torr of pressure (high vacuum), an analysis area of 130 x 130 mm, an increase of 1000X, and 100 s of acquisition time. Measurements was carried out in three different areas of the plates and the middle area of the screw threads.The elementary analysis (atomic weight percentage [% p] and atomic percentage [% at]) was performed in non-standard analysis mode, using the PROZA correction method (Phi-Rho-Z).

*Table I - Model and chemical composition of the internal fixation systems evaluated.*

| Brand | Internal fixation system | | Composition | | Production batch |
|---|---|---|---|---|---|
| | Plate (n= 3) | Screw(n=3) | Plate | Screw | |
| Toride® | Straight (4 holes) | 8 mm | 100% Ti | 100% Ti | 100413 |
| Engimplan® | Straight (4 holes) | 8 mm | 100% Ti | 100% Ti | 31700 |
| MDT® | Straight (4 holes) | 6 mm | 100% Ti | 90% Ti, 4%Al, 6%V | 15511N |
| MDT® | Straight (4 holes with intermediate) | 10 mm | 100% Ti | 90% Ti, 4% Al, 6%V | 06143Q |
| Promm® | Straight (4 holes with intermediate) | 11 mm | - | - | 59 |
| Osteomed® | Straight (4 holes) | 4 mm | 100% Ti | 90% Ti, 4% Al, 6%V | - |
| Osteomed® | Straight (4 holes with | - | 100% Ti | - | - |

| | | | | | |
|---|---|---|---|---|---|
| | intermediate) | | | | |
| Osteomed® | Curved (6 holes) | - | 100% Ti | - | - |
| Stryker® | Straight (4 holes) | 10 mm | - | - | 1000015441 |

Ti - Titanium; Al - Aluminum; V - Vanadium

## III. RESULTS

Plates

Figure 1 shows the morphological aspects of the surfaces of the tested plates. All plates had an irregular surface. No cracks were observed. Figure 2 shows the main defects found. Defects were not observed on the surfaces of the Toride®, Osteomed® straight 4-holes, or Stryker® plates. Signs of corrosion were observed only on the Promm® plate.

The main components found are shown in Table II. Essentially, the materials were formed by titanium (Ti), silicon (Si), and aluminum (Al). The phosphorus element (P) was found only on the Stryker® plate. Representative spectra of the EDX analysis are shown in Figure 3.

Screws

Figure 4 shows the morphology of the surfaces of the tested screws. It was found that all screws hadregular surfaces. Defects were observed both in the head and in the threads of the Toride®, Engimplan®, MDT®, Promm®, and Osteomed® screws (Figure 5). There were no defects in the Stryker® screws.

Representative spectra of the EDX analysis are shown in Figure 6. Most of the screws showed Ti and Al peaks, and the Promm® screws only consisted of Ti. Traces of vanadium (V) were identified in the Stryker® and Toride® screws, while the P element was shown only in the Stryker® screws.

*Table II - Chemical elements (mean and standard deviation) observed on the plates using energy dispersive X-ray (EDX).*

| | Chemical elements | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Al** | | **P** | | **Si** | | **Ti** | |
| **Plates** | %p | %at | %p | %at | %p | %at | %p | %at |
| Toride® | 0.07 ± 0.10 | 0.13 ± 0.19 | - | - | 0.10 ± 0.15 | 0.18 ± 0.15 | 99.82 ± 0.13 | 99.69 ± 0.23 |
| Engimplan® | 0.85 ± 0.24 | 1.50 ± 0.41 | - | - | 0.71 ± 0.53 | 1.18 ± 0.89 | 98.44 ± 0.76 | 97.32 ± 1.28 |
| MDT® | - | - | - | - | - | - | 100.00 ± 0.00 | 100.00 ± 0.00 |
| MDT®*** | - | - | - | - | - | - | 100.00 ± 0.00 | 100.00 ± 0.00 |
| Promm® | 2.58 ± 1.49 | 4.43 ± 2.52 | - | - | 1.84 ± 0.63 | 3.04 ± 1.06 | 95.57 ± 0.87 | 92.53 ± 1.49 |
| Osteomed® | 0.37 ± 0.07 | 0.64 ±0.12 | - | - | 2.77 ± 0.72 | 4.61 ± 1.18 | 96.86 ± 0.78 | 94.75 ± 1.29 |
| Osteomed®** | 0.20 ± 0.16 | 0.34 ±0.27 | - | - | 1.55 ± 1.02 | 2.60 ± 1.70 | 98.25 ± 1.18 | 97.05 ± 1.96 |
| Osteomed®* | 0.15 ± 0.21 | 0.26 ± 0.36 | - | - | 0.52 ± 0.22 | 0.88 ± 0.38 | 99.33 ± 0.40 | 98.86 ± 0.70 |
| Stryker® | 0.15 ± 0.21 | 0.26 ± 0.36 | 0.43 ± 0.31 | 0.67 ± 0.47 | - | - | 99.52 ± 0.36 | 99.24 ± 0.56 |

%p - percentage of atomic weight; %at - atomic percentage; *** 4-holes MDT plate with intermediate; ** Osteomed 4-holes curved plate; * Osteomed 4-holes plate with intermediate; Al - aluminum; P - phosphorus; Si - silicon; Ti - titanium.

## IV. DISCUSSION

Information on the surface characteristics and chemical composition of surgical materials represents a predictive factor for understanding their physical-chemical and biological properties[12,13,17].Knowing the morphology of the external surface and the chemical composition of

plates and screws used in the internal fixation of facial fractures will help in the selection of the best material to be used[18].

Quality control of the materials used to treat facial fractures is essential[19].The absence of surface defects is expected when acquiring and using these materials since it is impossible to detect them macroscopically. The results of the present study showed the absence of defects (scratches, corrosion, metal fragments, metal deformation, or protuberances[burr]) in the Toride®, Osteomed®, and Stryker® plates and in the Stryker® screws when analyzed by SEM. However, the Engimplan®, MDT® and Promm® plates, and the Toride®, Engimplan®, MDT®, Promm®, and Osteomed® screws showed defects, as also observed in other studies[14,17,18].Matthew et al.[18] evaluated the surface mini-plates and screws of Champy made of stainless steel and Ti and used in the treatment of mandibular fractures. Irregularities such as craters, cracks, and depressions were found on the surfaces of mini-plates that had been surgically removed. These irregularities were similar to those found on the surface of the control group's mini-plates, which suggests that these failures may be due to the manufacturing process. Damage to the surface of the screws due to manipulation wasalso observed. Some irregularities were found in the head of the screws in the control group. Trivellato et al.[17] performed a macroscopic study of the Ti plates and screws of the Engimplam®, Bucomax®, Synthes®, and W. Lorenz®systems.The authors concluded that the Engimplan and Bucomax systems showed terrible behavior concerning the standardization of their plates and screws' dimensions. Langford and Frame[14] evaluated the surfaces of Ti plates and screws used in maxillofacial surgery. Manufacturing defects were found in fourof the 18 plates and two of the 10 screws.These defects consisted of rough edges and metal protuberances located over the screw heads and around the screw holes. It is important to highlight that the tested material shave distinctive manufacturing process, which may justify the presence of plates and screws with varying quality standards.

The regularity of the surface represents a critical aspect commonly related to the adhesion of cells to the material, a fundamental factor in evaluating biocompatibility of biomaterials[11,20].SEM is an essential tool in studying the size and distribution of particles or granulations present on the external surfaces of dental materials[21,22].In the present study, the surfaces of the plates and screws were qualitatively evaluated. The analysis revealed that all the plates showed external surfaces with irregular features, especially the Toride® plate. However, no cracks were observed on the surfaces of the studied

materials. In a previously published study, several cracks on the surfaces of surgically removed plaques wereobserved[18].Krischak et al.[20] compared the corrosion and metal release rates between stainless steel plates and Ti-CP used in osteosynthesis in orthopedics. Stainless steel plates showed a greater extent of deterioration. The absorption of the measured ions increased after they were used, with high concentrations of iron (Fe), chromium (Cr), nickel (Ni), and molybdenum (Mo) being observed. No material caused a foreign-body reaction in local tissues.

The screws analyzed in this study showed regular surfaces. Thus, one can expect better results in terms of cell adhesion in these materials[9].However, it is worth noting that other factors also affect cell adhesion and the biocompatibility of a material, such as its chemical composition[7].This fact points out that the surface regularity of data should not be analyzed in isolation. The mapping of the components allows us to reveal the elements distributed along the external surfaces of the materials, which can maintain direct contact and influence the characteristics of the tissues' biological responses.

EDX is a reproducible and accurate method that allows qualitative and quantitative analysis of the main components or compounds present in a material or association of materials[21].This methodology is based on the interaction between particles (electromagnetic radiation) and matter and analyzes the emitted X-rays[22].Each chemical element has a unique atomic structure so that the emitted X-rays are characteristic of that structure and identify a givenelement[23,24].However, EDX has some limitations. In some cases, the interpretation of results may be hampered by continuous radiation or the overlapping of chemical elements[23].Also, the proportion of ionizing events, which result in the emission of X-rays, decreases as the number of the element's atomic weight becomes smaller. Thus, the quantification of organic compounds, which contain carbon, oxygen, and hydrogen, cannot be performed with precision[24].

EDX microanalysis revealed the existence of a similarity between the Toride®, Engimplan®, Promm®, and Osteomed® plates regarding the presence of Ti, Al, and Si (Table II).This finding is consistent with the results obtained by other studies that compared the chemical composition of these materials and observed small variations between them[9,14,17].Regarding the screws, most showed peaks of Ti and Al. Traces of V were identified in the Stryker® and Toride® screws, while the element P was evidenced only in the Stryker® screw.The presence of element V is justified by the type of alloy used. The

screws are generally made with Ti6Al4V alloy, which according to the ASTM F 1108-97[25] and ISO/DIS 5832-3[26] standards, provide more excellent resistance to flexion when compared to grade 1 pure titanium alloys. Silva et al.[27] highlighted that the combined use of commercially pure titanium and Ti6Al4V alloy is contraindicated due to the possibility of galvanic corrosion.

Elements that were not described in the manufacturers' composition base were identified. The Toride®, Promm®, and Osteomed® plates showed traces of Si. Traces of P were observed on the Stryker® plates and screw traces. These results can be attributed to contamination during the manufacturing or even while in the market reserve.

Several elements have been considered aggressive to human cells in specific concentrations such as Al[8]. Except for the MDT® plate, this element was found in all the tested plates, which justifies the results suggestive of cytotoxicity or genotoxicity[16].

The results of this study provide an understanding of the interactions between internal fixation materials and facial tissues. Such knowledge should help develop new materials with well-defined properties, for a wide variety of applications in surgery and oral and maxillofacial traumatology.

## V.     CONCLUSION

With the methodology used, it was possible to conclude the following:

1. The analyzed plates and screws showed surfaces with different aspects and defects.

2. There was a discrepancy between the elements found and the main elements described by the manufacturers.

## REFERENCES

[1] Jin, Z., Jiang, X., & Shang, L. (2014). Analysis of 627 hospitalized maxillofacial-oral injuries in Xi'an, China. *Dental traumatology,30*(2), 147–153.

[2] Guedes, O, A., Aranha, A. M. F., Moreira-Júnior, J. M., Deliberali, D. E., Porto, A. N., Pedro, F. L. M., Estrela, C. R. A., &Borges, Á. H. (2019)Maxillofacialfractures in a university hospital in Central Brazil. *Journal ofhealth sciences,21*(1):51-7.

[3] Kotecha, S., Scannell, J., Monaghan, A., & Williams, R. W. (2008). A four year retrospective study of 1,062 patients presenting with maxillofacial emergencies at a specialist paediatric hospital. *The British journal of oral & maxillofacial surgery*, *46*(4), 293–296.

[4] Scartezini, G. R., Guedes, O. A., Alencar, A. H. G., Estrela, C. R. A., &Estrela, C. (2016). Maxillofacial trauma in a public hospital in Central Brazil: A retrospective study of 405 patients. *Journal of dental science,31*(4):153-7.

[5] Gomes, P. P., Passeri, L. A., & Barbosa, J. R. (2006). A 5-year retrospective study of zygomatico-orbital complex and zygomatic arch fractures in Sao Paulo State, Brazil. *Journal of oral and maxillofacial surgery*, *64*(1), 63–67.

[6] Ehrenfeld, M., Manson, P. N., &Prein, J. (2012). *Principles of internal fixation of the craniomaxillofacial skeleton: Trauma and orthognathic surgery*. Davos: AOCMF.

[7] Dugal, A., &Dadhe, D. P. (2009). Evaluation of metal release and local tissue response to indigenous stainless steel miniplates used in facial fractures. *Journal of maxillofacialand oral surgery*, *8*(4), 344–347.

[8] Yeung, K. W., Poon, R. W., Chu, P. K., Chung, C. Y., Liu, X. Y., Lu, W. W., Chan, D., Chan, S. C., Luk, K. D., & Cheung, K. M. (2007). Surface mechanical properties, corrosion resistance, and cytocompatibility of nitrogen plasma-implanted nickel-titanium alloys: a comparative study with commonly used medical grade materials. *Journal of biomedicalmaterialsresearch. Part A*, *82*(2), 403–414.

[9] Matthew, I. R., & Frame, J. W. (1998). Ultrastructural analysis of metal particles released from stainless steel and titanium miniplate components in an animal model. *Journal of oral and maxillofacial surgery*, *56*(1), 45–50.

[10] Ray, M. S., Matthew, I. R., & Frame, J. W. (1999). Metallic fragments on the surface of miniplates and screws before insertion. *The British journal of oral &maxillofacialsurgery*, *37*(1), 14–18.

[11] Kosaka, M., Uemura, F., Tomemori, S., &Kamiishi, H. (2003). Scanning electron microscopic observations of 'fractured' biodegradable plates and screws. *Journal of cranio-maxillo-facial surgery*, *31*(1), 10–14.

[12] Theologie-Lygidakis, N., Iatrou, I., Eliades, G., &Papanikolaou, S. (2007). A retrieval study on morphological and chemical changes of titanium osteosynthesis plates and adjacent tissues. *Journal of cranio-maxillo-facial surgery*, *35*(3), 168–176.

[13] Mendes, M. B., Medeiros, R. C., Lauria, A., Marchiori, É., Sawazaki, R., Lopes, É. S., & Moreira, R. W. (2016). Mechanical and microstructural properties of fixation systems used in oral and maxillofacial surgery. *Oral andmaxillofacialsurgery*, *20*(1), 85–90.

[14] Langford, R. J., & Frame, J. W. (2002). Surface analysis of titanium maxillofacial plates and screws retrieved from patients. *Internationaljournal of oral andmaxillofacialsurgery*, *31*(5), 511–518.

[15] Pinto, C. M., Asprino, L., & de Moraes, M. (2015). Chemical and structural analyses of titanium plates retrieved from patients. *Internationaljournal of oral andmaxillofacialsurgery*, *44*(8), 1005–1009.

[16] Matthew, I. R., & Frame, J. W. (2000). Release of metal in vivo from stressed and nonstressed maxillofacial fracture plates and screws. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics*, *90*(1), 33–38.

[17] Trivellato, A. E., Mazzonetto, R., Passeri, L. A., &Consani, S. (2000). Estudo químico, macroscópico e da resistência à flexão de placas e parafusos de titânio usados na fixação

interna rígida. *Pesquisa Odontológica Brasileira*, *14*(4), 392-398.

[18] Matthew, I. R., Frame, J. W., Browne, R. M., & Millar, B. G. (1996). In vivo surface analysis of titanium and stainless steel miniplates and screws. *Internationaljournal of oral andmaxillofacialsurgery*, *25*(6), 463–468.

[19] Azevedo, C. R. F., &Hippert, Jr. E. (2002). Análise de falhas de implantes cirúrgicos. *Caderno de Saúde Pública*, *18*(5):1347-8.

[20] Krischak, G. D., Gebhard, F., Mohr, W., Krivan, V., Ignatius, A., Beck, A., Wachter, N. J., Reuter, P., Arand, M., Kinzl, L., &Claes, L. E. (2004). Difference in metallic wear distribution released from commercially pure titanium compared with stainless steel plates. *Archives of orthopaedicand trauma surgery*, *124*(2), 104–113.

[21] Estrela, C., Sousa-Neto, M. D., Guedes, O. A., Alencar, A. H., Duarte, M. A., & Pécora, J. D. (2012). Characterization of calcium oxide in root perforation sealer materials. *Brazilian dental journal*, *23*(5), 539–546.

[22] Guedes, O. A., Borges, Á. H., Bandeca, M. C., Nakatani, M. K., de Araújo Estrela, C. R., de Alencar, A. H., & Estrela, C. (2015). Chemical and structural characterization of glass ionomer cements indicated for atraumatic restorative treatment. *The journal of contemporary dental practice*, *16*(1), 61–67.

[23] Goldstein, J. I., Newbury, D. E., Echlin, P., Joy, D. C., Lyman, C. E., Lifshin, E., Sawyer, L., & Michael, J. R. (2003). *Scanning Electron Microscopy and X-ray Microanalysis: Third Edition*.

[24] Vaughan, D., &Kevex Corporation. (1989). *Energy-dispersive x-ray microanalysis: An introduction*. San Carlos, CA: KevexInstruments, Inc.

[25] American Society for Testing and Materials (ASTM). (1997) Standard specification for titanium- 6aluminum-4vanadium alloy castings for surgical implant (UNS R56406). Designation: F 1108–97. *In*: Annual book of ASTM standards. Medical devices and services, *13*(01):380-2.

[26] International Organization for Standardization/Draft International Standards (ISO/DIS). (1993). Implants for surgery – metallic materials – part 3: wrought titanium-6aluminium-4vanadium alloy. Reference number ISO/DIS 5832-3:1-4.

[27] Silva, R. A., Barbosa, M. A., Jenkins, G. M., & Sutherland, I. (1990). Electrochemistry of galvanic couples between carbon and common metallic biomaterials in the presence of crevices. *Biomaterials*, *11*(5), 336–340.
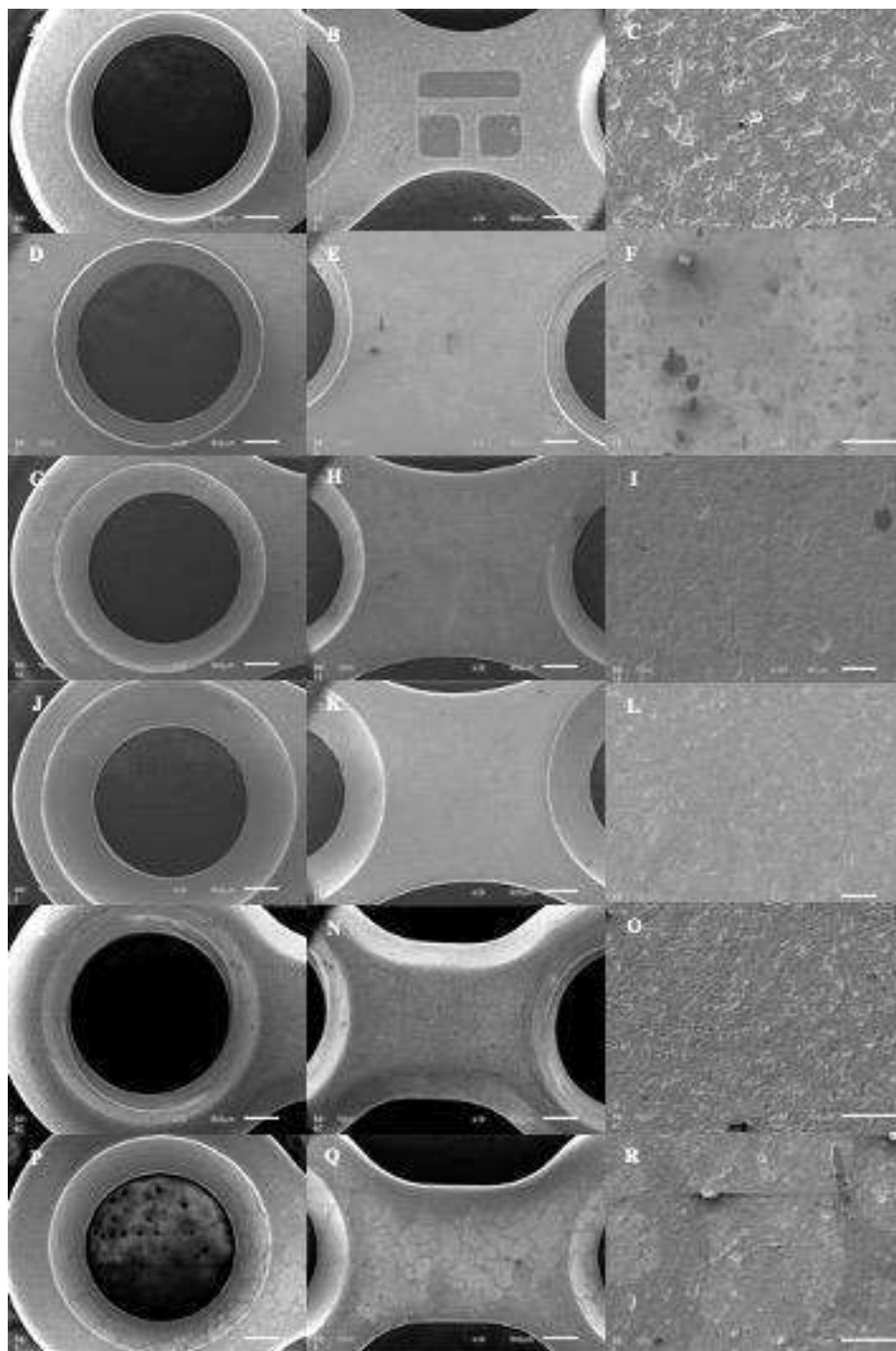
*Fig.1 -SEM images showing morphological aspects of the surfaces of the tested plates. Toride®: (A) screw insertion hole at 30X; (B) flat surface at 30Xand (C) surface irregularity at 300X; Engimplan®: (D) screw insertion hole at 30X; (E) flat surface at 30X (F) surface irregularity at 250X; Straight MDT®: (G) screw insertion hole at 30X; (H) flat surface at 30Xand (I) surface irregularity at 300X; Promm®: (J) screw insertion hole at 30X; (K) flat surface at 30Xand (L) surface irregularity at 300X; Osteomed® straight with intermediate: (M) screw insertion hole at 30X; (N) flat surface at 30X and (O) surface irregularity at 250X; Stryker®: (P) screw insertion hole at 30X; (Q) flat surface at 30X and (R) surface irregularity at 250X.*
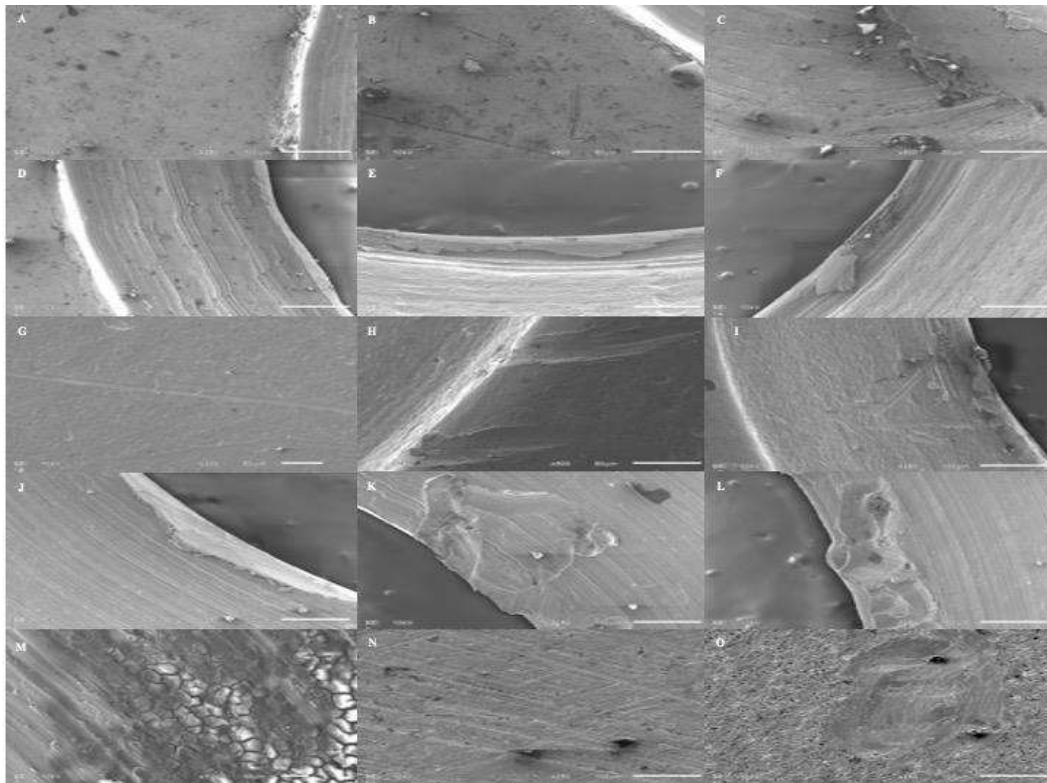
*Fig.2 -SEM images of defects found on the flat surface and holes in the plates. Engimplan®: (A) metal fragments at 250X; (B) scratches and metal fragments at500X; (C) burrs and metal fragments at250X and (D) deformation and metal fragments at500X; Straight MDT®: (E) and (F) burrs at 250X; Straight MDT® with intermediate: (G) scratches at 300X and (H) scratches at 500X and (I) scratches and burrs at 250X; Promm®: (J) deformation and burrs at 250X; (K) and (L) deformation and metal fragments at250X and (M) area of corrosion at1000X; Osteomed® curved: (N) scratches at250X and Osteomed® straight with intermediate: (O) deformation at250X.*
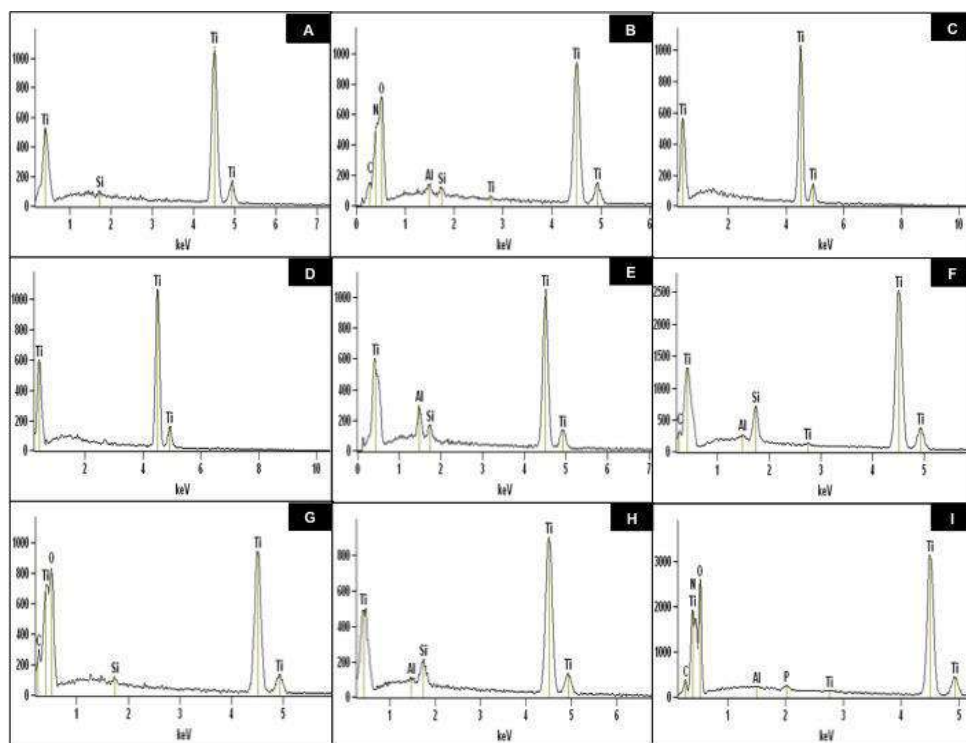


*Fig.3 - Representative EDX spectra of the tested plates: (A) Toride®; (B) Engimplan®; (C) MDT® straight; (D) MDT® with an intermediary; (E) Promm®; (F) Osteomed® straight; (G) Osteomed® curved; (H) Osteomed® with an intermediate; and (I) Stryker®.*
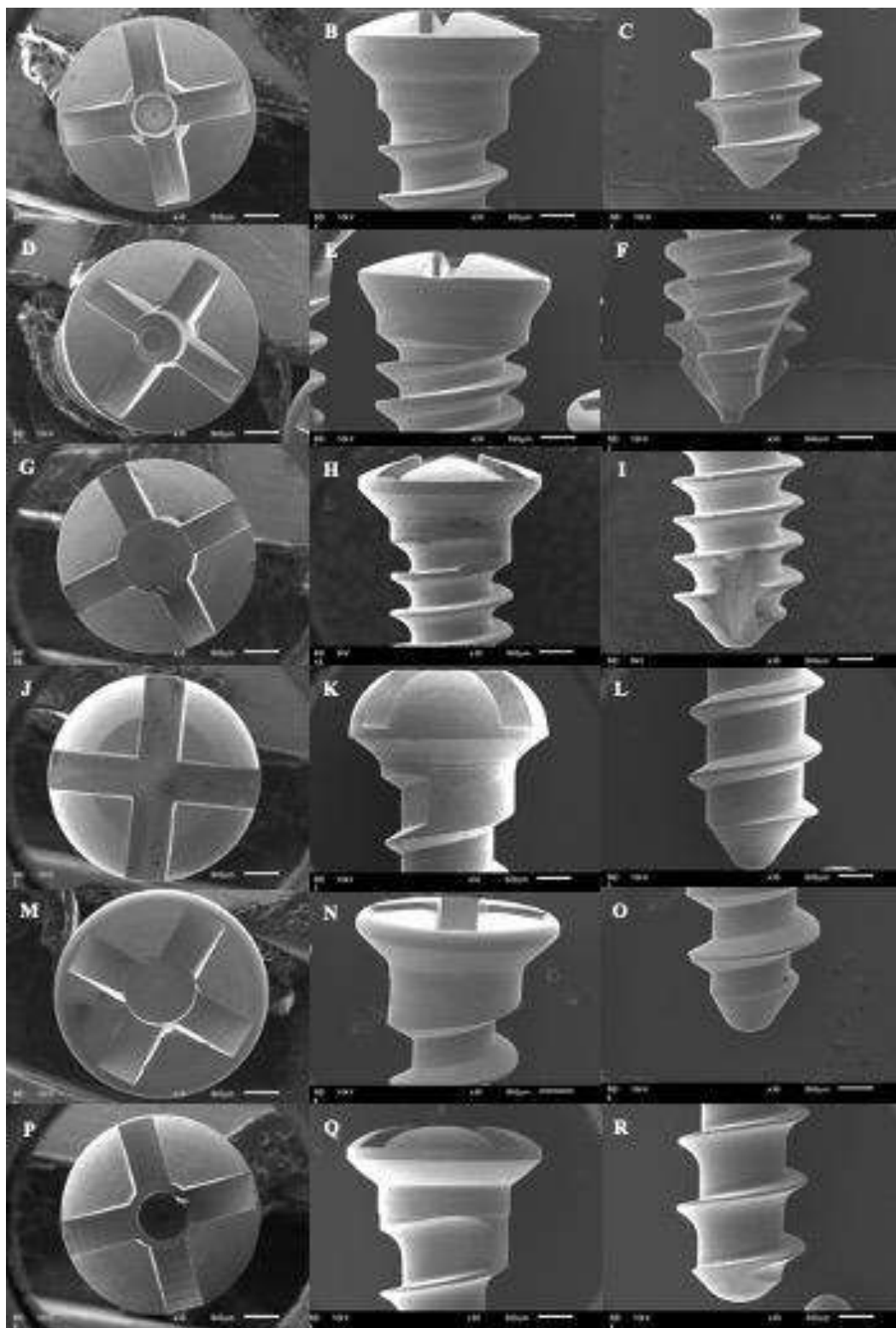
*Fig.4 -SEM imagesat30X magnification, showing the morphological aspects of the tested screw surfaces: head and body (thread). Toride®: (A), (B), and (C); Engimplan®: (D), (E), and (F); MDT®: (G), (H), and (I); Promm®: (J), (K), and (L); Osteomed®: (M), (N) and (O); and Stryker®: (P), (Q), and (R).*
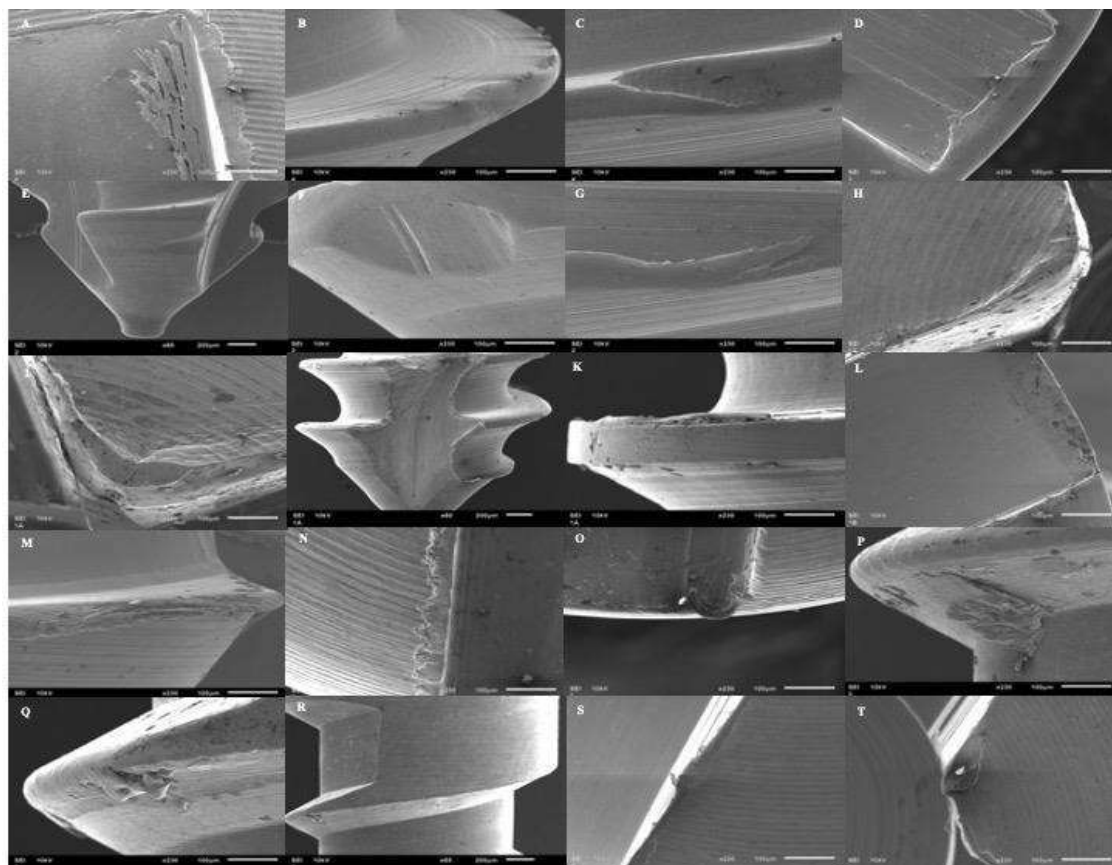
*Fig.5 -SEM images of defects found in screw heads and threads. Toride®: (A) burrs and fragments of metal at 230X; (B) and (C) deformation at 230X; Engimplan®: (D) and (E) burrs and deformation at 65X; (F) deformation at 230X; (G) burrs at 230X;MDT® 6mm: (H) metal fragments at 230X; (I) deformation and metal fragments at230X; (J) burrs and deformation at 60X and (K) burrs and metal fragments at 230X; MDT® 10mm: (L) and (M) burrs and metal fragments at230X; Promm®: (N), (P) and (Q) burrs at 230X and (R) metal fragments at 65X; and Osteomed®: (S) deformation and metal fragments at230X and (T) metal fragments at230X.*
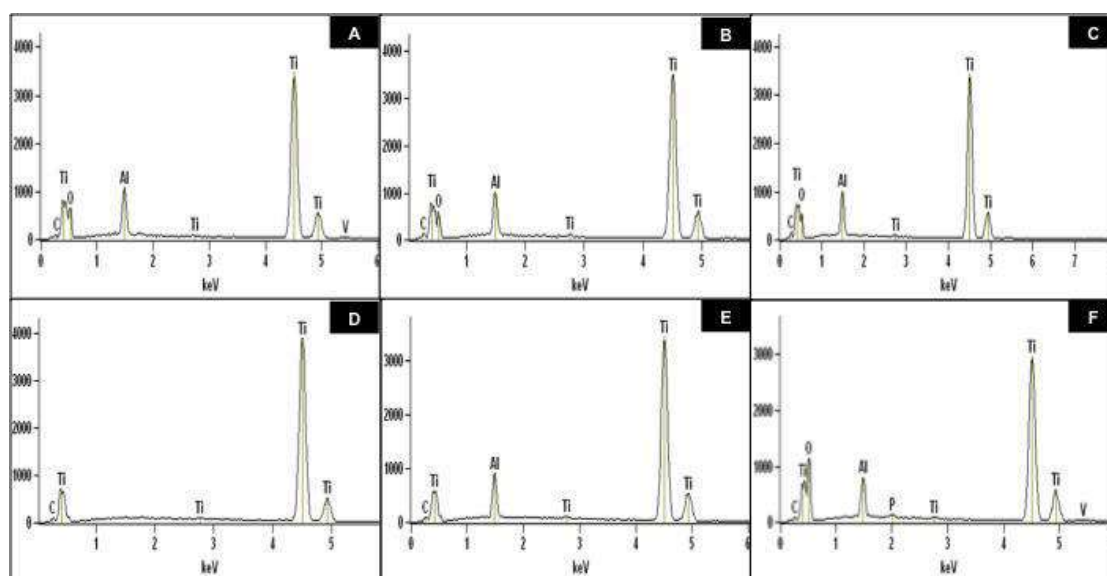


*Fig.6 - Representative EDX spectra of the tested screws: (A) Toride®; (B) Engimplan®; (C) MDT®; (D) Promm®; (E) Osteomed®; and (F) Stryker®.*

# Optimization of Stability of Building by Changing Thickness of Shear Wall at Corners for Same Concrete Grade

## Zamran Khan[1], Sagar Jamle[2], Arvind Vishwakarma[2]

[1]M Tech Scholar, Department of Civil Engineering, Oriental University, Indore, India

[2]Assistant Professor, Department of Civil Engineering, Oriental University, Indore, India

***Abstract**— Stability is to ensure the safety of structures from collapsing. Stability theory is crucial for structural engineering, aerospace, nuclear engineering, coastal, ocean and arctic engineering. It plays an important role in certain problems of space structures, geotechnical structures, geophysics and materials science .The project deals with the Response Spectrum Analysis of G+20 storeys Residential Apartment for different models. Total 12 models are modeled under the variations in thickness Shear Wall Provided at Corners from 0.130m to 0.150m thickness. The structure consists of 5 m. spacing of grid with total 6 bays in both major directions. The plinth area is taken 30mx30m (900 m2). The earthquake structure analysis for zone III with the help of analysis software. The project concluded that stability of structure is increases with increment in the thickness of shear wall. The lateral load capacity is much more in shear wall structure and increment in it also increases. The optimum structures observed for the current project is OSW10 & 11 in terms of stability with respect to result parameters.*

***Keywords**—Concrete Grade, Dual System, Dimension Change, Shear wall, Stability.*

## I. INTRODUCTION

A building is with stand under the lateral loads effect (earthquake) only when the building component is satisfying the lateral loads response. The shear wall is one of the important components in to it. Reinforced concrete (RC) buildings next to slabs, beams and columns often have vertical RC slab-like walls called shear walls. These walls usually start at the level of the foundation and are continuous throughout the height of the building. Their thickness can be up to 130 mm, or up to 450 mm high in tall buildings. Sliding walls are usually provided along the length and width of buildings. Shear walls are like vertically oriented wide beams that carry earthquake loads down to the foundation. The use of shear wall or their equivalents become mandatory in some high-rise building if inter storey deflection is controlled due to lateral loading. Shear walls also provides the solution against expensive non-structural harm during moderate seismic disturbance. The shear wall is actually a misnomer as far as tall buildings are concerned, when the lateral loads are applied to a tapered shear wall resulting in mainly momentary deflection and only very trivial shear deformation. Analysis of shear wall may appear as an

important design element because high rise structures are continuously becoming taller and slender. More often than not, shear walls are pierced by multiple openings. This type of sliding walls is known as connected sliding walls. The walls on either side of the opening are interconnected by short, often deep beams that form part of the wall or floor slab, or both. If these walls are installed systematically, then an improvement in stability will be achieved in them.

## II. SHEAR WALL

A structural component added to the multistoried building structure made up of stiff R. C. C. wall, is an additional member used to resist lateral effects on it. This R.C.C. vertical wall starts from foundation base to the top of the building. Ordinary RC structural walls and Ductile RC structural walls are classified by the Indian standardization. As per IS 13920, one doesn't meet the special detailing requirements for ductile behavior is considered as the former one meet the special detailing requirements for ductile behavior is considered as the later.

## III. OBJECTIVES OF THE PROJECT

This research is based on the variation in thickness of shear wall in G+20 Storey building. The following objectives are taken for these project areas follows:-

• To Study about shear wall behavior with variation in different parameters.

• To Modeled a G+20 storey multistory Building by software approach.

• To find different results parameters such as Maximum displacement, Base shear, axial force, bending moment, Torsional moment & Stresses in required X Y and Z directions.

• To compare the OSW0 (regular model) with OSW1 to OSW11 model (1 to 11 is changing the thickness of shear wall from 0.130 m. to 0.150 m. in the interval added 0.002 m.).

• To find the optimum structure & thickness of shear wall structure in G+20 Storey model.

## IV. MODELING AND ANALYSIS

The Different cases of G+20 Storey Residential Apartment with variation in Shear Wall thickness provided at corner are modeled by using fem based software. The Notations of cases are described in the table no. by OSWO to OSW11. Table 1 shows the Descriptions of model.

*Table 1: Model Descriptions*

| S. No | Model Cases | Descriptions |
|---|---|---|
| 1 | OSW0 | G+20 storey with no Shear Wall (Regular Structure) |
| 2 | OSW1 | G+20 storey with Shear Wall 0.130 thickness |
| 3 | OSW2 | G+20 storey with Shear Wall 0.132 thickness |
| 4 | OSW3 | G+20 storey with Shear Wall 0.134 thickness |
| 5 | OSW4 | G+20 storey with Shear Wall 0.136 thickness |
| 6 | OSW5 | G+20 storey with Shear Wall 0.138 thickness |
| 7 | OSW6 | G+20 storey with Shear Wall 0.140 thickness |
| 8 | OSW7 | G+20 storey with Shear Wall 0.142 thickness |
| 9 | OSW8 | G+20 storey with Shear Wall 0.144 |

| | | thickness |
|---|---|---|
| 10 | OSW9 | G+20 storey with Shear Wall 0.146 thickness |
| 11 | OSW10 | G+20 storey with Shear Wall 0.148 thickness |
| 12 | OSW11 | G+20 storey with Shear Wall 0.150 thickness |

Structural Parameters used in G+ 20 storey: Table 2 & Table 3 shows the basic parameters used in the analysis of building.
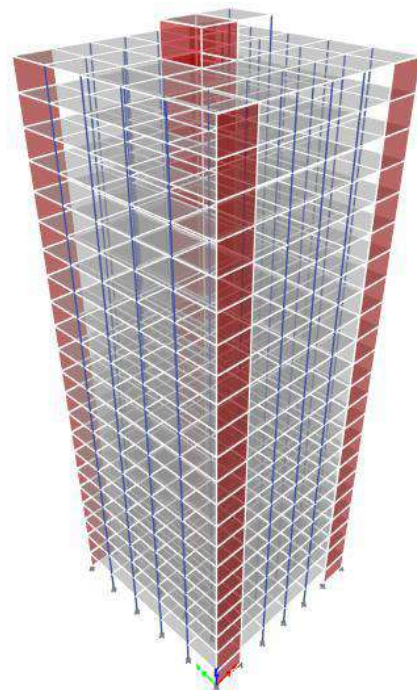


*Fig.1: G+20 Storey 3D view*

*Table 2: Structural Parameters*

| S. No. | Element Name | Description |
|---|---|---|
| 1 | Building Types | Residential |
| 2 | No. of Storey | G+20 |
| 3 | Plinth Area | 900 m² |
| 4 | Floor Height | 4.5 GF & 3.66 each floor |
| 5 | Dimensions of Beam | 0.50 m. x0.38 m. |
| 6 | Dimensions of Column | 0.55 m. x 0.60 m. |
| 7 | Slab Thickness | 0.150 m. |
| 8 | Shear wall | 0.130 m. thick(around lift area) At Corners: 0.130m, 0.132m, 0.134m, 0.136m, |

| | | 0.138m, 0.140m, 0.142m, 0.144m, 0.146m, 0.148m, 0.150m, |
|---|---|---|
| 10 | Grade of Concrete | M25 |
| 11 | Steel Used | Fe 500 |
| 12 | Grid Spacing in X-Direction | 5 m.@ 6 bays |
| 13 | Grid Spacing in Y-Direction | 5 m.@ 6 bays |

**Earthquake Parameters used:**

*Table 3: Earthquake Parameters*

| S. No. | Parameters | Description |
|---|---|---|
| 1 | Earthquake Code | IS 1893(Part 1):2016 |
| 2 | Earthquake Zone | III |
| 3 | Response Factor( RF) | 4 |
| 4 | Importance Factor(IF) | 1.2 |
| 5 | Soil Types | Medium |
| 6 | Damping | 0.05 (5%) |
| 7 | Time Period | 1.3944 second. |
| 8 | Structural Type | RCC Framed Building |
| 9 | Earthquake method | Response Spectrum Method |

## V.     RESULTS AND DISCUSSION

The Following results are to be obtained from the modeling and analysis of Multi storey building of G+20 Storey building in software. The results are as follows:

*Table 4: Maximum Displacement for G+20 Storey for different Models*

| Shear Wall Stability Case | Maximum Displacement(mm) | |
|---|---|---|
| | For X Direction | For Z Direction |
| Case OSW0 | 268.583 | 349.03 |
| Case OSW1 | 242.32 | 323.801 |
| Case OSW2 | 242.174 | 323.925 |
| Case OSW3 | 242.03 | 324.049 |
| Case OSW4 | 241.888 | 324.174 |
| Case OSW5 | 241.746 | 324.299 |
| Case OSW6 | 241.607 | 324.425 |
| Case OSW7 | 241.468 | 324.551 |

| Case OSW8 | 241.468 | 324.551 |
|---|---|---|
| Case OSW9 | 241.195 | 324.804 |
| Case OSW10 | 241.06 | 324.931 |
| Case OSW11 | 240.926 | 325.089 |
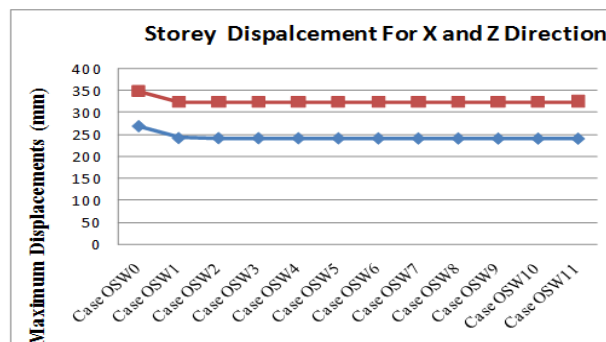


*Fig.2: Bar char of Maximum Displacement for G+20 Storey for different Models*

*Table 5: Base Shear for all Optimum Shear Wall Stability Case*

| Shear Wall Stability Case | Base Shear (KN) | |
|---|---|---|
| | X direction | Z direction |
| Case OSW0 | 4957.557 | 4957.5451 |
| Case OSW1 | 5146.7824 | 5146.7754 |
| Case OSW2 | 5149.5729 | 5149.5649 |
| Case OSW3 | 5152.3638 | 5152.3523 |
| Case OSW4 | 5155.1486 | 5155.1414 |
| Case OSW5 | 5157.9389 | 5157.9331 |
| Case OSW6 | 5160.7287 | 5160.7212 |
| Case OSW7 | 5163.5153 | 5163.5078 |
| Case OSW8 | 5163.5153 | 5163.5074 |
| Case OSW9 | 5169.0983 | 5169.0846 |
| Case OSW10 | 5171.8813 | 5171.8750 |
| Case OSW11 | 5174.6694 | 5174.6635 |
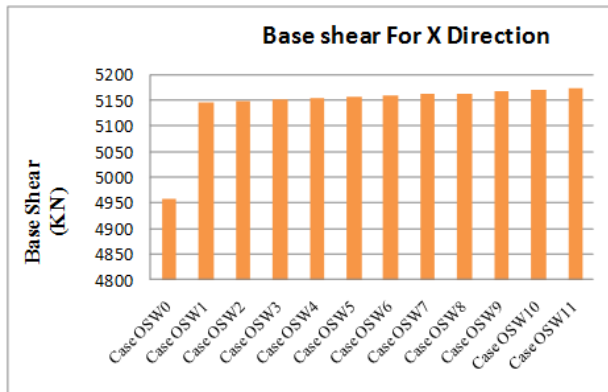
*Fig.3: Base Shear in X direction for all Optimum Shear Wall Stability Case*
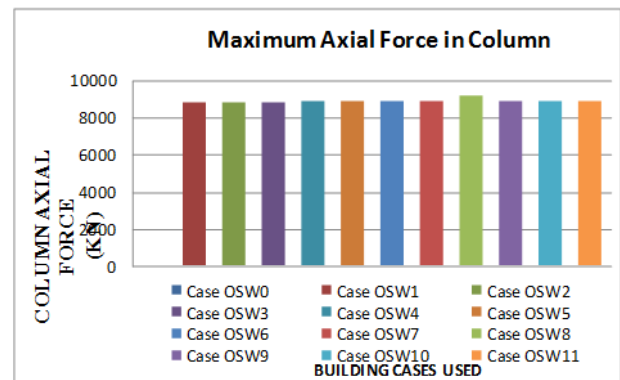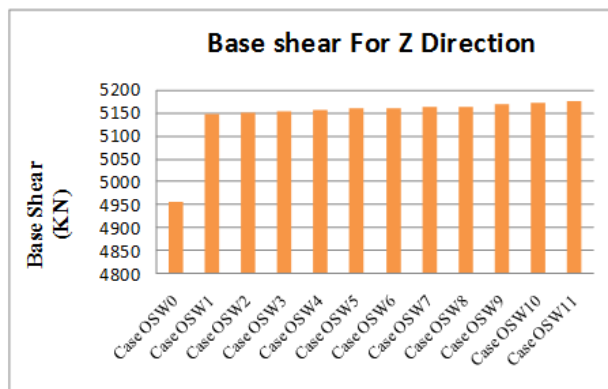


*Fig.4: Base Shear in Z direction for all Optimum Shear Wall Stability Case*

*Table 6: Maximum Axial Forces in Column for all Optimum Shear Wall Stability Case*

| Shear Wall Stability Case | Column Axial Force (KN) |
|---|---|
| Case OSW0 | 9189.2016 |
| Case OSW1 | 8854.1918 |
| Case OSW2 | 8856.7936 |
| Case OSW3 | 8859.4052 |
| Case OSW4 | 8862.0302 |
| Case OSW5 | 8864.6715 |
| Case OSW6 | 8867.3191 |
| Case OSW7 | 8869.9753 |
| Case OSW8 | 8869.9753 |
| Case OSW9 | 8875.3271 |
| Case OSW10 | 8878.0194 |
| Case OSW11 | 8880.7201 |



*Fig.5: Maximum Axial Forces in Column for all Optimum Shear Wall Stability Case*

*Table 7: Maximum Shear Force in Column for all Shear Wall Stability Cases*

| Shear Wall Stability Case | Column Shear Force (KN) | |
|---|---|---|
| | Shear along Y | Shear along Z |
| Case OSW0 | 121.1855 | 122.829 |
| Case OSW1 | 122.7198 | 121.8681 |
| Case OSW2 | 122.9672 | 121.8993 |
| Case OSW3 | 123.2112 | 121.9307 |
| Case OSW4 | 123.4517 | 121.9623 |
| Case OSW5 | 123.689 | 121.8142 |
| Case OSW6 | 123.923 | 122.0263 |
| Case OSW7 | 124.1539 | 122.0585 |
| Case OSW8 | 124.1539 | 121.883 |
| Case OSW9 | 124.6065 | 122.1238 |
| Case OSW10 | 124.8282 | 122.1567 |
| Case OSW11 | 125.0471 | 122.1898 |
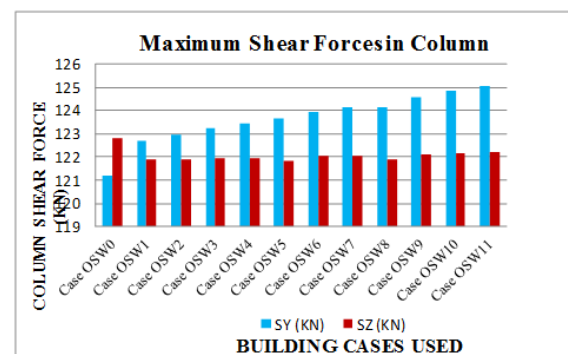


*Fig.6: Maximum Shear Force in Column for all Optimum Shear Wall Stability Case*

*Table 8: Maximum Bending Moment in Column*

| Shear Wall Stability Case | Column Bending Moment (KN.m) | |
|---|---|---|
| | Moment along Y | Moment along Z |
| Case OSW0 | 208.5969 | 220.4408 |
| Case OSW1 | 207.521 | 202.4762 |
| Case OSW2 | 207.8065 | 202.8719 |
| Case OSW3 | 207.8612 | 203.2622 |
| Case OSW4 | 207.9163 | 203.6469 |
| Case OSW5 | 207.9719 | 204.0266 |
| Case OSW6 | 208.0278 | 204.4011 |
| Case OSW7 | 208.0839 | 204.7706 |
| Case OSW8 | 208.0839 | 204.7706 |
| Case OSW9 | 208.1974 | 205.4952 |
| Case OSW10 | 208.2547 | 205.8502 |
| Case OSW11 | 208.3124 | 206.2007 |
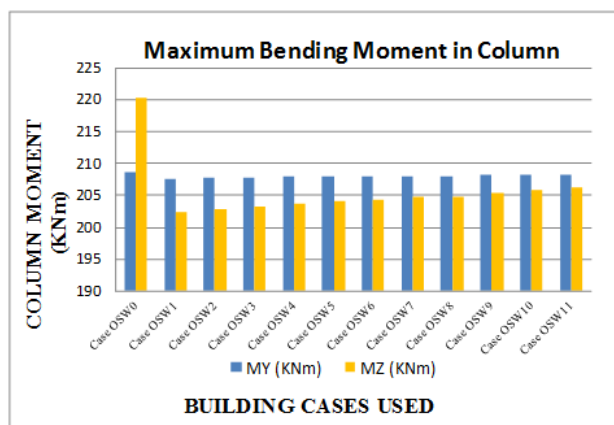


*Fig.7: Maximum Bending Moment in Column*

*Table 9: Maximum Shear Force in Beam for all Optimum Shear Wall Stability Case*

| Shear Wall Stability Case | Beam Shear Force (KN) | |
|---|---|---|
| | Shear along Y | Shear along Z |
| Case OSW0 | 155.6581 | 1.1827 |
| Case OSW1 | 147.4593 | 0.2535 |
| Case OSW2 | 147.5962 | 0.2526 |
| Case OSW3 | 147.7309 | 0.2517 |
| Case OSW4 | 147.8633 | 0.2508 |
| Case OSW5 | 147.9938 | 0.25 |
| Case OSW6 | 147.1222 | 0.2492 |
| Case OSW7 | 148.2485 | 0.2484 |
| Case OSW8 | 148.2485 | 0.2485 |
| Case OSW9 | 148.4955 | 0.2469 |
| Case OSW10 | 148.616 | 0.2461 |
| Case OSW11 | 148.7347 | 0.2454 |
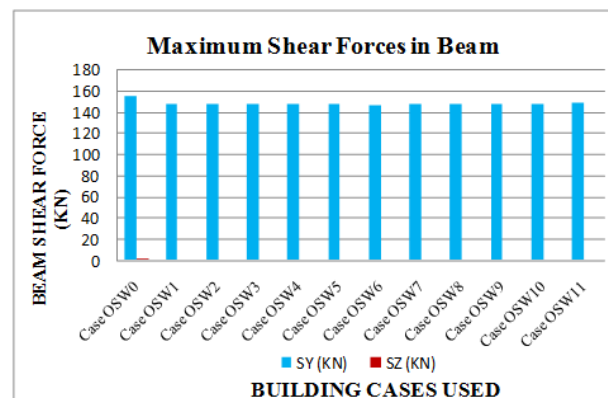


*Fig.8: Representation of Maximum Shear Force in Beam*

*Table 10: Maximum Bending Moment in Beam for all Optimum Shear Wall Stability Case*

| Shear Wall Stability Case | Beam Bending Moment (KN.m) | |
|---|---|---|
| | Moment along Y | Moment along Z |
| Case OSW0 | 2.6776 | 277.2208 |
| Case OSW1 | 0.6344 | 269.5813 |
| Case OSW2 | 0.6324 | 269.646 |
| Case OSW3 | 0.6304 | 269.7109 |
| Case OSW4 | 0.6285 | 269.7759 |
| Case OSW5 | 0.6266 | 269.8414 |
| Case OSW6 | 0.6248 | 269.9069 |
| Case OSW7 | 0.623 | 269.9725 |
| Case OSW8 | 0.623 | 269.9725 |
| Case OSW9 | 0.6196 | 270.1046 |
| Case OSW10 | 0.6179 | 270.171 |
| Case OSW11 | 0.6163 | 270.2375 |
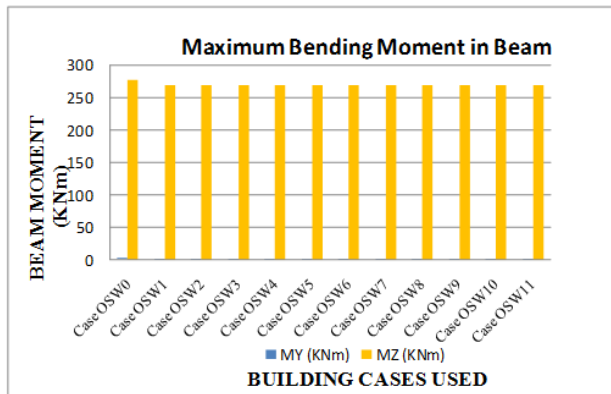
*Fig.9: Representation of Maximum Bending Moment in Beam*

*Table 11: Maximum Torsional Moments in Beam & Column Results*

| Shear Wall Stability Case | Beam Torsional Moments (KN.m) | Column Torsional Moments (KN.m) |
|---|---|---|
| Case OSW0 | 8.7148 | 19.8112 |
| Case OSW1 | 9.5852 | 4.5013 |
| Case OSW2 | 9.5909 | 4.4919 |
| Case OSW3 | 9.7109 | 4.4826 |
| Case OSW4 | 9.6023 | 4.4734 |
| Case OSW5 | 9.6079 | 4.4642 |
| Case OSW6 | 9.6136 | 4.4551 |
| Case OSW7 | 9.6192 | 4.446 |
| Case OSW8 | 9.6192 | 4.446 |
| Case OSW9 | 9.6304 | 4.4281 |
| Case OSW10 | 9.6359 | 4.4193 |
| Case OSW11 | 9.6415 | 4.4105 |



*Fig.10: Bar chart of Maximum Torsional Moments in Beams*



*Fig.11: Bar chart of Maximum Torsional Moments in Columns*

*Table 12: Maximum Principal Stresses for all Optimum Shear Wall Stability Case*

| Shear Wall Stability Case | Maximum Principal Stresses (Smax Top) (N/sq. mm) | Maximum Von Mises Stresses (SVM Top) (N/sq. mm) | Maximum Shearing Stresses (S12) (N/sq. mm) |
|---|---|---|---|
| Case OSW0 | 20.66 | 25.75 | 8.2 |
| Case OSW1 | 18.75 | 24.18 | 4.46 |
| Case OSW2 | 18.76 | 24.19 | 4.47 |
| Case OSW3 | 18.77 | 24.2 | 4.47 |
| Case OSW4 | 18.78 | 24.2 | 4.47 |
| Case OSW5 | 18.79 | 24.21 | 4.47 |
| Case OSW6 | 18.8 | 24.22 | 4.47 |
| Case OSW7 | 18.8 | 24.23 | 4.48 |
| Case OSW8 | 18.8 | 24.23 | 4.48 |
| Case OSW9 | 18.8 | 24.24 | 4.48 |
| Case OSW10 | 18.83 | 24.25 | 4.48 |
| Case OSW11 | 18.84 | 24.26 | 4.48 |

*Fig.12: Maximum Principal Stresses for all Optimum Shear Wall Stability Case*



*Fig.13: Maximum Von Mises Stresses for all Optimum Shear Wall Stability Case*
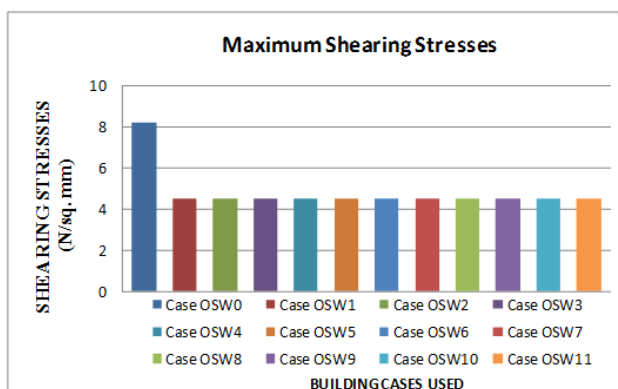


*Fig.14: Maximum Shearing Stresses for all Optimum Shear Wall Stability Case*

## VI. CONCLUSIONS

The following conclusions are obtained based the different results obtained of model OSW0 to model OSW11.

The Response spectrum approach is adopted in it. The entire conclusion are valid only and only for this project. The conclusions are as follows:

1. There is decrement in storey displacement of 9.78%, 9.83%. 9.89% 9.94%. 9.99%, 10.04%, 10.10%, 10.10%, 10.20%, 10.30% is observed in model OSW1 to OSW11 with respect to OSW0(reference model) in X direction. Similarly 7.23%, 7.19%, 7.16%, 7.12%, 7.09%, 7.055, 7.01%, 7.01%, 6.94%, 6.90%, 6.86% with respect to OSW0 (reference model) in Z-direction.

2. There is increment is observed in base shear which is 3.82%, 3.87%, 3.93%, 3.99%, 4.04%, 4.10% ,4.15% 4.15% 4.27%,4.32%, 4.38% in OSW1 to OSW11 models with reference to basic model in both major direction.

3. The axial forces value is also reduces in OSW1 to OSW11 which is 3.65%,3.62%,3.59%,3.56%,3.53%,3.50%,3.47%,3.47%,3.42%,3.39%,3.36% with references to OSW0.

4. There is increment in column shear force in OSW1 to OSW11 which is 1.27%,1.47%,1.67%,1.87%,2.07%2.26%,2.45%,2.45% ,2.82%,3.01%,3.19%, with respect to basic structure in X direction. Similarly in Z direction decrement is observed 0.78%, 0.76%, 0.73%, 0.71%, 0.83%, 0.65%, 0.63%, 0.77%, 0.57%, 0.55%, 0.52%.

5. There is minute reduction of 0.14% to 0.50% observed in bending moment in column in the models having shear wall variation with thickness in x Direction. But in case of z direction decrement value is observed in between 6 to 8 % with respect to normal model.

6. There is reduction in beam shear force is observed. The average 5% & 78 % reduction in Y & Z direction respectively in shear wall models with reference to regular model.

7. There is reduction in bending moment in beam is observed. The average 76.50 % & 2.65 % reduction in Y & Z direction respectively in shear wall models with reference to regular model.

8. The increment in value of Torsional moment in beam is observed which is 9.99%,10.05%,11.43%,10.18%,10.25%,10.31%,10.38%,10.38%,10.51%,10.57%,10.63%, in OSW1 to OSW 11 models with respect to basic model.

9. The decrement in value of Torsional moment in column is observed which is 77.28%,77.33%,77.37%,77.42%,77.47%,77.51%,77.56%,77.56%,77.65%,77.69%,77.74% in OSW1 to OSW 11 models with respect to regular model(OSW).

10. The reduction is observed in stresses when increment in shear wall thickness in models. The avg. 9%, 6%, 45 % reduction in stresses i.e. Maximum Principal Stresses

Maximum, Von Mises Stresses, Maximum Shearing Stresses respectively with reference to regular model stresses.

The final concluded that there is decrement is observed on affected parameters on the structure with increment in shear wall thickness. The lateral loads resisting capacity is improved with increment in thickness in shear wall. The optimum structure is observed is OSW10 & 11.

## ACKNOWLEDGEMENT

## REFERENCES

[1] Sagar Jamle, Dr. M.P. Verma, Vinay Dhakad, (2017), "Flat Slab Shear Wall Interaction for Multistoried Building Analysis When Structure Length is greater than width under seismic Forces", *International Journal of Software & Hardware Research in Engineering (IJSHRE)*, ISSN: 2347-4890 Vol.-05, Issue-3, pp. 32-53.

[2] Neeraj Patel, Sagar Jamle, (2019), "Use of Shear Wall Belt at Optimum Height to Increase Lateral Load Handling Capacity in Multistory Building: A Review", *International Journal of Advanced Engineering Research and Science*, (ISSN : 2349-6495(P) | 2456-1908(O)),vol. 6, no. 4, pp. 310-314, https://dx.doi.org/10.22161/ijaers.6.4.36

[3] Sachin Sironiya, Sagar Jamle, M. P. Verma, (2017), "Experimental Investigation On Fly Ash & Glass Powder As Partial Replacement Of Cement For M-25 Grade Concrete", *IJSART* - Volume 3 Issue 5, ISSN- 2395-1052, pp. 322-324.

[4] Prabhulal Chouhan, Sagar Jamle, M.P. Verma, (2017), "Effect of Silica Fume on Strength Parameters of Concrete as a Partial Substitution of Cement", *IJSART* - Volume 3 Issue 5, ISSN- 2395-1052.

[5] Sagar Jamle, Dr. M.P. Verma, Vinay Dhakad, (2017), "Flat Slab Shear Wall Interaction for Multistoried Building under Seismic Forces", *International Journal of Software & Hardware Research in Engineering (IJSHRE),* ISSN: 2347-4890 Vol.-05, Issue-3, pp. 14-31.

[6] Taha A. Ansari, Sagar Jamle, (2019), "Performance Based Seismic Analysis of Regular R.C. Building", *International Journal of Management, Technology And Engineering*, ISSN: 2249-7455, Vol. 09, no. 07, pp. 342-351, DOI:16.10089.IJMTE.2019.V9I7.19.28639

[7] Prakash Mandiwal, Sagar Jamle, (2018), "Use of Polyethylene Glycol as Self Curing Agent in Self Curing Concrete - An Experimental Approach", *International Research Journal of Engineering and Technology*, (ISSN: 2395-0072(P), 2395-0056(O)), vol. 5, no. 11, pp. 916-918.

[8] Surendra Chaurasiya, Sagar Jamle, (2018), "Determination of Efficient Twin Tower High Rise Building Subjected to Seismic Loading", *International Journal of Current Engineering and Technology*, INPRESSCO, E-ISSN 2277 – 4106, P-ISSN 2347 – 5161, Vol. 8, No. 5, pp. 1200 – 1203, DOI: https://doi.org/10.14741/ijcet/v.8.5.1

[9] Archit Dangi, Sagar Jamle, (2018), "Determination of Seismic parameters of R.C.C. Building Using Shear Core Outrigger, Wall Belt and Truss Belt Systems", *International Journal of Advanced Engineering Research and Science*, (ISSN : 2349-6495(P) | 2456-1908(O)),vol. 5, no. 9, pp.305-309, https://dx.doi.org/10.22161/ijaers.5.9.36

[10] Mohd. Arif Lahori, Sagar Jamle, (2018), "Investigation of Seismic Parameters of R.C. Building on Sloping Ground", *International Journal of Advanced Engineering Research and Science*, (ISSN: 2349-6495(P), 2456-1908(O)), vol. 5, no. 8, pp.285-290, https://dx.doi.org/10.22161/ijaers.5.8.35

[11] Gaurav Pandey, Sagar Jamle, (2018), "Optimum Location of Floating Column in Multistorey Building with Seismic Loading", *International Research Journal of Engineering and Technology*, (ISSN: 2395-0072(P), 2395-0056(O)), vol. 5, no. 10, pp. 971-976.

[12] Suyash Malviya, Sagar Jamle, (2019) ,"Determination of Optimum Location of Rooftop Telecommunication Tower over Multistory Building under Seismic Loading", *International Journal of Advanced Engineering Research and Science*, (ISSN : 2349-6495(P) | 2456-1908(O)),vol. 6, no. 2, 2019, pp. 65-73, https://dx.doi.org/10.22161/ijaers.6.2.9

[13] Neeraj Patel, Sagar Jamle, (2019), "Use of Shear Wall Belt at Optimum Height to Increase Lateral Load Handling Capacity in Multistory Building", *International Journal for Research in Engineering Application & Management* (ISSN : 2454-9150),vol. 4, no. 10, pp. 596-603, doi: 10.18231/2454-9150.2018.1372

[14] Taha A. Ansari, Sagar Jamle, (2019), "Performance Based Analysis of RC Buildings with Underground Storey Considering Soil Structure Interaction", *International Journal of Advanced Engineering Research and Science* (ISSN: 2349-6495(P) | 2456-1908(O)),vol. 6, no. 6, pp. 767-771, https://dx.doi.org/10.22161/ijaers.6.6.89

[15] Sagar Jamle and Shirish Kumar Kanungo, (2020), "Determination of Stable Underground Storage Reservoir System- Recent Advancements in Structural Engineering Volume 1", *LAP LAMBERT Academic Publishing, Mauritius*, ISBN: 978-620-2-51435-4.

[16] Sagar Jamle, Nirmal Delmiya, Rahul Singh, (2020), "Efficient Use of UPV Meter: A Non Destructive Test of Concrete by Fragmentation Analysis", Journal of Xi'an University of Architecture & Technology, ISSN: 1006-7930, vol. 12, no. 4, pp. 3385-3394. https://doi.org/10.37896/JXAT12.04/1078

[17] Pankaj Kumar Dhakad, Sagar Jamle, (2020), "Base Shear Reduction by Using Optimum Size of Beams in Top Floors with Different Grades in Multistoried Building at Different Levels", *International Journal of Advanced Engineering Research and Science*, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 4, pp. 170-178. https://dx.doi.org/10.22161/ijaers.74.20

[18] Gagan Yadav, Sagar Jamle, (2020), "Use of Shear Wall with Opening in Multistoried Building: A Factual Review", *International Journal of Current Engineering and Technology*, (ISSN: 2277-4106 (O), 2347-5161(P)), vol. 10, no. 2, pp. 243-246. https://doi.org/10.14741/ijcet/v.10.2.9

[19] Surendra Chaurasiya, Sagar Jamle, (2019), "Twin Tower High Rise Building Subjected To Seismic Loading: A Review", *International Journal of Advanced Engineering Research and Science*, (ISSN : 2349-6495(P) | 2456-1908(O)), vol. 6, no. 4, pp. 324-328, https://dx.doi.org/10.22161/ijaers.6.4.38

[20] Archit Dangi, Sagar Jamle, (2019), Stability Enhancement of Optimum Outriggers and Belt Truss Structural System", *International Research Journal of Engineering and Technology*, (ISSN: 2395-0072(P), 2395-0056(O)), vol. 6, no. 2, pp. 772-780.

[21] Durgesh Kumar Upadhyay, Sagar Jamle, (2020), "Stability Enhancement in Wall Belt Supported Dual Structural System using Different Grades of Concrete*", International Journal of Current Engineering and Technology*, (ISSN: 2277-4106 (O), 2347-5161(P)), vol. 10, no. 2, pp. 237-242. https://doi.org/10.14741/ijcet/v.10.2.8

[22] Mohd. Arif Lahori, Sagar Jamle, (2019), "Response of Multistory Building Located on $20^0$ and $30^0$ Sloping Ground under Seismic Loading", *International Research Journal of Engineering and Technology*, (ISSN: 2395-0072(P), 2395-0056(O)), vol. 6, no. 1, pp. 1063-1069.

[23] Romesh Malviya, Sagar Jamle, (2020), "Increasing Stability of Multistoried Building using Different Grades of Concrete in Column Member Sets at Different Locations", *International Journal of Current Engineering and Technology*, (ISSN: 2277-4106 (O), 2347-5161(P)), vol. 10, no. 2, pp. 208-213. https://doi.org/10.14741/ijcet/v.10.2.3

[24] Mohammad Bilal Rasheed, Sagar Jamle, (2020), "Conceptual Approach on Effect of Various Concrete Grade in Outrigger and Wall Belt Supported System: A Perceptional Review", International Journal of Advanced Engineering Research and Science, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 5, pp. 100-104. https://dx.doi.org/10.22161/ijaers.75.14

[25] Sagar Jamle and Roshan Patel, (2020), "Analysis and Design of Box Culvert- A Manual Approach in Structural Engineering", *LAP LAMBERT Academic Publishing, Mauritius*, ISBN: 978-620-0-78760-6.

[26] Mohit Kumar Prajapati, Sagar Jamle, (2020), "Strength irregularities in multistoried building using base isolation and damper in high Seismic zone: A theoretical Review", *International Journal of Advanced Engineering Research and Science*, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 3, pp. 235-238. https://dx.doi.org/10.22161/ijaers.73.37

[27] Gagan Yadav, Sagar Jamle, (2020), "Opening Effect of Core Type Shear Wall Used in Multistoried Structures: A Technical Approach in Structural Engineering", *International Journal of Advanced Engineering Research and Science*, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 3, pp. 344-351. https://dx.doi.org/10.22161/ijaers.73.50

[28] Durgesh Kumar Upadhyay, Sagar Jamle, (2020), "A Review on Stability Improvement with Wall Belt Supported Dual Structural System Using Different Grades of Concrete", *International Journal of Advanced Engineering Research and Science*, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 3, pp. 293-296. https://dx.doi.org/10.22161/ijaers.73.43

[29] Pankaj Kumar Dhakad, Sagar Jamle, (2020), "Base Shear Reduction by using Optimum Size of Beams with same Grade of Concrete: An Informative Review", *International Journal of Current Engineering and Technology*, (ISSN: 2277-4106 (O), 2347-5161(P)), vol. 10, no. 2, pp. 259-262. https://doi.org/10.14741/ijcet/v.10.2.12

[30] Manoj Patidar, Sagar Jamle, (2020), "Optimization of Stability of Multistoried Structure by Changing Grades of Concrete in Shear Wall Member", *Journal of Xi'an University of Architecture & Technology*, ISSN: 1006-7930, vol. 12, no. 4, pp. 2479-2497. https://doi.org/10.37896/JXAT12.04/979

[31] Manoj Patidar, Sagar Jamle, (2020), "Use of different Grades of Concrete in Shear Wall: A Comprehensive Review", International Journal of Advanced Engineering Research and Science, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 4, pp. 355-359. https://dx.doi.org/10.22161/ijaers.74.44

[32] Sagar Jamle, Nirmal Delmiya, Rahul Singh, (2020), "Efficient Use of UPV Meter: A Non Destructive Test of Concrete by Fragmentation Analysis", Journal of Xi'an University of Architecture & Technology, ISSN: 1006-7930, vol. 12, no. 4, pp. 3385-3394. https://doi.org/10.37896/JXAT12.04/1078

# The effect of underdrain box storage (UBS) as an instrument for reducingwater runoff in Mardika residential areas at Ambon City

Obednego Dominggus Nara, Paulina Limba, John Rikumahu

Lecturer Polytechnic Ambon, Jl. IrPutuhenaWailela – Ambon Indonesia

*Abstract— Land use change due to housing development can damage water catchment areas indirectly. This condition results in reduced rainwater catchment areas which cause rainwater to collect in existing drainage channels.Underdrain Box Storage is a means to collect rainwater and soak it into the ground. Rainwater that falls on the roof of the house is not flowed down into the gutter or the yard of the house, but it is flowed by using water channels into the underdrain box storage (UBS) so as to reduce the amount of runoff that occurs. Based on the results of the analysis of the combination of the correlation curve between Fr and $Q2 / (h15.g)1/2$, it is found that the regression model $Q2 / (h15.g)1/2 = 0.25757Fr2 - 0.612Fr + 0.0064$ and between Fr and $a / h12$ in the model regression $a/h12 = 0.1Fr2$ with the formula of flow through the hole with Cd the discharge coefficient of the contraction vein flow equation at the bottom of the tank is $Q = Cd. (2gh)1/2$, found the discharge coefficient (Cd) with a value of 0.85-0,96 with the regression model $Cd = 0.6473.h0.144$. The area of the hole for the underdrain storage box has 2 "(inch) as a diameter and the filling time which is planned to speed up the entry of water into the reservoir is 2 minutes due to the small diameter of the holes, so that the required number of holes is 12 with a distance between the holes is 13.5 - 14 meters. If there rain happened for 1 hour, the underdrain box system can reduce flooding / inundation by 25.47% for the 2-year plan rainfall 11.44% for the 5-year plan rainfall and 7.35% for the 10-year plan rainfall of the total water volume rain.*

*Keywords— Underdrain box storage, discharge coefficient, land use, rainfall plan.*

## I. INTRODUCTION

Changes in land use due to housing development can damage water catchment areas indirectly. This results in reduced rainwater catchment areas which cause rainwater to collect in existing drainage channels.This condition will increase the volume of surface water that enters the drainage channel and the forming of puddles or even flooding when the water is overflows in the channel. Drainage planning needs to put more attention to the drainage function which is based on the concept of environmentally development. This concept is related to the conservation of water resources by slowing down and controlling the flow of rainwater runoff, so that it can sink into the ground through infiltration structures such as Underdrain Box Storage. Underdrain Box Storage is a means to collect rainwater and soak it into the ground. Rainwater that falls on the roof of the house is not flowed

down into the gutter or the yard of the house, but it is flowed by using water channels into the underdrain box storage (UBS) so as to reduce the amount of runoff that occurs. The value of surface runoff which is greater than the absorption capacity of the soil causes stagnation of water immediately after the rain occurs. Continuous standing water due to the inability of the soil to absorb rainwater results in flooding.

From the direct observations at densely populated residential areas in Mardika at Ambon City, it is found that there are puddles and flooding when it rains. This condition can disrupt the activities of local residents or pedestrians. For this reason, it is necessary to make an adequate channel capacity complete with Underdrain Box Storage as an alternative method to deal with the amount of runoff and inundation in the area.

## II.    LITERATURE REVIEW

The Underdrain Box Storage is a drainage concept with conservation-based and the development of an existing drainage system, including infiltration well drainage, perforate precast rainwater channels, and swale drainage. The technical concept of drainage is rainwater runoff (run off) is flowed through an open channel (open channel drainage) where at the bottomthere are some holes that arranged in a series along the channel as a function to fill the long storage space. The bottom of the storage space is directly related to soil. Underdrain Box Storager construction consists of rainwater drain, vertical drain hole, and box storage. Rainwater drainage channel functions to receive surface runoff due to standing rainwater. Vertical drain hole functions to forward rainwater runoff into the storage box. Meanwhile, box storage functions as a long storage that accommodates rainwater runoff and then naturally seeps water into the soil. In this system, domestic sewage is placed separately from rainwater drains.
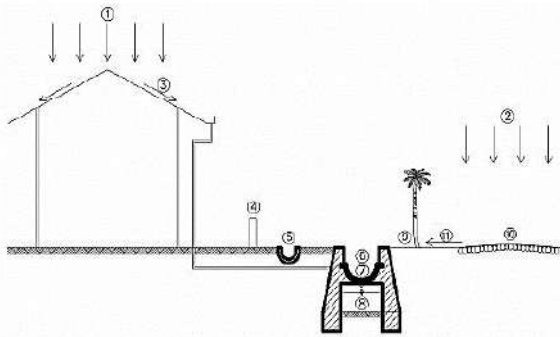


*Fig 1. Underdrain Box Storage concept*

Rainfall that falls on the roof,  drain holes,

Rainfall that falls on the land,

The flow from the roof to the gutter,

Domestic sewer,

Rain water drain,

Vertical hole

Storage space (box-storage),

Roadside,

The Road,

Runoff Surface.

### 2.1  Hidrology Analysis

In order to provide reliable results, probability analysis must begin with the provision of relevant, adequate and accudischarge data sets. Relevant means that the data must be able to provide answers to the problem.The adequacy of the data mainly refers to the length of the measurement records, but then it was discovered that the data collection stations were very scarce. The accuracy of the data refers mainly to the problem of homogeneity. The selection of data is inseparable from understanding the concepts to be applied and the location of the research in order to get maximum results.

### 2.2  Rainfall Intensity

Rainfall intensity (I) states the amount of rainfall in a certain period expressed in units of mm / hour. To calculate the rain intensity, an empirical formula can be used, including the Monobe formula, because it can be used for any time t

$$I = \frac{R}{24}\left(\frac{24}{tc}\right)^{2/3} \tag{1}$$

### 2.3  Runoff Discharge Analysis

The analysis of runoff discharge consists of land runoff, roof runoff, and runoff from the road. The analysis of land runoff uses the modified rational method formula.

Qlahan= 0,00278 .Cs. C.I.A

### 2.4 Flow Through Hole

The liquid particles which are flowing through the holes came from all directions. Because the liquid has a thickness, some particles that have a turning path will lose energy. After flowing through the hole, the water jets will contract, which is indicated by locking the flow.Maximum contraction occurs at a little section downstream of the hole, where the water jets is more or less horizontal. The size of the contraction coefficient depends on the energy level, shape and size of the hole, with the mean value being about Cc = 0.64.

A tank with cross-section A which flows the liquid through an opening of area a which lies at the base as shown in fig. 2
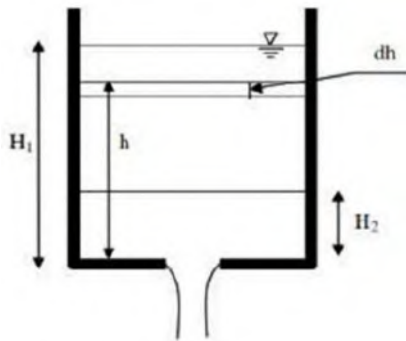
*Fig. 4.2 Flow through the Hole Which is Positioned under the Tank*

On a surface of the liquid in the tank that is at a height h above the hole, then the flow velocity at that time is:

$$V = Cv\sqrt{2gh} \tag{2}$$

And the flow discharge is:

$$Q = Cd.a\sqrt{2gh} \tag{3}$$

Cd value is 0,98, so that the discharge through the hole is:

$$Q = 0.98.a\sqrt{2gh} \tag{4}$$

2.5 Dimensional Analysis

Dimensional analysis using the Langhaar Matrix Method (Vries, 1997: 16) provides a dimensionless number, which states the flow parameters that need to be studied further in research, namely

$$\Pi_1 = \frac{Q2}{\sqrt{h1^5.g}} \quad \Pi_2 = \frac{V_1}{\sqrt{h_1.g}} \quad : \quad \Pi_3 = \frac{a_1}{h1^2} \quad : \quad \Pi_3 = \frac{a_1}{h1^2} \quad :$$

$$\Pi_4 = \frac{Q2}{\sqrt{h1^5.g}} = \frac{V_1}{\sqrt{h_1.g}} \tag{5}$$

2.6 Research Procedure

Before conducting the research with a series of discharge experiments, first of all, calibratethe measuring instrument so that the discharge that passes through each measuring instrument used can be measured correctly, precisely and accurately in accordance with the conditions of the channel and the equipment used in the study.

The research was conducted with the following activity stages:

Calibrate the discharge measuring instrument and the speed measuring device to get the accuracy of the experimental discharge operation.

Installing the research device on the flume, by determining the diameter of a certain hole (d), the distance between the holes (L), according to the specified design.

The experiment was carried out by flowing a certain discharge (Q1) with several variations in the water level (h1) and the distance between the holes (L).

By measuring the volume of water that enters the storage room (V) and the time it takes until the reservoir is full (t), it will be possible to know the amount of discharge through the filling hole.
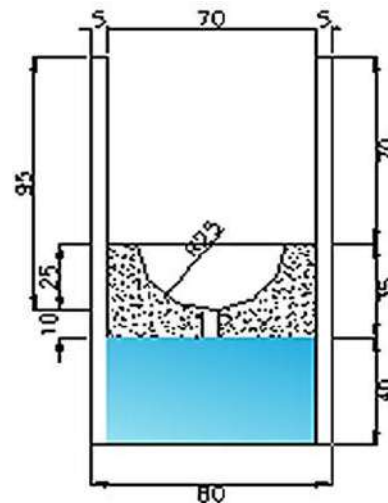


*Fig 3. The Shape of The Channel Model*

## III.     METHODOLOGY
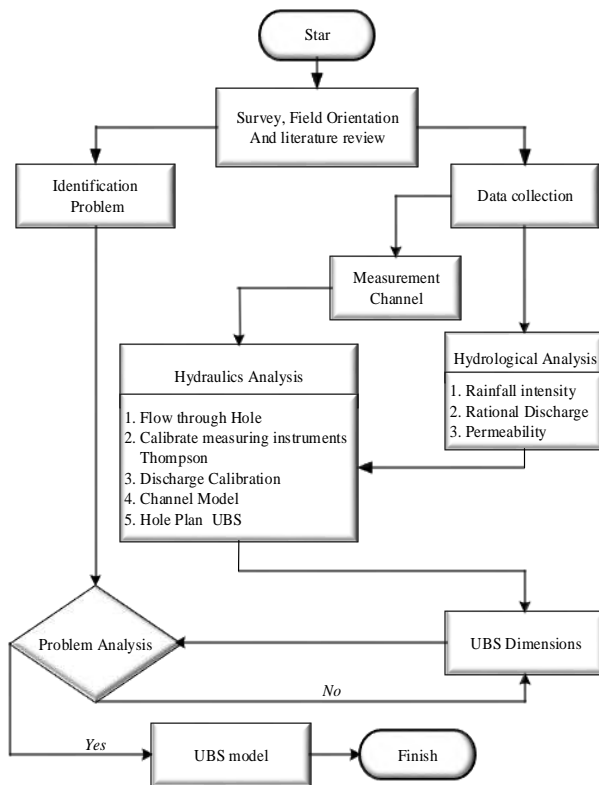


*Fig 4 Research Flow Diagram*

## IV. Discussion and Results

### 4.1 The Calculation of Rainfall Intensity (I)

To calculate the amount of rainfall intensity, an empirical formula from Mononobe is used. The amount of rainfall intensity based on the results of calculations using the Mononobe formula for a concentration time of 0.491 hours (29.44 minutes) is presented in table 1

*Table 1: Rainfall Intensity*

| Tr | Coef Runoff | Intensity | Area | Discharge |
|---|---|---|---|---|
| (Year) | C | (mm/hour) | (km2) | (m3/detik) |
| 2 |  | 74.59 |  | 0.23 |
| 5 | 0.742 | 165.99 | 1.482 | 0.51 |
| 10 |  | 258.28 |  | 0.79 |
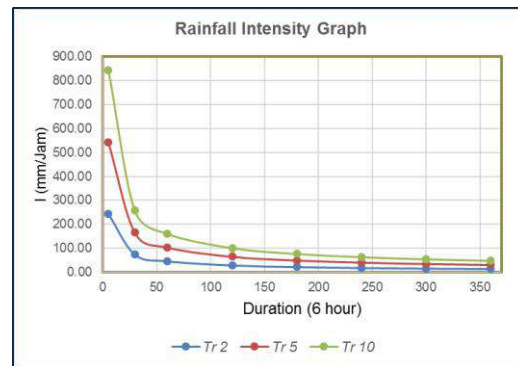


**Fig. 5 Rainfall Intensity Curve**

### 4.2 Land Use Cooficient (C)

The coefficient C is defined as the ratio between the peak runoff discharge and the rain intensity. The main factors that influence the value of C are the soil infiltration discharge, land cover crops and the intensity of rain (Arsyad, 2006). The area of the research is 14818.72 m2 consisting of buildings, concrete roads and vegetation as shown

**Table 2.** Land Use Coefficient

| Use | Area $(km^2)$ | coefficient C | Coeff C Sub watershed |
|---|---|---|---|
| Building | 1.450 | 0.75 | 1.087 |
| Asphalt or concrete roads | 0.032 | 0.8 | 0.026 |
| Vegetation | 0.025 | 0.2 | 0.005 |
| Total | **1.507** |  | **0.742** |

### 4.3 Coefficient of Cd hole

As water flow passes through the hole then it will contracts, which are indicated by the locking of the flow. Due to the influence of flow velocity in the channel, the direction of flow through the hole is not perpendicular but forms a certain angle. From the analysis, the equation for the hole discharge coefficient Cd is:

$Cd = 0.6473.h^{0.144}$

$R2 = 0.9823$

It can be seen that: The correlation coefficient = 0.9823 close to 1 means that the correlation or closeness of the relationship between the two variables is strong.
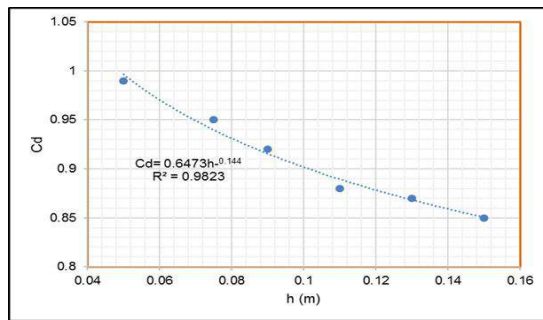
*Fig 6: The Correlation between Water Level (h) and discharge Coefficient (Cd)*

To determine whether the correlation between two or more variables is strong or not, it is indicated by the correlation coefficient (R). The stronger the relationship, the closer the correlation value is to the value of 1 or -1 and vice versa. Meanwhile, to determine the magnitude of the influence of the independent variables on the fixed variables, the coefficient of determination (R2) is used. Based on statistical analysis, the regression models that give better results are:
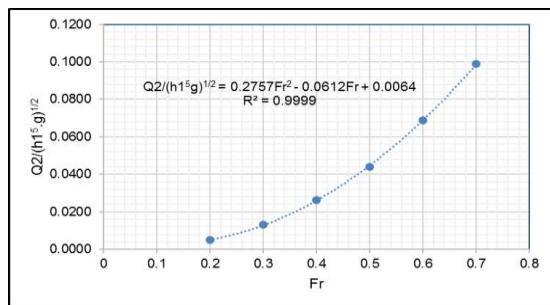


*Fig 7: The Correlation Between Fr and*
$Q_2/(h1^5.g)^{1/2}$
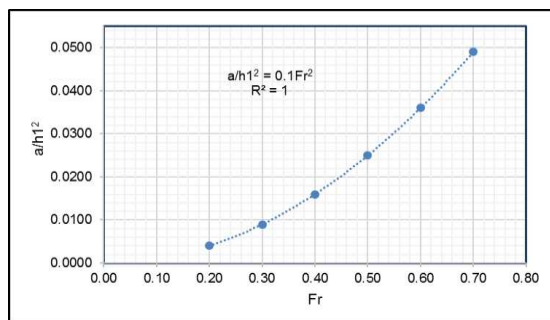


*Fig 8: The Correlation Between Fr and $a/h_1^2$*

- The correlationbetween Fr and $Q2/(h_1^5.g)^{1/2}$ (Fig7) $Q2/(h_1^5.g)^{1/2} = 0,2757Fr^2 - 0.612Fr + 0,0064$ with correlation coefficient (R) = 0,999 and determination coefficient (R2) = 0,999.
- The correkation between Fr and $a/h_1^2$ (fig8) : $a/h_1^2 = 0,1Fr^2$with coorelation coefficient (R) = 1 and determination coefficient ($R^2$) = 1

## 4.4 Diameter Planning of UBS Filling Hole lubang pengisian

The planning of the filling hole is inseparable from the dimensions of the hole used for, that it is necessary to find the diameter of the hole. Calculation of channel dimensions: Planned channel shape as sketched below. b = 0.30 m d '= 0.3 m
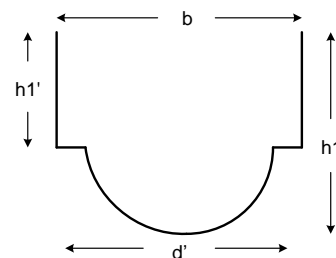


*Fig 9: Plann Channel Cross Section*

from the trials we found: h1' = 0,30 m,

so h1 = h1' + (0,5 x d') = 0,45 m

h1 = 0.45 m

by using Froude's number equation

$$Fr = \frac{v}{\sqrt{g.h}}$$
$$Fr = \frac{1.197}{\sqrt{9,81.0,45}} = 0,57$$

a) Based on Fig. 4.8 the correlation between Fr and $Q_2/(h_1^5.g)^{1/2}$ with Froude's number 0.57 so Q2 is 0.058 m$^3$/det by using the graph of Fig. 7.The correlation between water level (h) with discharge coefficient (Cd) found the area of the hole is 0.026 m$^2$or 5.1 cm diameter of the hole is 2".

b) From the results of Froude's number, the area of the UBS filling hole can be found, using the graph of the correlation between Fr and a / h2. If Fr = 0.57 then it is included in the sub-critical flow, namely the flow with low velocity because Fr <1. Next, look for the area of the UBS hole as follows:

$a/h_1{}^2 = 0,021Fr^2 + 0,005$ then the value of $a/h_1{}^2 = 0.033$ and h1 = 0.45 m is 0.011 m$^2$ orusing the hole with 2" as its diameter.

## 4.4 Box storage planning

Planned dimension of box storage is

B  = 0,6 m

h2  = 0,80 m

The volume of rainwater that can be accommodated is V = 77.28 m$^3$The time it takes to fill the reservoir is :

t = 77.28/0,0058 = 890.23 second = 1335.34 minute = 0.37 hour -To speed up the entry of water into the reservoir it is planned that the filling time is 2 minutes due to the diameter of the small holes, so that the required number of holes is 12 with a distance between the holes is 14.5 - 15 meters.

## 4.5 The calculation of  pervasive water discharge

It is known that the value of K = 10-8 Cm / s because based on the field data, the soil at this location is vertisol soil, a kind ofclay soil. After getting the K value based on the existing theory, this K value must be below in m / s so the value = 10-8 m / sec.

Duration / peak time t = 38.64/0,0041 = 931.37 second = 15.52 minute = 0.26 hour

A = B x the total length of box storag*e*

A = 0,6 x 161.41

A = 96.85$m^2$

$V_R = Q_{res} \, x \, t$

$Q_{res} = K.A$

$Q_{res} = 9.68 * 10^{-7} m^3/second$

So

$V_R = Q_{res} \, x \, t$

$V_R = 0,000862 \, m^3$

For the return period the storage plan before there is a storage box that can be seen  in table 3 below



*Fig10: Flow Volume Reduction Graph*
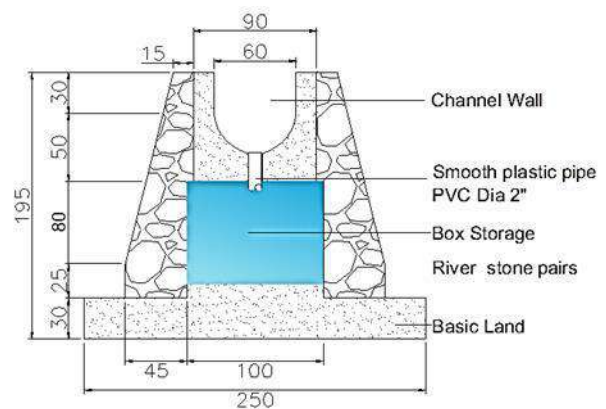


*Fig 11: Design of underdrain box storage*

# V.  CONCLUSION

Channels with flat elevations are very likely to be inundated so that a channel with several holes installed in series is required; the amount of discharge entering the hole is not the same where the downstream is getting smaller. Testing holes in the underdrain storage box can be approached in two ways

a) Combined curve of the correlation between Fr and Q2 / (h15.g) 1/2 in Figure 7 and the through-hole flow formula with Cd in Figure 6 where the equation of the discharge coefficient of the contraction vein flow equation at the bottom of the tank is Q = Cd. 2gh) 1/2, needs to be corrected so that it can be used for the calculation of the flow capacity through the catchment filling hole under the drainage channel. The experimental results are valued at 0.85-0.96 which has a theoretical difference with the average flow coefficient through the hole of 0.62

b) The correlation curve between Fr and a / h12 in Figure 8 relatively gives the same result as the approximate relationship between Fr and Q2 / (h15.g) ½

*Table 3: Percentage of UBS storage*

| Tr | Channel Volume | UBS Volume | Runoff Volume | Reduction | Runoff magnitude |
|---|---|---|---|---|---|
| (Tahun) | (m3) | (m3) | (m3) | (m3) | (%) |
| 2 | | | 304,24 | 25,47 | 74,53 |
| 5 | 41,97 | 77,48 | 677,02 | 11,44 | 88,56 |
| 10 | | | 1053,45 | 7,35 | 92,65 |

c) The area of the hole for the underdrain storage box with a diameter of 2 "and to speed up the entry of water into the reservoir, the planned filling time is 2 minutes due to the diameter of the small holes, so that the required number of holes is 12 with a distance between the holes to the holes 13.5 - 14 meters.

d) If there rain is happened for 1 hour, the underdrain box system can reduce flooding / inundation by 25.47% for the 2-year plan rainfall, 11.44% for the 5-year plan rainfall and 7.35% for the 10-year plan rainfall of the total water volume rain.

## REFERENCES

[1] Alwib. "Mengenaljenis-jenistanah, ciri-ciri, gambar, dan pemanfaatannya" 5 januari 2018.https://www.google.co.id/amp/s/alwib.net/jenisjenis-tanah/amp/

[2] Edwards, D., Hamson, M. 1989. Guide to Mathematical Modelling. London: Macmillan Education Ltd. Hasmar, H.A. 2011. DrainasiTerapan. UII Press, Yogyakarta. Kamiana, I Made. 2011. Teknik Perhitungan Debit RencanaBangunan Air. GrahaIlmu, Yogyakarta.

[3] Kuncoro,Yudo Tri, Dian Sisinggih, dan DwiPriyantoro. Mei 2013. Uji Model FisikKapasitasAliran Pada LubangPengisianTampungan Bawah SaluranDrainase (Underdrain Box Storage) Kamus Drainase.blogspot.co.id. 2015

[4] Pranoto, EkoSuryo. 2013. Upayapenanggulangangenangan dan peningkatanresapan air menggunakan underdrain box storage di kawasankampusuniversitasbrawijaya.

[5] Obednego Dominggus Nara, Paulina Limba, John Rikumahu 2019 Application of the Porous water Receipt well to Reduce the Puddle in Passo Village, Ambon City, International Journal of Advanced Engineering Research and Science (IJAERS)

[6] Sunjoto. 1998. SistemDrainase Air Hujan Yang BerwawasanLingkungan.

[7] Suripin. 2004. SistemDrainasePerkotaan yang Berkelanjutan. Yogyakarta : Andi.

[8] Soedarmo,GDjatmiko dan S. J Edy Purnomo. 1993. Mekanika Tanah I. Kanisius, Malang Triatmojo,B. 1993. Hidraulika II. Beta offset, Yogyakarta.

[9] Triatmodjo, Bambang. 2008. HidrologiTerapan. Beta Offset, Yogyakarta.

[10] Wordpress. "bebasbanjir 2015. DAS lestari, sungaijernih" 20 April 2017 https://bebasbanjir2025.wordpress.com/teknologipengendalia n-anjir/sumurresapan.

[11] Yantoro, Pridkk. Mei 2013. Penerapan UB – Drainase (Underdrain Box Storage) untukMereduksiGenangan dan Meningkatkan Resapan Air di Kampus Universitas Brawijaya. Malang

# Anchoring elements for fiber optic sensor cables: part of a system for monitoring slopes surface movements

Marcelo Buras[1], Luiz Alkimin de Lacerda[2], Nayhara Arielly Pinto Paulino[3], Renato Seixas da Rocha[4], Rodrigo Moraes da Silveira[5]

[1,2,3]Lactec – Curitiba, Parana, Brazil
[4]Petrobras, CENPES – Fundão, Rio de Janeiro, Brazil
[5]Lactec, PUCPR – Curitiba, Parana, Brazil

*Abstract* **—** *The fiber optic industry had a significant development from the late 80's. Besides communication, this technology is also being used for measuring a monitoring deformation, displacement, acceleration, pressure, temperature and chemical properties among others (MORIKAWA, 2004). Among the technological advantages of the use of fiber optic sensors, the most notable are: (i) sensing the possibility of several signals over a single optical fiber (multiplexing data), (ii) ease of reading of the signals (good value signal versus noise), (iii) measurements over long distances (remote sensing), (iv) immunity to electromagnetic fields, (v) absence of spark, and (vi) low weight and low material reactivity. The use of fiber optics as a tool for different kinds of geotechnical monitoring can become a highly attractive and cost effective when compared to conventional instruments such as piezometers, inclinometers, among others. A single fiber optic cable may cover a larger monitoring area compared to conventional instrumentation, and the possibility of monitoring more than one physical quantity with the same fiber optic cable. This paper covers all steps undertaken to define the size of one type of cable Anchoring Element (AE) for monitoring soil movement in natural hillslopes. To fulfill this objective laboratory tests were carried out in LACTEC, Curitiba-PR, and results and conclusions are shown in this paper.*

*Keywords— DTSS, Fiber Optic, Brillouin, BOTDR, Geotechnical Monitoring, Mass Movements, Laboratory Experiment.*

## I. INTRODUCTION

The fiber optic environmental robustness makes it possible to monitor large civil structures at low cost (KLUTH et at., 2014) and this technology, due to its characteristics and advantages, can be used in different areas to monitor different quantities.

According to Zeni et al. (2015), the main requirements for the implementation of geotechnical instrumentation in areas susceptible to soil movements are cost and reliability of the equipment, continuous monitoring and low probability of error. Taking this into account and the fiber optic distributed detection ability, such technology can be applied in the geotechnical instrumentation, making monitoring more attractive and cost effective when compared to the conventional instrumentation now used.

In the case of this research, the variations in the strain of an anchored fiber optic cable caused by laboratory-induced strains were evaluated, which helps in monitoring and understanding possible soil movements in natural hillslopes, besides implying a new geotechnical instrumentation.

## II. DTSS

As commented by Goltz and Aufleger (2009) "the measuring principle of distributed fiber optic strain sensing is based on the fact that after sending a light pulse by a powerful light source (laser) into a glass fiber, a very small proportion of this light is backscattered at each point along the fiber". The scattered light undergoes a shift in frequency, called Brillouin frequency shift, which depends

on the strain and temperature variations. Brillouin is an inelastic phenomenon, result of the interaction of incident light with fluctuations in the properties of the medium that are propagated in the material as acoustic waves or acoustic phonons (FEBBO, 2016). Fig. 1 illustrates the scattered light spectrum.
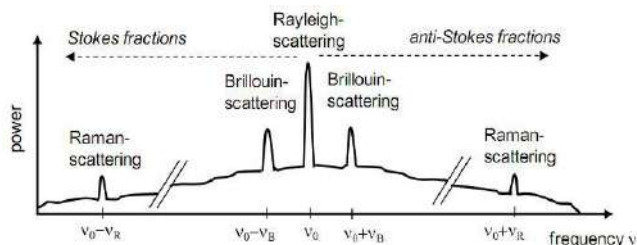


*Fig. 1: Scattered light spectrum*

The analyzed section of the optic fiber is determined with the commercially available Brillouin Optical Time Domain Reflectometer (BOTDR) system. With the knowledge of the light speed in the material it is possible to identify the corresponding Brillouin spectrum of each section. The reading unit used in the laboratory tests, called Distributed Temperature and Strain Sensor (DTSS), records both Stokes and anti-Stokes light portions of the Brillouin spectrum, shift and power. Analysis of this data allows the strain and temperature evaluation along the fiber or cable.

Other important characteristics of the available equipment are that the strain measurement corresponds to the average strain within 1 m spatial resolution, up to 24 km of optical fibers can be monitored, strain resolution is $\pm 20$ µm at 1 m intervals and a temperature resolution of $\pm 1$ °C at 1 m intervals.

The type of cable or fiber must be informed to the system, including characteristics such as those listed in TABLE 1, which define the cable used in this work.

*Table 1: Optic cable parameters recorded in the DTSS system*

| Coefficient | Description | Value |
|---|---|---|
| $Cv\varepsilon$ | Brillouin shift coefficient with deformation | 0,0481 MHz / µε |
| $CvT$ | Brillouin shift coefficient with temperature | 2,488 MHz / K |
| $Cp\varepsilon$ | Brillouin power change coefficient with deformation | -1,4 10-3% / µε |
| $CpT$ | Brillouin power change coefficient with temperature | 0,417% / K |

The cable strength is limited to 3 kN guaranteed by the Kevlar material in its core. The external diameter is 5 mm and within the cable there are two singlemode and two multimode fibers (Fig. 2).
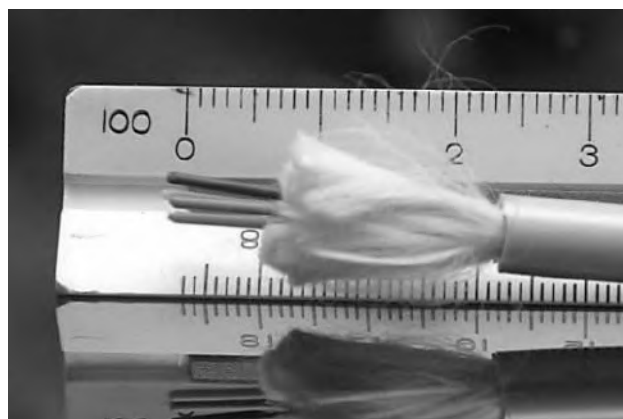


*Fig. 2: Fiber optic cable*

## III. GEOTECHNICAL MONITORING THROUGH DTSS

In the recent years, the DTSS system has become a widely used technology. However, geotechnical applications of this technology are not well established yet. It considers that the combination of the optical fiber and the soil results in difficulties. Additionally, because of anisotropy and heterogeneity of soils and rocks, added to the complexity of local hydrological conditions, a series of uncertainties about soil deformation arise (ZHANG et al., 2014) and a deeper understanding of the geomechanical principles is necessary in order to achieve meaningful results when this technology is used.

Field measurements suggest that soil movements commonly exceed tolerable limits, causing the soil to suffer shear resistance reduction, which can lead to geomorphological catastrophes, causing hundreds of deaths and severe damage to urban infrastructure (GUERRA et al., 2017). An application of the DTSS method for detecting soil movements is to install fiber optic cables in excavated trenches with depth of approximately 15 cm. To ensure a good transmission of the movements for the cable, special anchors were installed along the optic fiber cables. They also used DTSS technology to detect shear surfaces using a direct

installation in inclinometers casing (HOEPFFNER et al., 2008).

A novel monitoring technique which can be used for monitoring of hillslope movements with DTSS sensing. The limits and applicability of this monitoring technique was investigated for the evaluation of soil movement in natural hillslopes. To fulfill this objective laboratory tests were carried out in LACTEC, Curitiba-PR. The presented experiments and results showed on their work indicate the potentiality of this novel monitoring technique for evaluating soil mass movement conditions (LACERDA et al., 2011).

## IV.  LABORATORY EXPERIMENT

The laboratory tests were carried out at LACTEC/LAME – Laboratory of Materials and Structures.

### 4.1 Materials for the Pure Axial Strain Test

The initial testing facility setup is illustrated in Fig. 3, and it consists of a U-shape metallic structure with 5.60 m and special edges (1 and 2) for stretching cables and/or fibers (Fig. 4) and clamping (Fig. 5), respectively.



*Fig. 3: U-shape metallic structure*



*Fig. 4: Stretching cables*
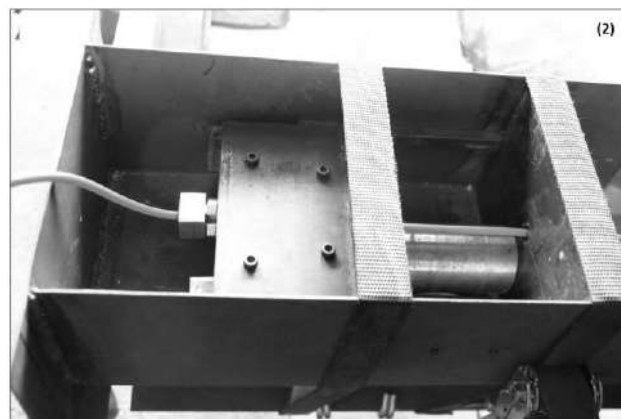


*Fig. 5: U-shape clamping*

The Fig. 6 shows the U-shape cross section with the fiber optic cable position on the tests carried out.
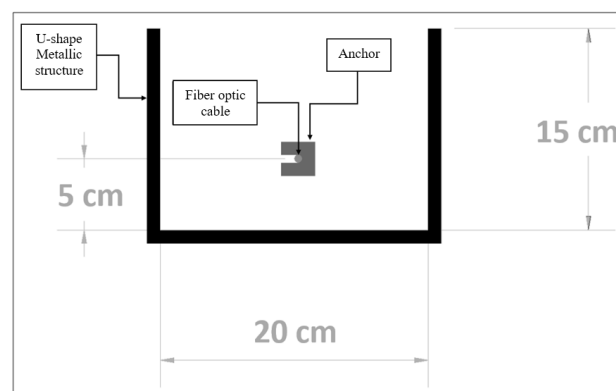


*Fig. 6: Cross section U-shape metallic structure*

### 4.2 Anchoring Elements for the cable

Aiming to detect mass movements, a fiber optic sensor cable installed in the subsurface must be well connected to the surrounding medium. Regarding this, tests were performed using elements which hold the fiber optic cable, named Anchoring Elements (AE) of the cable. The geometry of the AE had been largely studied until the idealization of the most appropriate shape.

Previous research conducted by the Institute for Technology Development (LACTEC) concluded that the simple settlement of the fiber optic cable directly on the ground would allow movement detection. However, the use of AE provides greater sensitivity for movement detection.

The AE are cubic metal parts that hold the fiber optic cable that can be manually installed in any position of the cable, without using any tools. In Fig. 7 it is possible to see an illustration of the AE.
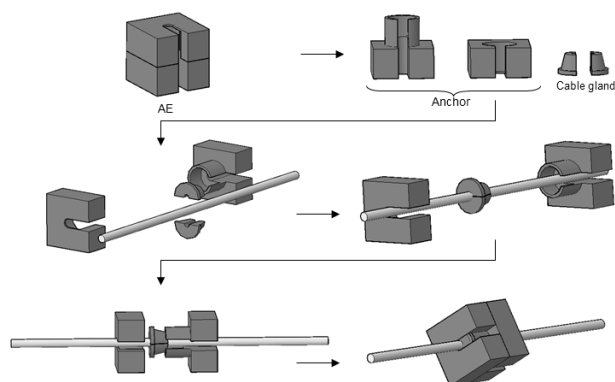
*Fig. 7: Anchoring Elements applied to the cable*

## 4.3 Sandy Soil

The soil selected for the experiments with the U-shape metallic structure refers to a sand with uniform particle size distribution with grain diameters between 0.50 mm and 0.90 mm. The procedures for testing the geotechnical characterization of the sand (grain density, particle size analysis and voids maximum and minimum) were executed in accordance with Brazilian standards ABNT NBR 6508:1984, ABNT NBR 12004:1990 and ABNT NBR 12051:1991. The results are shown in TABLE 2. All tests were conducted with dry sand.

*Table 2: Basic soil data*

| Property | Result |
|---|---|
| Specific gravity ($\gamma s$) | 26 kN/m³ |
| Maximum void ratio ($e_{max}$) | 0,80 |
| Minimum void ratio ($e_{min}$) | 0,58 |

## 4.4 Pure Axial Strain Test

The pure axial strain tests were performed in the U-shape metallic structure. Initially, the structure was filled with a 5 cm thickness dry sandy soil. Then the cable was placed, and further sand was put till the top. To prepare the tests, it was decided to use the sand close to minimum void ratio (0.58). The procedures for testing were executed in accordance with ASTM D 4253/1983 (PRESTI et al., 1992). The cable was pulled to a strain close of 1500 microstrains. Fig. 8 illustrates the test being assembled.
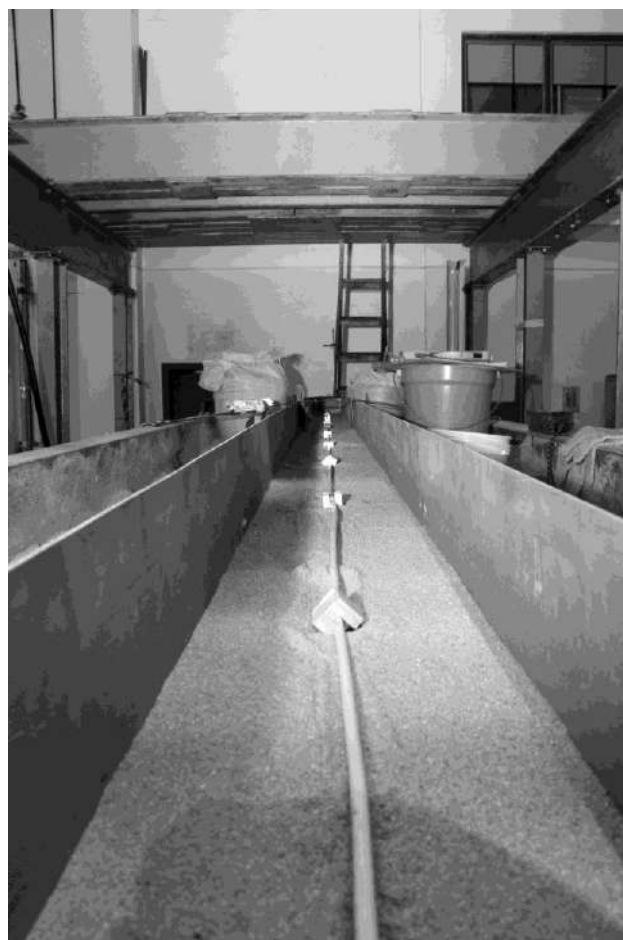


*Fig. 8: Assembling of the fiber optic and the anchoring*

Four AE spacing conditions (models) were evaluated as shown in Fig. 9. In the first model, no AE were used. In the second model, the AE was installed at 2.00 m spacing distances. In the third one, the spacing between AE was set to 1.00 m and in the last model, the spacing between AE was set to 0.50 m. The DTSS unit was configured to record data at a regular 2 minutes interval.
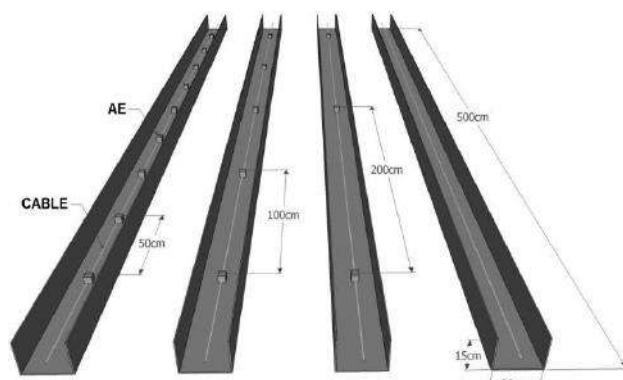


*Fig. 9: Test configuration*

## V. RESULTS AND DISCUSSION

In Fig. 10 it is possible to see the forces that work on cable-soil interaction. The results of the pullout tests are interpreted by analyzing the interaction between the fiber optic cable and soil and checking the level of maximum strain recorded in the DTSS unit. Fig. 11 shows a graph comparing results of the 4 tests.



Legend:
(1) Direction of movement;    (3) Friction Cable-soil;
(2) Fiber optic cable;    (4) AE.
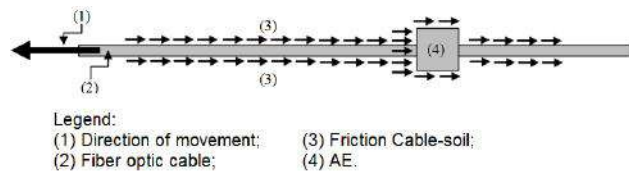
*Fig. 10: Forces working on cable-soil*
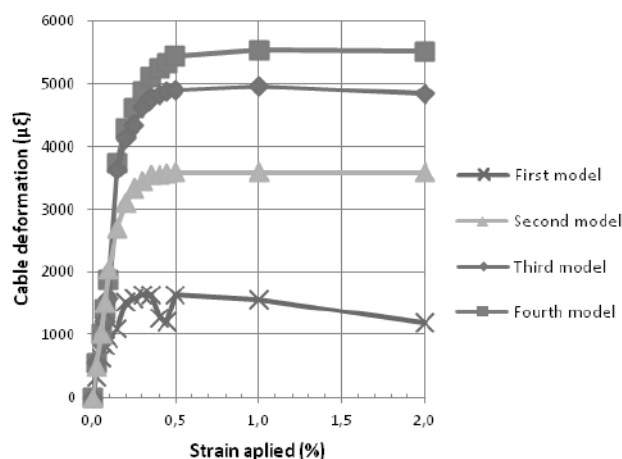


*Fig. 11: Comparison between tests*

The vertical axis shows the strain recorded in the DTSS unit and the horizontal axis shows the strains imposed on the system. Analyzing the first model (no AE) it is possible to note that the maximum strain recorded was near 1600 microstrains when 0.2% strain was imposed to the system. After this magnitude, the cable-soil bonding condition is changed (rupture) and further pulling does not imply in greater cable strain.

The installation of AE on the fiber optic cable increased the sensitivity for detecting the pullout movement. For the 2.0 m AE spacing (second model) the maximum strain recorded was approximately 3500 microstrains, yielding a gain of more than 100% in the strain signals. When AE were installed at smaller spacing conditions (third and fourth models) the recorded signals were even greater, making the system more and more sensitive to smaller movements.

## VI. CONCLUSION

The results presented showed that the AE is efficient. It makes the DTSS monitoring system more sensitive to smaller mass movements. The AE amplify the recorded strain signals. However, a careful evaluation of AE spacing must be carried out for field installations since the fiber optic cables cannot usually strain beyond 15000 microstrains.

It is noted that the presented results are inherent to the applied testing conditions, including soil type. Further similar tests are being carried out with other soil types.

## REFERENCES

[1] Morikawa, S. R. K. (2004). Acelerômetro triaxial a redes de Bragg [Bragg triaxial accelerometer] (Doctoral dissertation, Tese de doutorado em Engenharia Mecânica. PUC-Rio. Brasil).

[2] Kluth, R., Watley, D., Farhadiroushan, M., Park, D. S., Lee, S. U., Kim, J. Y., & Kim, Y. S. (2006, April). Case studies on distributed temperature and strain sensing (DTSS) by using optic fibre. In Proceedings of the International Conference on Condition Monitoring and Diagnosis, Changwon, Korea (pp. 2-5).

[3] Zeni, L., Picarelli, L., Avolio, B., Coscetta, A., Papa, R., Zeni, G., ... & Minardo, A. (2015). Brillouin optical time-domain analysis for geotechnical monitoring. Journal of Rock Mechanics and Geotechnical Engineering, 7(4), 458-462.

[4] Goltz, M. and Aufleger, M., 2009. Distributed Fibre Optics Temperature Measurements Using the Heat-Up Method – Laboratory Tests to Determine Progression of The Wet Front. Report presented at a meeting held in December 2009, between the University of Innsbruck and LACTEC.

[5] Febbo, M. D. (2017). Método de interrogação de fibra óptica para detecção de intrusão [Fiber optic interrogation method for intrusion detection] (Doctoral dissertation, Universidade de São Paulo).

[6] Zhang, C. C., Zhu, H. H., Shi, B., & She, J. K. (2014). Interfacial characterization of soil-embedded optical fiber for ground deformation measurement. smart Materials and structures, 23(9), 095022.

[7] Guerra, A. J. T., Fullen, M. A., Jorge, M. D. C. O., Bezerra, J. F. R., & Shokr, M. S. (2017). Slope processes, mass movement and soil erosion: A review. Pedosphere, 27(1), 27-41.

[8]   Hoepffner, R., Singer, J., Thuro, K., & Aufleger, M. (2008). Development of an integral system for dam and landslide monitoring based on distributed fibre optic technology. In Ensuring reservoir safety into the future: Proceedings of the 15th Conference of the British Dam Society at the University of Warwick from 10–13 September 2008 (pp. 177-189). Thomas Telford Publishing.

[9]   Lacerda, L. A. de, Rocha, R. P. O., Kapeller, G., Silveira, R. M. da, Rocha, R. and Amaral, C. S., 2011. Distributed Fiber Optic Temperature and Strain Sensors for Monitor Soil Movement in Natural Hillslopes. In: Rio Pipeline.

[10]  ABNT, N. (1984). Grãos de solos que passam na peneira de 4,8 mm - Determinação da massa específica [Soil grains passing through the 4.8 mm sieve – Determination of the bulk specific gravity].

[11]  ABNT, N. (1990). 12004. Determinação do índice de vazios máximos de solos não coesivos – Método de ensaio [Soil - Determination of the maximum index void ratio of cohesionless soils – Method of test].

[12]  ABNT, N. (1991). 12051. Determinação do índice de vazios mínimos de solos não coesivos [Soil - Determination of minimum index void ratio of cohesionless soils – Method of test].

[13]  Presti, D. L., Pedroni, S., & Crippa, V. (1992). Maximum dry density of cohesionless soils by pluviation and by ASTM D 4253-83: A comparative study. Geotechnical Testing Journal, 15(2), 180-189.

# Epidemiological and toxicological profile of a community exposed environmentally to mercury in the amazon

Antônio Marcos Mota Miranda[1*], Iracina Maura de Jesus[1], Elisabeth Conceição de Oliveira Santos[1], Marcelo de Oliveira Lima[1], Kleber Raimundo Freitas Faial[1], Marluce Matos de Moraes[1], Renato Lopes Fernandes de Medeiros[1], Fernanda do Espírito Santo Sagica[1], Hirokatsu Akagi[2], Carmem Ildes Rodrigues Fróes Asmus[3]

[1]Instituto Evandro Chagas (IEC). Ananindeua, Pará, Brazil,
[2]Laboratório Internacional de Mercúrio (LIM), Minamata, Japão.
[3]Universidade Federal do Rio de Janeiro /Programa em Saúde Coletiva, Rio de Janeiro, Brasil.
[*]Corresponding Author

*Abstract— Objective: to know the epidemiology and the toxicological profile in relation to the total Hg in the sample of the population of Sena Madureira, in the State of Acre, northern region of Brazil. Method: Cross-sectional, population-based, descriptive study with a quantitative approach. Result: The sample consisted of 302 484 people from a community in the municipality of Sena Madureira, state of Acre, Brazil, located southwest of the northern region of Pan-Amazon. This study found that total blood and hair Hg levels were above the limits considered safe by the World Health Organization. The presence of total Hg in the blood and in the capillary matrix shows that the population of the municipality of Sena Madureira is environmentally exposed to metal. This exposure occurs through the existence of the biogeochemical cycle with the participation of fish consumption and the anthropic activity of artisanal gold mining in the bordering region of the state of Acre. Conclusion: The high content of total Hg in the biological matrices of the studied population indicates the physiological dynamics of the metal in the organism. The distribution of mercury in both sexes and in different age groups, suggests that there is a significant risk to the health of individuals, especially women and children.*

*Keywords— Metals Heavy, Mercury, epidemiology, Toxicological Phenomena.*

## I. INTRODUCTION

The Amazon Basin is the most extensive hydrographic network on the planet, with 25,000 kilometers of navigable rivers. Its area corresponds to 6.1 million square kilometers distributed in five countries (Brazil, Bolivia, Peru, Colombia and Venezuela) that form the Pan-Amazon region[1].

In the Triple Border (Brazil, Bolivia and Peru), since the 1970s there has been an intensification of gold mining, mainly in the Department of Madre de Dios, in Peru[2]. The use of a large amount of mercury (Hg) for its extraction, contaminated the aquatic environment, contributing to the exposure of riverside communities, through the consumption of fish with high levels of methylmercury (MeHg) in the region[3].

In continuity, in the Amazon context, it is estimated that there are about 300 thousand gold miners and about 3 thousand tons of Hg were dumped in the rivers of the region[4]. In Madre de Dios, Peru, illegal gold activity produces about 18,000 kg per year of Hg, with an average of 2.8 kg for each kilogram of gold produced[5].

The Hg is a natural element that can be distributed in the environment by natural processes and human activities, whose high persistence in different environmental compartments produces toxicity for several biological species, including humans[6]. Therefore, it is highlighted that human activities are related to the burning of fossil

fuels, industrial waste, mineral activity, erosion process and leaching of particles that promote soil exposure[7].

In addition, artisanal gold mining uses amalgam of mercury to extract this ore, which represents a significant source of exposure for workers and nearby populations[8]. This artisanal activity is responsible for 37% of anthropogenic mercury, whose persistence of metallic vapor in the atmosphere and its precipitation in different aquatic compartments is part of the biogeochemical cycle of the place[9], and this process may explain the presence of the metal in places without industry and mining activities.

Os efeitos tóxicos do mercúrio dependem da espécie química do metal e do tempo de exposição, cujos efeitos adversos variam em diferentes grupos populacionais[10]. Destaque para o MeHg, que, ao entrar no corpo, produz graves alterações nos órgãos e tecidos humanos. Além disso, esse metal pode cruzar a barreira hematoencefálica e atingir gravemente o sistema nervoso central. Em mulheres grávidas, pode cruzar a barreira placentária e prejudicar gravemente o desenvolvimento fetal[11].

Hg concentrations in blood and hair have been used as biomarkers to assess human exposure[12]. Total Hg in human hair is an efficient indicator of long-term exposure to MeHg, while blood establishes an early relationship with metal[13].

In this study, epidemiological and toxicological indicators were used to assess environmental exposure to total Hg in the population sample of the municipality of a region of the Pan Amazon, free from this economic activity. From this, the objective was to know the epidemiology and the toxicological profile in relation to the total Hg in the sample of the population of Sena Madureira, in the State of Acre, northern region of Brazil.

## II. METHOD

Cross-sectional, population-based, descriptive study with a quantitative approach conducted with 484 people from a community in the municipality of Sena Madureira, state of Acre, Brazil, located southwest of the northern region of Pan-Amazon.

This survey included people who lived in the city in question for at least 12 months. For the selection of individuals, a spatial distribution of the conglomerate type was performed, that is, a street was drawn in the neighborhood, totaling 21 neighborhoods. In each street 5 families were visited until reaching 24 individuals, regardless of age.

From then on, the Informed Consent Term was made available and questionnaires with socioeconomic and epidemiological information and eating habits of the interviewees were applied. Blood and hair samples were collected from the participants during the home visit, through biosafety procedures with biological material. In addition, this research was approved by the Human Research Ethics Committee of the Evandro Chagas Institute (Reference nº 141.519, CAAE: 10114212.1.0000.0019/2012).

Venous blood samples were collected in 10 mL of 10% EDTA tubes and stored and transported at 40°C to the IEC toxicology laboratory. Hair samples were collected from the occipital region and stored in white paper envelopes and kept at room temperature until analysis. The determinations of total Hg were made from the opening with nitric/perchloric acid 1:1 and sulfuric acid, whose calibration curve for blood and hair showed excellent linearity (0 -100 µg/L) with detection limit 0.1 µg/L and 1.0 µg/kg, respectively.

The certified reference for Seronorm™ Trace Elements L-1 whole blood, certified concentration of 1.97 µg/L Hg and standard deviation of 0.15 µg/L, while for hair the IAEA 085 certified reference which has a certified concentration of 23 , 2 µg/g Hg, reproducibility was 90.35% with a standard deviation of 0.25 µg/g. Analyzed by Atomic Absorption Spectrometry with the Cold Steam Generation System (CV-AAS) (Mercury Analyzer, Hg-201, Sanso Inc), according to the method proposed by Akagi[14].

Descriptive statistical analyzes and correlation studies were performed with Microsoft Excel 10 and MINITAB 17. The distribution of data by matrices considered the 95% confidence interval. For univariate and bivariate continuous analysis for two or more groups, parametric and nonparametric tests were used, when indicated. The Mann-Whitney test was used to analyze categorical variables. In Spearman's correlation analysis, generalized linear models were used when considering quantitative variables[15].

## III. RESULTS

The sample consisted of 484 people of both sexes, 61.2% women and 38.8% men. Most patients were between 18 and 39 years old, most of these individuals (52.69%) reported residing at the study site between 10 and 29 years old. In addition, it was observed that the consumption of fish represented a frequent eating habit that occurred twice a month for 69.63% of the interviewees, as shown in Table 1.

*Table 1 – Description of the researched population in relation to sex, age in years, residence time and fish consumption, Sena Madureira, AC. 2018.*

| All participants | n=484 | % | Man (n=188) | | Woman (n=296) | |
|---|---|---|---|---|---|---|
| | | | n | % | n | % |
| Age (years) | | | | | | |
| 0-09 | 33 | 6.82 | 16 | 8.51 | 17 | 5.74 |
| 10-17 | 95 | 19.63 | 45 | 23.94 | 50 | 16.89 |
| 18-39 | 193 | 39.88 | 67 | 35.64 | 126 | 42.57 |
| 40-59 | 92 | 19.01 | 27 | 14.36 | 65 | 21.96 |
| $\geq 60$ | 71 | 14.67 | 33 | 17.55 | 38 | 12.84 |
| Residence time | | | | | | |
| 0-9 | 91 | 18.80 | 38 | 20.21 | 53 | 17.91 |
| 10-29 | 255 | 52.69 | 100 | 53.19 | 155 | 52.36 |
| 30-59 | 122 | 25.21 | 44 | 23.40 | 78 | 26.35 |
| $\geq 60$ | 16 | 3.31 | 6 | 3.19 | 10 | 3.38 |
| Fish consumption | | | | | | |
| 0-2 times/week | 337 | 69.63 | 122 | 64.89 | 215 | 72.64 |
| 3-5 times/week | 132 | 27.27 | 60 | 31.91 | 72 | 24.32 |
| > 5 times/week | 15 | 3.10 | 6 | 3.19 | 9 | 3.04 |

As for sex, age group, residence time and fish consumption with their average levels of total Hg in the blood and hair, it is observed that the average metal in the blood was 11.92 (0.00-176, 95) µg.L-1 and hair 3.65 (0.00-55.40) µg.g-1. It is noteworthy that the Spearman Correlation (r = 0.8256; t = 32.1215; p <0.0001) was positive among the biological matrices investigated. In addition, the mean total Hg, in both sexes and in biological matrices, was above normal limits for the unexposed population. Another important finding highlights that an age group above 60 years has greater exposure to metal in the blood and hair.

The residence time above 30 years and the significant consumption of fish seem to influence the increase in the average of total Hg among the individuals surveyed. These averages practically double with the increase in the values of the studied variables. In addition, in this study, the shorter residence time in the region showed levels considered high for the dynamics of exposure to mercury in the region, that is, the longer the residence time, the greater the exposure. This fact can be justified by the marked migration in the Amazon region, as shown in Table 2.

*Table 2 – Association of mean total Hg in blood and without hair and its relationship with sex, age group, residence time and fish consumption, Sena Madureira, AC, 2018.*

| All Participants | Hg in Blood Mean (µg.L$^{-1}$) | Hg in Hair Mean (µg.g$^{-1}$) |
|---|---|---|
| Total | 11.92 (0.001-176,95) | 3.65(0.001-55.40) |
| Sex | | |
| Woman | 10.85(0.00-142.62) | 3.47(0.04 - 45.08) |
| Man | 13.62(0.00 -176.95) | 3.94(0.00 - 55.40) |

| Age (years) | | |
|---|---|---|
| 0-11 | 9.2(0.00 -52.74) | 2.8(0.06-17.51) |
| 12-19 | 9.35(0.00-176.90) | 2.75(0.05-55.40) |
| 20-59 | 13.4(0.00-130.27) | 4.0(0.07-42.43) |
| ≥60 | 13.75 (0.00-132.57) | 4.2(0.00-22.44) |
| Residence time | | |
| 0-9 | 8.75(0.00-176.96) | 2.79(0.06-55.40) |
| 10-29 | 4.69(0.00-145.18) | 1.65(0.00-36.21) |
| 30-59 | 9.20(0.72-103.34) | 3.02(0.10-26.76) |
| ≥60 | 7.39(0.66-44.11) | 1.89(0.18-13.15) |
| Fish Consumption | | |
| 0-2 times/week | 7.43(0.00-142.62) | 2.69(0.00-45.08) |
| 3-5 times/week | 14.68(0.00-176.96) | 4.77(0.00-55.40) |
| > 5 times/week | 14.01(1.21-35.80) | 4.4(0.48-9.14) |

Regarding the distribution of total Hg according to sex and age group, it was observed that 296 women had an average total Hg of 10,851 (0.001-142,622) μg.L-1 in the blood. Among men (n = 188), the total mean Hg in the blood was 13.62 (0.001-176.956) μg.L-1 in the blood and 3,938 (0.001-55,400) μg.g-1 in the hair. The Mann-Whitney test, for the means in the biological matrices of both sexes, did not reveal a statistically significant difference for the results found in blood (Z = 0.36, p = 0.36) and in hair (Z = 1, 03, p = 0.15).

In addition, the highest mean of total Hg coincided in the age group of 20 to 59 years in both sexes. In particular, the level of metal in women indicates long-term exposure in the municipality of Sena Madureira, in the state of Acre, as shown in Table 3.

*Table 3 – Average total Hg according to sex and age group. Sena Madureira, AC. 2016.*

| Age (Years) | N | Woman | | | Man | | |
|---|---|---|---|---|---|---|---|
| | | N | $\bar{X}$ Blood | $\bar{X}$ Hair | N | $\bar{X}$ Blood | $\bar{X}$ Hair |
| 0 a 11 | 52 | 30 | 6.40 | 2.00 | 22 | 12.00 | 3.60 |
| 12 a 19 | 88 | 45 | 9.70 | 2.60 | 43 | 9.00 | 2.90 |
| 20 a 59 | 273 | 183 | 12.41 | 4.10 | 90 | 14.40 | 3.90 |
| ≥ 60 | 71 | 38 | 8.54 | 2.70 | 33 | 19.00 | 5.70 |
| Total | 484 | 296 | 10.85 | 3.47 | 188 | 13.62 | 3.94 |

In relation to the average levels of total Hg by gender and age groups, it is observed that the majority of participants were in the age group of 20 to 59 years, as well as the highest levels of metal in the blood and hair.

The average total Hg by age group is compared with the normal limit values in both blood and hair. Spearman's correlation for age and total mean Hg concentration: blood (r = 0.2337; t = 5.2766) and hair (r = 0.2969; t = 6.1340)

does not show a significant correlation between these variables In both biological matrices, as shown in the

figures below.
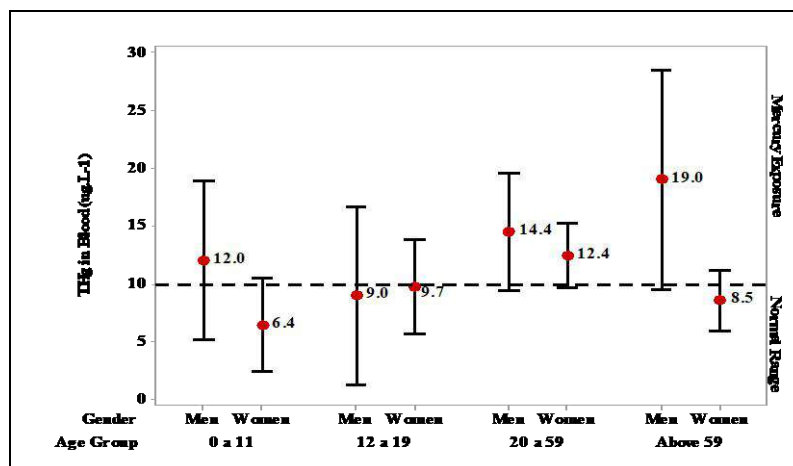


*Fig.1: Average total Hg in the blood by gender and age group in years. Sena Madureira, AC. 2018.*
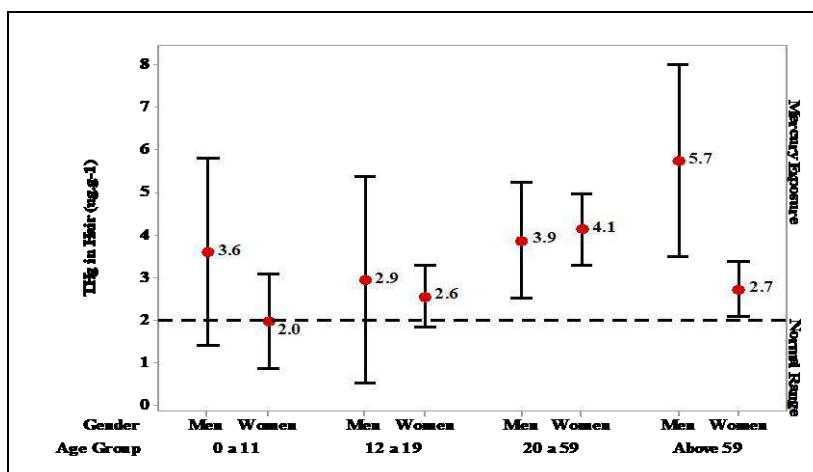


*Fig.2: Average total Hg in hair by gender and age group in years. Sena Madureira, AC. 2018.*

The average residence time was 22 years and 77% were informal workers. The eating habits of 84.9% of the population indicated eating up to 4 meals a day, of that total, 94% said they consume fish in their diet. Therefore, the fish-based diet represented approximately 17.5 meals / month in the region of the municipality surveyed.

Regarding the community's perception of mercury in the Amazon environment, only 24.9% of participants recognized the metal as a risk to human health in the region. The source of information most used by the population is radio and television with reports on gold mining, thus, the participants associate only gold mining with human contamination by Hg.

## IV.    DISCUSSION

The World Health Organization (WHO) considers the range of 5 to 10 µg.L-1 as a normal reference for total Hg in the blood, while the Biological Tolerance Limit (BTL) is 30 µg.L-1. In hair, this range is between 1 and 2 µg.g-1 and the BTL is 6 µg.g-1. Hair has been shown to be an excellent bioindicator of prolonged exposure to metal, while in the blood it indicates a recent presence[16].

From this, this research showed that the average levels of total Hg in the blood and hair of the researched population are higher than the safety limits established by the WHO, that is, this evidence indicates that the researched population is exposed to Hg environmentally in the long term. These results corroborate other studies that indicate a significant circulation of Hg in the environment and in the populations that live in the Amazon region[17].

The total blood and hair Hg levels in the study population indicate a positive correlation between these biological matrices. Hair is widely used to assess exposure to metals and bioaccumulation in the population[13]. The excellent correlation of total Hg in blood and hair is indicative of the flow and accumulation in the body of the individuals in this study. The concentrations of metals in these matrices are used as biomarkers to assess human exposure, whose origin is environmental[3].

The level of total Hg in the hair is associated with the presence of MeHg in the fish-based diet in individuals[18]. The averages of total Hg in blood and hair were increasing in relation to age group, residence time and fish consumption in the individuals investigated. Except among children with shorter residence times, probably due to the intense migration of individuals from places heavily impacted by metal in the region.

The presence of natural and anthropic factors, related to the Hg cycle in the Amazon, promotes different levels of exposure of needs to metal. The illegal activity of gold mining on an artisanal scale, contributes to the production of metallic residues in the atmosphere and in the complex hydrography of the region, conditions that raise MeHg levels in aquatic biota[19].

In this study, the total concentration of Hg in blood and hair indicates a risk of vulnerability to the child's health, due to the possibility of negative metallic interference in the child's neuropsychomotor development. Studies with children of different ages found a directly proportional relationship between the frequency of fish consumption and the Hg concentrations in the hair[20]. In the Amazon, several studies indicate health risks for children with high fish consumption and exposure to total Hg in the region[21-22].

The Hg rates in the blood and hair of the population in this study suggest an increase in the presence of the metal in both sexes, although some age groups indicate a greater accumulation among women. The metal content in the hair of women in the reproductive phase above normal limits, allows vertical transmission during pregnancy[23].

Women in the reproductive phase are concerned with the evolution of pregnancy and the possibility of having children with high levels of total Hg at birth, characterizing congenital mercurialism. In the studies by Santos et al., (2007) a highly significant correlation (r = 0.8019; p = 0.000) was found between blood levels of total Hg (11.5 µg.L-1; 0.4 to 117 , 6 µg. L-1) and blood levels of the umbilical cord (16.7 mg.L-1 0.3 - 135.0 µg.L-1) in 1,510 women and their newborns in the Tapajós River

basin, in the state of Pará, a situation that suggests the passage of metal from the mother to the fetus.

In this study, the residence time at the study site and the consumption of fish seem to be decisive for the bioaccumulation and biomagnification of Hg in the region, factors that cause the accumulation of the metal, progressively over time, in the human organism. The high presence of total Hg in the blood and hair reveals the presence of a strong correlation between the biological matrices of the population and anthropic activities in the Pan-Amazon region.

In continuity, it is worth noting that the significant increase in artisanal gold mining activity in Madre de Dios, Peru, which makes up Pan Amazonia, coincides with the high presence of Hg in the fish and hair of local populations[24]. Therefore, populations living on the banks of rivers and tributaries that pass-through mining are at high risk for Hg in the region.

Although there is no mining in the state of Acre, the levels of total Hg in the individuals selected in this study are high. This contamination, therefore, is justified by the fact that the biogeochemical cycle of the metal in the region allows Hg to be transported to individuals by atmospheric air and by fish, widely found in rivers in the region[25].

In addition, a review study on Hg in populations from various states in the Amazon region indicates high levels of metal in the hair in both sexes and in various age groups, including among indigenous people[17]. Some results go beyond the limits considered safe for the health of the population, whose deficiency in the health surveillance system makes it difficult to diagnose and quantify the risk.

The impact of Hg on the health of the Amazonian population depends on the coexistence of the human organism with different exposures to metal, associated with infectious and non-infectious comorbidities, in addition to the genetic characteristics of individuals. It is necessary to structure the environmental health surveillance system for the early detection of physiological changes and the development of biochemical indicators, related to the action of metal in the body.

In the Amazon region, it is appropriate to suggest that the population groups that live in the riverside communities have similarities in relation to geographic isolation, low education, low income, precariousness of the home infrastructure and fish feeding, conditions that contribute to the persistence of Hg in the body of the individuals. This scenario contributes to the decrease in the population's quality of life, due to the involvement of

organs with silent clinical symptoms in widely impacted individuals[26].

In view of the reality observed in this research, the need for adequate studies to understand the reality of risk groups, such as pregnant women and children, to identify vertical transmission and the relationship between metal and its complications in the studied populations is highlighted.

## V. CONCLUSION

The presence of total Hg in the blood and in the capillary matrix shows that the population of the municipality of Sena Madureira is environmentally exposed to metal. This exposure occurs through the existence of the biogeochemical cycle with the participation of fish consumption and the anthropic activity of artisanal gold mining in the bordering region of the state of Acre.

The high content of total Hg in the biological matrices of the studied population indicates the physiological dynamics of the metal in the organism. The distribution of mercury in both sexes and in different age groups, suggests that there is a significant risk to the health of individuals, especially women and children.

It is essential to develop a network for monitoring the environmental health of mercury among the countries that make up the Pan-Amazon. Therefore, studies aimed at recognizing the health-disease process in relation to Hg should be part of the routine of assessing the health of individuals in the region.

## REFERENCES

[1] IBGE. Instituto Brasileiro de Geografia e Estatística. Bacia Amazônica; IBGE: Rio de Janeiro, Brasil, 2012.

[2] Coelho MCN, Wanderley LJM. Peru-Bolívia-Brasil: garimpeiros e ideia de região transfronteiriça. Rev. ANPEGE. 2013. [access: 21 set 2020]; 9(12):5-16. Available: https://doi.org/10.5418/RA2013.0912.0001.

[3] WHO. World Health Organization. Primary Care, Now More than Ever. 2020. [access: 21 set 2020]. Available online: https://apps.who.int/medicinedocs/documents/s22232en/s22232en.pdf.

[4] Damonte GH. Taming the "Wilderness": Government Quest for Formalization and Conflict Among Small-Scale Miners in the Peruvian Amazon. Antipode 206, 48, 956-976.

[5] Hentschel T, Hruschka F, Priester M. Global Report on Artisanal & Small-Scale Mining. Mining, Minerals and Sustainable Development. 2002 jan. [access: 21 set 2020]; 70. Avaliable online: http://pubs.iied.org/pdfs/G00723.pdf.

[6] Sari MM, Inoue T, Matsumoto Y, Yokota K. Measuring total mercury due to small-scale gold mining activities to determine community vulnerability in Cihonje, Central Java, Indonesia. Water Sci Technol. 2016. [access: 20 set 2020]; 73(2):437-444. Available: https://doi.org/10.2166/wst.2015.503.

[7] Figueiredo BR., Campos AB, Silva R, Hoffman NC. Mercury sink in Amazon rainforest: soil geochemical data from Tapajos National Forest, Brazil. Environ. Earth Sci. 2018. [access: 20 set 2020]; 77:296. Available: https://doi.org/10.1007/s12665-018-7471-x.

[8] Wyatt L, Ortiz EJ, Feingold B, Berky A, Diringer S, Morales AM, Jurado ER, Hsu-Kim H, Pan W. Spatial, Temporal, and Dietary Variables Associated with Elevated Mercury Exposure in Peruvian Riverine Communities Upstream and Downstream of Artisanal and Small-Scale Gold Mining. Int J Environ Res Public Health. 2017 Dec 15. [access: 20 set 2020]; 14(12):1582. Available: https://doi.org/10.3390/ijerph14121582.

[9] Joas A, Schwedler G, Choi J, Kolossa-Gehring M. Human biomonitoring: science and policy for a healthy future. Int J Hyg Environ Health. 2017 06 Feb. [access: 20 set 2020]; 220(2 Pt A):299-304. Available: https://doi.org/10.1016/j.ijheh.2017.01.013.

[10] Andreoli V, Sprovieri F. Genetic Aspects of Susceptibility to Mercury Toxicity: an Overview. Int J Environ Res Public Health. 2017 Jan. [access: 21 set 2020]; 14(1):14-93. Avaliable: https://doi.org/10.3390/ijerph14010093.

[11] WHO. World Health Organization.Children's Exposure to Mercury Compounds; WHO: Geneva, Suiça, 2010.

[12] Cerná M, Puklová V, Hanzlíková L, Sochorová L, Kubínová R. 25 years of HBM in the Czech Republic.Int J Hyg Environ Health. 2017. [access: 21 set 2020]:220:35. https://doi.org/10.1016/j.ijheh.2016.08.004.

[13] EFSA. European Food Safety Authority. Scientific Opinion on the risk for public health related to the presence of mercury and methylmercury in food. EFSA J. 2012 dec 20. [access: 21 set 2020];10(12): 2985. Avaliable: https://doi.org/10.2903/j.efsa.2012.2985.

[14] Akagi H. Mercury Analysis Manual; Ministry of the Environmental: Japan, 2004.

[15] Dawson B. Basic & Clinical Biostatistics, 4th ed.; Lavoisier Librairie: Paris, 2004. 416 p.

[16] OPAS, Organização Pan-Americana da Saúde. Organização Pan-Americana da Saúde. Cooperação Técnica entre Brasil, Bolívia e Colômbia: Teoria e prática para o fortalecimento da vigilância em saúde de populações expostas a mercúrio. OPAS/OMS: Brasília, Brasil, 2011. 101 p.

[17] Castro NSS, Lima MO. Hair as a Biomarker of Long-Term Mercury Exposure in Brazilian Amazon: A Systematic Review. Int J Environ Res Public Health. 2018 Mar 12. [access: 20 set 2020];15(3):500. Available: https://doi.org/10.3390/ijerph15030500.

[18] Giang A, Selin NE. Benefits of mercury controls for the United States. Proc Natl Acad Sci USA. 2016 Jan 12.

[access: 20 set 2020]; 113(2):286-91. Available: https://doi.org/10.1073/pnas.1514395113.

[19] UNEP. United Nations Environment Programme. Global Mercury Assessment. 2020 mar. [access: 14 mar 2020]. Available: http://www.eurocbc.org/final-assessment-report-25nov02.pdf.

[20] Kusanagi E, Takamura H, Chen SJ, Adachi M, Hoshi N. Children's Hair Mercury concentrations and seafood consumption in five regions of Japan. Arch Env Contam Toxicol. 2018 jan 08. [access: 20 set 2020]; 74(2):259-272. Available: https://doi.org/10.1007/s00244-017-0502-x.

[21] Hacon S, Barrocas PRG, Vasconcellos ACS, Barcellos C, Wasserman JC, Campos RC. Um panorama dos estudos sobre a contaminação de mercúrio na Amazônia Legal no período de 1990 a 2005 – avanços e lacunas. Geochimica Brasiliensis. 2009. [access: 20 set 2020]; 23(1):029-048.

[22] Costa Junior JMF, Silva CIM, Lima AAS, Júnior DR, Silveira LCL, Souza GSS et al. Teores de mercúrio em cabelo e consumo de pescado de comunidades ribeirinhas na Amazônia brasileira, região do Tapajós. Ciência & Saúde Coletiva. 2018 mar. [access: 20 set 2020]; 23(3):805-812. Available: https://doi.org/10.1590/141381232018233.09492016.

[23] Sakamoto M, Ital T, Murata K. Effects of Prenatal Methylmercury Exposure: From Minamata Disease to Environmental Health Studies. Nippon Eiseigaku Zasshi. 2017. [access: 20 set 2020]; 72(3):140-148 Available: https://doi.org/10.1265/jjh.72.140.

[24] Yard EE, Horton J, Schier JG, Caldwell K, Sanchez C, Lewis L, Gastanaga C. Mercury Exposure Among Artisanal Gold Miners in Madre de Dios, Peru: A Cross-sectional Study. J. Med. Toxicol. 2012 dec. [access: 20 set 2020]; 8(4):441-8. Available: https://doi.org/10.1007/s13181-012-0252-0.

[25] UNEP. Guidance for identifying populations at Risk from mercury exposure; UNEP: Geneva, Switzeand, 2010.

[26] Miranda AMM, Jesus IM, Matos HJ, Lima MO, Faial KRF, Moraes MM et al. The behavior of thyroid hormones in a population exposed to mercury and selenium, which inhabits a municipality located in the Western Amazon, in Brazil. International Journal of Development Research. 2020. [access: 20 set 2020]; 10(07):37675-37680. Available: https://doi.org/10.37118/ijdr.19363.07.2020.

# Technological characterization of wood residues from the Amazon for the production of briquettes*

Andreia Picanço da Silva[1], Claudete Catanhede do Nascimento[2], Cristiano Souza do Nascimento[3], Marcela Amazonas do Carmo[2], Roberto Daniel de Araújo[2] and Jorge Alves de Freitas[2]

[1]Master's, Graduate Program in Environmental and Forestry Sciences – PPGCIFA, UFAM, BRAZIL
[2]Technology and Innovation Coordination – COTEI, INPA, BRAZIL
[3] Ph.D Candidate, Graduate Program in Tropical Forest Sciences – PPGCFT, INPA, BRAZIL
*Research Group on Technological Developments in Wood Products/CNPq, BRAZIL

*Abstract* — *The study aimed to evaluate the potential of briquettes produced from wood residues from five forest species in the Amazon. Wood residues were obtained in Manaus - AM/Brazil, fragmented to obtain sawdust and determination of the Physical and Chemical Properties of wood, coal and briquettes. In chemical analysis, Extractives ranged from 9.76 to 12.08% , and the Ash content was 0.48% on average. As for physical properties, Basic density ranged from 870 to 980 Kg/m³, Moisture from 7.38 to 9.03%, and PCS from 5,213.50 to 5,883.50 Kcal/Kg. The PCS of coal was higher than that of wood, and the best correlations of PCS were with Extractives, Lignin, Moisture and Basic density. Regarding the DE estimate considering wood as firewood, Jatobá residues presented the highest valor, and this material when compacted (Briquette), the energy efficiency increased effectively with a range of 6.36 to 7.51 MKcal/m³. The material, when carbonized, presents a higher concentration of fixed carbon, which justifies the high DE values for both coal and coal briquettes, where in the coal a variation of 6.25 to 8.51 MKcal/m³ and coal briquettes from 8.01 to 11.42 MKcal/m³. The studied residues presented high PCS, both wood and coal. In general, all species showed high Basic density and low Moisture, which favors the indication of these materials for energy purposes. Charcoal briquettes from Angelim pedra and Angelim vermelho showed Energy density above 10.00 MKcal/m³, indicating the energy potential of this product that combines technical and economic viability.*

*Keywords*— *Amazonian woods, Briquettes, Energy density and Higher calorific value.*

## I. INTRODUCTION

The forest-based industry has been growing significantly in the world market, where wood, whether planted or managed area, is the main raw material for the cellulose, energy, furniture and reconstituted products sector. One of the major bottlenecks in the timber industry in the Amazon is the low yields in the split, which causes a large amount of waste. The correct use of these residues has become a sustainable practice, given its possibility of recycling, as well as the elimination of waste, thus being an alternative for environmental balance [1 and 2].

Substrates based on wood, agricultural and agro-indus

trial residues can be used for energy purposes, in poultry farming, cultivation of edible fungi and also for the production of agglomerates. The use of biomass as an energy source is technically and economically viable, given the large supply of this material and the demand by the steel industry [3, 4 and 5].

The plant matrix consists of Cellulose and Hemicellulose (Polysaccharides), Lignin (Aromatic polymer) and also low molecular weight substances such as extracts and mineral residues. The quantification of these compounds is essential for the technological characterization of aggregate products that will indicate the best energy efficiency of biomass, such as, for

example, the high content of aromatic substances, such as some Extractives and Lignin, generates a coal with a higher Basic density and more resistant, in terms of Physical-Mechanical properties [6 and 7].

A product from wood that produces more energy than firewood and charcoal is called a briquette. Also known as ecological firewood, it is a product of the wood residues densification process. Briquetting is an alternative to add value to waste of agroforestry origin and consists of compacting the sawdust at high pressures and temperature, but for this, sophisticated equipment is necessary to reach the level of compactness or densification. In general, briquettes are formed from charcoal powder that has already undergone carbonization. Recognized by companies in the forestry sector as the energy of the future, the briquette is very useful in generating heat energy in greenhouses, boilers, stoves with automatic feeding, in industries, as well as in maintaining fire in fireplaces, barbecues and homes [8 and 9].

In Brazil, around 1.2 million tons of briquettes are produced per year, of which 930 thousand tons are made of wood. The manufacture of wooden briquettes is a smart way to take advantage of discarded sawmill items such as deformed logs, coastal logs, shavings, shavings, and especially sawdust [10]. Knowledge about raw materials for indication in briquetting is important to discipline the use of stocked resources, under the new paradigm of the sector, which is sustainable development. Technological knowledge about the properties of wood is fundamental for the generation of standardized and eco-efficient products in the Amazon, however, the Amazon biome presents forest species that have not been studied for energy purposes [11, 12 and 13].

Briquette technology, as a fuel and energy production process, has not been fully explored. Therefore, it is necessary to develop research that will increase the yield of this matrix, as well as diagnose species with energy potential. Falemara et al. [14] evaluated the Physical and Energetic properties of briquettes produced from agroforestry residues, and concluded that the sawdust of the African tropical species *Anogeissus leiocarpus* (African birch) contained low Mineral content and high Superior calorific value (PCS = 8,222 Kcal/Kg), and the mixture with others agricultural substrates generated a product with better quality in terms of densification and combustion, therefore suitable as an alternative to an ecologically healthy energy source.

Antwi-Boasiako and Acheampong [2] studying the energetic potential of sawdust briquettes from three tropical woods of different densities (Ako - *Antiaris*

*toxicaria*, Samaúma - *Ceiba pentandra* and Okan - *Cylicodiscus gabunensis*), found that wood Density was a limiting factor for an efficient composite, that is, Samaúma wood had low yields and PCS = 3,825 Kcal/Kg. In Brazil, Pinheiro et al. [15] used waste from the agricultural and tropical Brazilian wood sectors to determine its energy density. The result was an average PCS of 4,500 to 5,000 Kcal/Kg. While Gentil1 and Vale [16] using *Pinus* based briquettes with different Moisture, obtained an average PCS of 4,837 Kcal/Kg, where the substrate with a high Moisture content, presented low energy yield. Corrêa [17] was one of the forerunners of studies on the chemical conversion of Amazonian wood into energy, when he described processes for manufacturing briquettes from alternative forest products for energy generation. Species of botanical families Chrisobalanaceae, Humiraceae, Lecythidaceae, Leguminosae and Sapotaceae were used for charcoal production and later compaction in briquettes, where it found PCS of 6,602 Kcal/Kg, indicating the energy potential of wood in the region.

In this context, the study aimed to assess the potential of briquettes produced from wood waste from five forest species in the Amazon.

## II. MATERIAL AND METHODS

The residues constituted by shavings, battens and backlines were collected at Company Portela Wood (Manaus - AM/Brazil) and transported to the Cellulose and Paper/Charcoal Laboratory/COTEI/INPA - Brazil. Initially, cuts were obtained to obtain sampling for species identification (Table 1), which was the responsibility of specialist JA Freitas from the Laboratory of Anatomy and Wood Identification - LAIM/COTEI/INPA - Brazil. At the same time, the material was fragmented to obtain sawdust (20, 40 and 60 mesh) that was used to determine the Physical and Chemical properties of wood, coal and briquettes.

### 2.1 Characterization of Physical Properties

#### 2.1.1 Basic density

This property was determined as described in NBR 7190: 1997 [18], using the water displacement method. Initially, specimens were made (2.00 x 2.00 x 3, 00 cm), and then they were saturated to obtain the green volume determined by the liquid displacement method, then they were dried in an oven (100 ± 3 ºC) until they reach constant weight (72 h). Subsequently, the Basic density was calculated according to the formula: Basic density = $P_d/V_s$, $P_d$ = Dry weight in grams, $V_s$ = Volume of the sample in a saturated state in $cm^3$.

*Table 1: Taxonomic identification of wood residues.*

| Species | Xiloteque Registration | General characteristics* |
|---|---|---|
| Angelim pedra<br>*Hymenolobium petraeum*<br>Ducke | X – 8894 | Medium density wood, light brown heartwood with dark hues, yellowish sapwood, interlocked grain, medium to coarse texture, indistinct smell and taste. |
| Angelim vermelho<br>*Dinizia excelsa*<br>Ducke | X – 7978 | High density wood, light reddish-brown heartwood, slightly different from red dish-gray sapwood, straight to irregular grain, medium texture, characteristic smell and indistinct taste. |
| Cumaru<br>*Dipterix odorata*<br>(Aubl.) Willd | X-8,338 | High density wood, dark brown-yellow heartwood, light beige sapwood, interlocked grain, medium texture, unpleasant smell when green, disappearing after drying, of moderate luster and indistinct taste. |
| Cumarurana<br>*Dipterix polyphylla*<br>Huber | X -8,355 | High density wood, dark brown heartwood, creamy yellowish sapwood, interlocked grain, medium texture relatively prominent figure indistinct smell and taste. |
| Jatobá<br>*Hymenaea courbaril* L. | X-10,12 | Medium density wood, red heartwood accentuated to reddish-brown with some times dark spots, grayish-white sapwood, straight to wavy grain, medium texture indistinct smell and taste. |

* [13 and 33]

### 2.1.2 Moisture

1.00 g of wood sawdust (40 mesh) were weighed in a weighing filter, being subjected to drying in an oven at 100 ± 3 °C, in a period of 4 hours, according to the norm of ABNT 8112: 1986 [19]. At the end, the material was weighed to constant weight, and the Moisture was calculated according to the formula: Moisture$_\%$ = P$_w$ -

$P_d/P_d$ x 100, $P_w$ = Weight of wet mass and $P_d$ = Weight of the dry mass.

### 2.1.3 Calorific value

The Superior calorific value (PCS) were performed on a dry basis, with the aid of a calorimetric pump, ASTM D2015-00: 2000 [20]. About 0.80 g of sawdust (60 mesh) was placed in the metallic capsule and a wool thread was inserted into the pump and placed next to the ignition wire, the pump is closed, and oxygen gas is injected. The pump is placed in a metal bucket with water, and the ignition system of the calorimeter is coupled to the pump, where quantification begins. After 15 min. the operating system of the PARR calorimeter prints the result of the reading in Kcal/Kg. This determination was made for wood and coal.

The Lower calorific value (PCI) was estimated by the equation of Brum et al. [21]: PCI = PCS - (600*9 (H/100)), where the percentage of hydrogen was 6% and the result in Kcal/Kg.

### 2.2 Characterization of Chemical Properties

#### 2.2.1 Extractives

The Extractives content (Ethanol; Ethanol-toluene) was determined from 2.00 g of sawdust (60 mesh) in Soxhlet extractor for a period of 8 hours, TAPPI 264 om-88:1996 [22]. At the end, the solubilized Extractives was weighed and quantified by the equation: Extractives$_\%$ = $P_{ext}/P_d$ x 100, $P_{ext}$ = Mass - final extract and $P_d$ = Weight of the dry base sample.

#### 2.2.2 Lignin

In the material obtained after extraction (extraction-free sawdust), 1.00 g of sawdust was hydrolyzed with 72% $H_2SO_4$ for about six hours, TAPPI 222 om-02: 2006 [23]. At the end, this material is washed with hot water, filtered, dried in an oven at 100 °C, being subsequently weighed and the lignin content calculated. The percentage of Lignin is determined using the formula: Lignin$_\%$ = $P_{Lig}$/ $P_d$ x 100, $P_{Lig}$= Lignin weight obtained and $P_d$= Weight of the dry base sample.

#### 2.2.3 Ash

In porcelain crucible 1.00 g of sawdust (60 mesh) is added and taken to the oven (100 ± 3 °C) for 1 hour, to remove moisture. Then, the container is taken to the muffle for incineration, starting with the gradual heating up to 580 – 600 °C, ASTM D1102-84: 2013 [24]. After incineration, the crucible is weighed to a constant weight. The ash content is determined by the formula: Ash$_\%$ = $P_{Ash}/P_d$ x 100, $P_{Ash}$ = Ash weight and $P_d$= Weight of the dry base sample.

2.2.4 Holocellulose

The holocellulose content was estimated by adding the percentages of extractives, lignin and ash, and subtracting this value from 100% according to Silva et al. [11]: Holocellulose$_\%$ = 100 - (Extractives + Lignin + Ash).

## 2.3 Production and Analysis of Briquettes

Initially, the residues of each wood and wood mixture (Mix) were carbonized at 400 °C in an electrically heated retort at the Cellulose and Paper/Charcoal Laboratory/COTEI/INPA - Brazil. A set of parameters was initially evaluated to define the briquette pattern, they were granulometry (20, 40 and 60 mesh), pressure (500 to 1,000 Kgf/cm$^2$, temperature (100 to 130 °C) and mass (20.00, 30.00 and 40.00 g). The briquettes were prepared in a Briquette Machine (Fig. 1) at a temperature of 120 °C ($\pm$ 5 °C), pressure of 700 and 1,000 Kgf/cm$^2$, compaction time of 5 min., where the ideal humidity of the material to be briquetted must be 12%, Silva et al. [25].



*Fig. 1: Briquetting machine (Lippel- model LB-32) used in the study (Cellulose and Paper/Charcoal Laboratory/COTEI/INPA – Brazil).*

30.00 g of coal were used for each briquette, obtaining at the end a sample of ~ 3.00 cm in length and ~ 4.00 cm in diameter. Ten briquettes were produced per wood, totaling 50 briquettes. For each sample, the actual volume

(Digital caliper), Density (m/v) and finally the Energy density - DE (Material density x PCS) were determined.

## 2.4 Data analysis

The values of the results obtained in the chemical, physical and energetic tests of the wood and briquettes were submitted to analysis of variance (ANOVA) with the aid of the software PAST Version 2.17c, in order to verify if there was a statistical difference between the treatments. For data that differed statistically, that is, when the F value was significant ($\alpha$ = 0.05), the Tukey mean test at 5% significance level was applied.

## III. RESULTS AND DISCUSSION

Vegetable biomass, which can be obtained from various sources, such as agricultural and forest residues, is one of the sources of energy that presents the most economic and sustainable viability since its raw material can be obtained from renewable resources, such as wood. However, its properties are parameters that can influence the amount of energy, hence the need to evaluate the chemical, physical and energetic properties of the studied residues.

### 3.1 Chemical Properties

The wood consists of Cellulose, Hemicellulose and Lignin, these being macro components of cellular appearance and also Extractives and Mineral compounds. In this study, the chemical composition of wood residues from the Amazon was evaluated, a raw material commonly wasted by the regional industry. Table 2 shows the average values of Extractives (ethanol-toluene), Lignin, Holocellulose (Cellulose + Hemicellulose) and Ash (Mineral residues) of the five residues studied.

The Tukey test (p $\leq$ 0.05) showed a significant difference for the content of Extractives, Lignin and Ash. Regarding the content of extractives, the concentration varied from 9.76 to 12.08%, Angelim pedra and Angelim vermelho, respectively. For Lignin, the variation was from 30.47% (Angelim vermelho) to 41.72% (Cumarurana). Holocellulose was 54.48%, while the ash content was 0.48% on average.

Chemical characterization is a primary step in studies of raw materials for energy purposes, given the influence of chemical compounds, mainly Lignin and Extractives that have a positive correlation with Calorific value [11 and 26]. Santana and Okino [27] evaluating the chemical composition of 36 Amazonian woods obtained Extractives values of up to 17.30%. While Moutinho et al. [28] when studying the energetic characteristics of wood of the genus *Eschweilera* (Lecythidaceae) found Extractives values that

ranged from 3.63 to 11.16%. Regarding Lignin, Cavalcante et al. [29] found 23.74% of Lignins for various woods of the genus *Eperua* (Fabaceae). Silva et al. [11] evaluating wood residues obtained average values of 27.90%, in our study the Lignin concentration was much higher (34.06%). According to Fengel and Wegener [30], Lignin is the second chemical constituent in greater proportion in wood, varying from 20-40%, depending on the species, which gives a certain difference in the results obtained.

*Table 2: Chemical properties of the studied woods.*

| Wood | Extr% | Lign% | Holocell% | As% |
|---|---|---|---|---|
| Angelim pedra | 9.76 b | 32.57 c | 57.19 | 0.48 b |
| Angelim verm | 12.08 a | 30.47 d | 56,70 | 0.75 a |
| Cumaru | 11.76 a | 31.21 d | 56.71 | 0.32 b |
| Cumarurana | 11.62 a | 41.72 a | 46.30 | 0.36 b |
| Jatobá | 9.93 b | 34.35 b | 55.49 | 0.23 b |
| | 1.03 | 34.06 | 54.48 | 0.48 |
| Average | (0.98) | (4.06) | (4.13) | (0.19) |

Legend: Extr = Extractives; Lign = Lignin; Holocell = Holocellulose; As= Ash. Means followed by the same letter do not differ statistically by the Tukey test at the 5% probability level; Value in parentheses standard deviation.

Printes et al. [31] characterizing wood residues from Central Amazonia found Holocellulose values from 43.58 to 54.85% (Louro faia - *Roupala montana*, Jatobá - *Hymenaea courbaril*, respectively). Silva et al. [11] also studying other wood residues from the same region, reached higher values such as 58.68% (Louro - *Ocotea* sp.) to 70.55% (Cedrinho - *Scleronema* sp.). Holocellulose is the main component of vegetables and one of nature's most abundant carbon compounds and encompasses both Cellulose and Hemicellulose. Depending on the origin of each species, it can vary from 40 to 60% of the dry weight of the wood, considering both hardwood and coniferous woods [32]. In this study, Cumarurana wood obtained the lowest percentage (46.30%) while Angelim pedra presented the highest content (57.19%), which are within the range defined in the literature.

Regarding the Ash content, Cunha et al. [33] is a reference study for woody species in the Amazon, which quantified the ash from 55 woods, finding values that varied from 0.03 to 3.00%. However, Mitchual et al. [34] evaluating the energetic properties of six tropical wood species from Ghana found values of 5.04% of Ash for Aniégré (*Aningeria robusta*) wood. In this study, the highest Ash concentration was 0.75% (Angelim vermelho). However, Pettersen [35] reports that Ash values for tropical wood are usually high, where the greatest exception ever recorded was for Guayacan (*Tabebuia guayacan*)with ~ 13%. According to Martins [36], the ashes are products of the combustion of biomass, however certain Mineral residues do not degrade becoming undesirable elements for the generation of energy.

## 3.2 Physical and Energetic Properties

The Basic density, Moisture, Superior and Lower calorific value (PCS, PCI) of wood and coal can directly answer about the efficiency of the waste energy potential. Table 3 shows the results of these properties. The Density values varied from 870 to 980 Kg/m$^3$, and for this property there was no statistical difference between the woods, which confirms the grouping of the woods in high density class. While, for dry Moisture, it varied from 7.38 to 9.03%, where the statistical analysis indicated the formation of three groups/class for this property. The Calorific values ranged from 5,213.50 to 5,883.50 Kcal/Kg (PCS), and from 3,931.64 to 4,602.33 Kcal/Kg (PCI), for the PCS the Tukey test did not reveal statistical differences between the woods, and for PCI only Angelim pedra was grouped in another class. The PCS and PCI of coal were superior to those of wood, with a variation from 6,385.00 to 9,367.50 Kcal/Kg (PCS), and from 5,103.83 to 8,086.33 Kcal/Kg (PCI).

The results also show, with the exception of Angelim pedra, that the residues of the other species can be used together for the production of energy without interfering in quality.

The Density expresses the amount of mass contained in a given volume of material. According to Nascimento et al. [37], the Basic density is the most important parameter for technological studies of wood, as this property is related to several characteristics, such as Anatomical, Physical, Chemical and Energetic. Barros et al. [38] evaluating the energetic potential of Acácia, Ingá and Tachi wood (*Acacia mangium*, *Inga edulis* and *Tachigalia chrysophyllum*) for firewood production, obtained the average value for Basic density of 530 Kg/m$^3$, and Silva et al. [11] found values close to 600 Kg/m$^3$ for wood residues from the Amazon. While Cunha et al. [33] reached a larger spectrum (350 to 1,040 Kg/m$^3$) that included low, medium and high Density wood. High Density wood generates firewood/charcoal with higher energy quality. In this study, all wood showed high Density, which may explain the high energy potential of the residues.

*Table 3: Physical and energetic properties of wood residues from the Amazon.*

| Wood/Waste | Basic density (g/cm$^3$) | Moisture (%) | Calorific value (Kcal/Kg) | | | |
|---|---|---|---|---|---|---|
| | | | PCS* | PCI* | PCS** | PCI** |
| Angelim pedra | 870 a | 8.10 b | 5,213.50 a | 3,931.64 b | 9,367.50 a | 8,086.33 a |
| Angelim verm | 980 a | 9.03 a | 5,497.50 a | 4,216.33 a | 8,689.00 a | 7,407.83 a |
| Cumaru | 970 a | 7.38 c | 5,675.00 a | 4,393.83 a | 7,453.50 b | 6,172.33 b |
| Cumarurana | 950 a | 8.24 b | 5,488.00 a | 4,206.83 a | 6,741.50 bc | 5,462.72 b |
| Jatobá | 980 a | 8.50 ab | 5,832.00 a | 4,550.83 a | 6,385.00 c | 5,103.83 b |
| Mixture (MIX) | - | - | 5,883.50 a | 4,602.33 a | - | - |
| Average | 950 (50.00) | 8.25 (0.60) | 5,598.25 (249.89) | 4,316.97 (250.11) | 7,727.30 (1,271.18) | 6,446.61 (1,270.72) |

Legend: * Wood; ** Coal; Means followed by the same letter do not differ statistically by the Tukey test at the 5% probability level; Value in parentheses standard deviation.

The acceptable Moisture content for a biomass to be considered of good quality, for energy purposes, should not exceed 12% [39]. Antwi-Boasiako and Acheampong [2] call attention to other factors that Moisture can influence when calculating economic viability, for example, costs with pre-drying of very humid material and another in transport, a biomass with a high content of general humidity increase in transport cost. However, Moisture cannot always be considered a negative characteristic. Demirbas and Sahin-Demirbas [40]. reported that a high Moisture content can favor the compressive strength and fracture index of the briquette.

Antwi-Boasiako and Acheampong [2] evaluating the resistance and Calorific value of tropical wood briquestes observed a Moisture variation of 12.05 to 12.95%. Mean values of 13% were found by Silva et al. [11] for Amazonian forest residues. In the present study, the maximum Moisture content on a dry basis was 9.03% for residues of Angelim vermelho wood, which may be a good indicator for the energetic properties of wood.

The Calorific value is a physical variable that expresses the amount of heat released by the complete combustion of the fuel mass unit, it is widely used as an energy parameter. Moutinho et al. [28] reached average PCS values of 4,554.30 Kcal/Kg for woods of matá-matá (*Eschweilera* sp.) hyperdominant species in the Amazon rainforest. Mitchual et al. [34] found PCS values for tropical African woods that varied from 4,815.13 Kcal/Kg for Mokolongo (*Celtis mildbreadii*) and 5,307.16 Kcal/Kg for Limba (*Terminalia superba*). In Germany DIN 51731/DINplus defines the range of 4,179.80 - 4,657.50 Kcal/Kg for the use of energy biomass [41], and in Austria NORM M7135 the minimum value for PCS is 4,299.23

Kcal/Kg [42]. As expected, the PCS of charcoal is superior to wood, and this behavior may be associated with the reduction of humidity, and the potentiation of carbon fixation in the substrate. The biomass quantified in the current study was an average of 5,598.25 Kcal/Kg for wood and 7,727.30 Kcal/Kg for coal, which indicates excellent parameters for energy production.

After evaluating the results of the Chemical, Physical and Energetic tests of the wood, the existence of a correlation between the data was verified by means of Pearson's coefficient (Table 4). The correlation measures the direction and the degree of the linear relationship between the quantitative variables, in statistical terms, two variables are associated when they have similarities in the distribution of their scores. More precisely, they can be associated through the distribution of frequencies or through the sharing of variance [43]. In all evaluated properties, a significant and directly proportional correlation was detected.

The PCS variable is the best indicator in energy studies and a direct correlation with the other properties can explain several events. The best correlations of PCS were with Extractives (0.8540), Lignin (0.9820), Moisture (-0.9359) and Basic density (0.8451). For Extractives and Ash, $R^2 = 0.5583$, although the coefficient was a little low, it was still considered significant.

Cunha et al. [33] reached similar relationships to this study when he observed a direct correlation between the PCS and the Basic density and also with the Lignin content. Moutinho et al. [28] and Silva et al. [11] found significant correlations when analyzing the content of Extractives and Lignin, this event was also observed in the

study, possibly explaining that the higher the content of Extractives, the greater the concentration of Lignin and consequently the PCS. A high negative correlation was observed for Moisture *v* PCS ($R^2$ = -0.9359), this fact is

well explained in energy studies of biomass, since the higher the Moisture content of the wood, the lower its combustion power due to moisture evaporation process, which absorbs energy in combustion [26].

*Table 4: Pearson's correlation coefficient, obtained from the correlations between Chemical, Physical and Energetic variables.*

|               | Extractives | Lignin | Holocellulose | Ash    | Moisture | Basic density | PCS     | PCI     |
|---------------|-------------|--------|---------------|--------|----------|---------------|---------|---------|
| Extractives   |             | 0.9844 | 0.6631        | 0.5583 | 0.9549   | 0.5642        | 0.8540  | 0.8531  |
| Lignin        |             |        | -0.9660       | 0.8882 | 0.9882   | 0.9442        | 0.9820  | 0.9823  |
| Holocellulose |             |        |               | 0.6769 | 0.9679   | 0.8881        | 0.6874  | 0.5880  |
| Ash           |             |        |               |        | 0.5674   | 0.9148        | -0.5789 | -0.5783 |
| Moisture      |             |        |               |        |          | 0.7118        | -0.9359 | 0.9362  |
| Basic density |             |        |               |        |          |               | 0.8451  | 0.8455  |
| PCS           |             |        |               |        |          |               |         | 0.9998  |
| PCI           |             |        |               |        |          |               |         |         |

All results show significant; test done with 95% confidence.

## 3.3 Energy Properties of briquettes

Briquettes are sustainable products made up of several biomasses where their greatest characteristic is the compaction of agroforestry substrates, at temperatures above 120 ºC, high pressures forming a block with reduced volume, but with great calorific value [44]. In Fig. 2, the general aspects of the briquettes produced with the residues of Amazonian wood can be observed. The standard moisture was 12% and the average dimensions Ø = 3.25 cm, l = 2.77 cm and color ranging from light yellow to dark brown.



*Fig. 2: Briquettes produced with wood residues from the Amazon.*

Energy density (DE) comprises the amount of energy per unit volume and can be used to compare the energy efficiency of various materials such as wood, coal and briquettes [45]. The DE estimate of wood waste is shown

in Fig. 3. Considering wood as firewood, Angelim Pedra and Jatobá residues had the lowest and highest DE (4.53 and 5.71 MKcal/m$^3$), and this material when compacted (Wood briquette), energy efficiency effectively increased with a variation of 6.36 to 7.51 MKcal/m$^3$ (Angelim Pedra, and mixture of all residues/MIX). The material, when carbonized, presents a higher concentration of fixed carbon, which justifies the high DE values for both coal and coal briquettes, where in the coal a variation of 6.25 to 8.51 MKcal/m$^3$ (Jatobá, Angelim Vermelho) and coal briquettes from 8.01 to 11.42 MKcal/m$^3$ (Jatobá, Angelim pedra).

DE is one of the main properties that define the quality of the briquette, as it summarizes the physical-chemical characteristics and the amount of heat of the final product in a single variable. Silva et al. [11] evaluating the energetic properties of tropical wood residues, reached DE 3.09 MKcal/m$^3$ (Piquiarana – *Caryocar villosum*), where this variable showed a positive
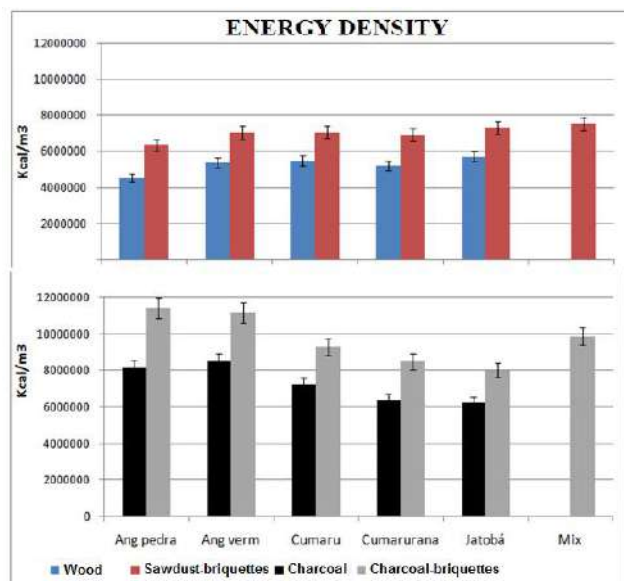
*Fig. 3: Energy estimates of briquettes made from Amazonian wood residues.*

Standard error bar (5%).

correlation with Basic density. When compacted sawdust for making briquettes, Souza and Vale [43] reached an average DE of 4.61 MKcal/m$^3$, where the Cumaru wood briquette (*Dipterix odorata*) showed values of 4.67 MKcal/m$^3$. Close values were found for briquettes made with a mixture of Baru (*Dipterix alata*) and Eucalyptus residues (Eucalyptus spp.) 4.88 MKcal/m$^3$ [44]. In the current study, the amount of heat produced by volume was much higher compared to data from the literature, on average 5.27 MKcal/m$^3$ for wood sawdust and 7.04 MKcal/m$^3$ for wood briquette, that is, compaction guarantees an energy gain of about 25%.

Sette Junior et al. [46]. evaluated the energy potential of coal and coal briquettes from bamboo sawdust, found DE for coal of 2.72 MKcal/m$^3$ and 5.13 MKcal/m$^3$ for coal briquettes. The estimate for DE of coal and coal briquette made from waste from Amazonian wood was higher than the research cited, on average 7.31 MKcal/m$^3$ for coal and 9.71 MKcal/m$^3$ for coal briquette. As it is biomass with a different chemical (Lignin, Extractives, and Ash) and physical (Moisture and Density) profile, these values may be in line with a matrix derived from tropical woods [26 and 34]. As for the increase in energy of the coal and compacted biomass matrix (Briquette), the variables that can explain this increase are compaction density, PCS, Extractives and Lignin, that is, higher values of these variables corroborate with greater amount of energy, as well as lower ash concentration.

The general data on Energy density presented in Fig. 3 allows us to draw a relationship of the type of material with energy efficiency: Charcoal briquette > Charcoal > Wood briquette > Wood. When comparing these different types of materials, whether by compaction (Briquetting) or carbonization, it appears that it is possible to enhance the use of regional wood residues as a good energy input, due to their physical-chemical characteristics. Using briquette means improving this input through compaction, which facilitates storage and transportation. And, depending on the purpose of using this input, carbonizing it is a way to enhance these residues. From an economic point of view, the energy produced from wood waste may be an alternative for use by a small community, even by companies in the wood industry segment. While, from the environmental point of view, plant biomass is a sustainable product in the long term, which avoids the disposal of this direct matrix in the environment, avoiding the production of decomposing gases such as methane [34 and 47].

## IV. CONCLUSION

The indication of the use of biomass for the generation of energy products depends on several chemical and physical characteristics of this material. The study evaluated the energy properties of wood residues from Amazonian forests. It can be concluded by the results that the studied residues presented high PCS, both wood and coal, ranging from 5,213.50 - 5,883.50 Kcal/Kg for wood and from 6,385.00 - 9.367,50 Kcal/Kg for coal. The residues of Angelim vermelho, Cumaru and Cumarurana presented the highest value of total Extractives, and for Lignin the highest concentrations were found for the woods of Angelim pedra and Jatobá, while the lowest Ash content was obtained for the Jatobá residue. Regarding physical properties, Density and Moisture, in general all species showed high Density and low Moisture content, which favors the indication of these materials for energy purposes. The results also indicated that the briquettes charcoal of Angelim pedra and Angelim vermelho showed Energy density above of 10 MKcal/m$^3$, where the densification of sawdust and coal for the production of briquettes is technically and economically feasible, since its attainment comes from residues from the timber industry.

## REFERENCES

[1] Cavalcanti, M.A.; Nascimento, C.C. (2012). Avaliação do rendimento de duas espécies de madeiras da Amazônia. In: Vianez, B.F. et al. (Org.), *Potencial tecnológico de madeiras e resíduos florestais da Amazônia Central.* Manaus: INPA, pp. 225-234. https://repositorio.inpa.gov.br/handle/1/34012

[2] Antwi-Boasiako, C.; Acheampong, B.B. (2016). Strength properties and calorific values of sawdust-briquettes as wood-residue energy generation source from tropical hardwoods of different densities. *Biomass and Bioenergy*, v. 85, pp. 144-152. February. https://doi.org/10.1016/j.biombioe.2015.12.006

[3] Cacuro, T.A.; Waldman, W.R. (2015). Cinzas da Queima de Biomassa: Aplicações e Potencialidades. *Revista virtual de química*, v. 7, n. 6, pp. 2154-2165. November/ December. DOI: 10.5935/1984-6835.20150127

[4] Saad, A.L.M.; Viana, S.R.F.; Siqueira, O.A.A.P.; Sales-Campos, C.; Andrade, M.C.N. (2017). Aproveitamento de resíduos agrícolas no cultivo do cogumelo medicinal *Ganoderma lucidum* utilizando a tecnologia chinesa 'Jun-Cao'. *Ambiência, Guarapuava*, v. 13, pp. 271-283. January. DOI: 10.5935/ambiencia.2017.03.03

[5] Azambuja, R.R.; Castro, V.G.; Trianoski, R.; Iwakiri, S. (2018). Recycling wood waste from construction and demolition to produce particleboards. *Maderas, Ciencia y Tecnologia*, Concepción, v. 20, pp. 1-16. October. http://dx.doi.org/10.4067/S0718-221X2018005041401

[6] Varejão, M.J.C.; Nascimento, C.S.; Cruz, I.A. (2012). Avançando fronteiras: potencial químico, ecológico-econômico de espécies florestais de São Gabriel da Cachoeira, AM. In: Souza, LAG; Guillermo-Castellón, E.. (Org.). *Desvendado as Fronteiras do conhecimento na região Amazônica do alto rio Negro.* Manaus: INPA - Projeto FRONTEIRAS, pp. 51-67. https://repositorio.inpa.gov.br/handle/1/34376

[7] Vindaurre, G.B.; Carneiro, A.C.O.; Vital, B.R.; Santos, R.C.; Valle, M.L.A. (2012). Propriedades energéticas da madeira e do carvão de paricá (*Schizolobium amazonicum*). *Árvore*, Viçosa, v. 36, n. 2, pp. 365-371. March. http://dx.doi.org/10.1590/S0100-67622012000200018.

[8] Dias, J.M.C.S.; Souza, D.T.; Onoyama, M.M.; Miranda, C.H.B.; Barbosa, P.F.D.; Rocha, J.D. (2012). *Produção de briquetes e péletes a partir de resíduos agrícolas, agroindustriais e florestais*. Brasília: Embrapa Agroenergia, 130 p.

[9] Silva, C.J.; Vale, A.T. (2018). Energy density model for forest species from cerrado. *Revista Caatinga*, Mossoró, v. 31, n. 2, pp. 396 – 404. April/June. https://doi.org/10.1590/1983-21252018v31n216rc

[10] Arranz, J.I.; Miranda, M.T.; Montero, I.; Sepúlveda, F.J.; Rojas, C.V. (2015). Characterization and combustion behaviour of comercial and experimental wood pellets in South West Europe. *Fuel*, Londres, v. 142, pp. 199–207. February. https://doi.org/10.1016/j.fuel.2014.10.059

[11] Silva, D.A.; Almeida, V.C.; Viana, L.C.; Klock, U.; Muñiz, G.I.B. (2014). Avaliação das propriedades energéticas de resíduos de madeiras tropicais com uso da espectroscopia NIR. *Floresta e Ambiente*, Rio de Janeiro, v. 21, n. 4, pp. 561-568. October/December. DOI: 10.1590/2179-8087.043414

[12] Nascimento, C.S.; Nascimento, C.C.; Higuchi, N.; Cruz, I. A. Caracterização tecnológica da madeira de matá-matá (*Eschweilera odora* Poepp. Miers). In: *Seminário Internacional de Ciências do Ambiente e Sustentabilidade na Amazônia*, 5, 2018, Manaus. Anais. Manaus: EDUA, pp. 1-14. https://repositorio.inpa.gov.br/handle/1/24949

[13] Araujo, R.D.; Santos, J.; Nascimento, C.C.; Nascimento, C.S.; Barros, S.V.S.; Lima, M.P. (2019). Surface roughness of Edge Glued Panels (EGP) of amazon grown species. *Ciência e Agrotecnologia*, Lavra, v. 43, pp. 1-8. December. https://doi.org/10.1590/1413-7054201943019119

[14] Falemara, B.C.; Joshua, V.I.; Aina, O.O.; Nuhu, R.D. (2018). Performance evaluation of the physical and combustion properties of briquettes produced from agro-wastes and wood residues. *Recycling*, v. 3, n. 37, pp. 1-13. August. DOI: 10.3390/reciclagem3030037

[15] Pinheiro, G. F.; Rondeiro, G.; Pinho, J. T. (2005). Densidade energética de resíduos vegetais. *Biomassa & Energia*, v. 2, n. 2, pp. 113-123. June.

[16] Gentil, L.V.; Vale, A.T. (2015). Energy balance and efficiency in wood sawdust briquettes production. *Floresta*, Curitiba, v. 45, n. 2, pp. 281 – 288. April/June. DOI: http://dx.doi.org/10.5380/rf.v45i2.36954

[17] Corrêa, A.A. (1980). Conversão química de madeiras da Amazônia - carvão e briquetes de carvão vegetal. *Acta amazonica*, Manaus, v. 18, n.1-2, pp. 93-108. January/February. http://dx.doi.org/10.1590/1809-43921988182108

[18] Associação Brasileira de Normas Técnicas – ABNT. (1997). *Determinação da densidade, do teor de umidade e da retração - NBR 7190*. Rio de Janeiro: ABNT, 105 p. Associação Brasileira de Normas Técnicas – ABNT. (1986). *Análise imediata - NBR 8112*. Rio de Janeiro: ABNT, 5 p.

[19] American Society Testing and Materials – ASTM. (2013). *Standard test method for gross calorific value of coal and coke by the adiabatic bomb calorimeter (Withdrawn 2000) - ASTM D2015-00/2000.* West Conshohocken, PA. 6 p.

[20] Brun, E.J.; Bersch, A.P.; Pereira, F.A.; Silva, D.A.; Barba, Y.R.; Dorini Junior, J.R. (2018). Caracterização energética da madeira de três materiais genéticos de *Eucalyptus* sp. Floresta, Curitiba, v. 48, n. 1, pp. 87-92. January/March. DOI: 10.5380/rf.v48i1.51673

[21] Technical Association of the Pulp and Paper Industry – TAPPI. (1996). *Solvent extractives of wood and pulp (Proposed revision of T 204 cm-97) - TAPPI 264 om-88*. Peachtree Corners, GA: TAPPI, 4 p.

[22] TAPPI 222 om-02: 2006 Technical Association of the Pulp and Paper Industry – TAPPI. (2006). *Acid-insoluble lignin in wood and pulp (Reaffirmation of T 222 om-02) - TAPPI 222 om-02*. Peachtree Corners, GA: TAPPI, 7 p.

[23] American Society Testing and Materials – ASTM. (2013). *Standard test method for ash in wood - ASTM D1102-84*. West Conshohocken, PA. 2 p.

[24] Silva, D.A.; Yamaji, F.M.; Barros, J.L.; Roz, A.L.; Nakashima, G.T. (2015). Caracterização de biomassas para a briquetagem. *Floresta*, Curitiba, v. 45, n. 4, pp. 713-722. October/December. DOI: 10.5380/rf.v45i4.39700

[25] Assis et al. 2016). Assis, M.R.; Brancheriau, L.; Napoli, A.; Trugilho, P.F. (2016). Factors affecting the mechanics of carbonized wood: Literature review. *Wood Science and Technologic*. Berlin, v. 50, pp. 519–536. March. DOI: 10.1007/s00226-016-0812-6

[26] Santana, M.A.E.; Okino, E.Y.A. (2007). Chemical composition of 36 Brazilian Amazon Forest Woods species. *Holzforschung*, Berlin, v. 61, pp.468-477. May. DOI: 10.1515/HF.2007.084

[27] Moutinho, V.H.P.; Couto, A.M.; Lima, J.T.; Aguiar, O.J.R.; Nogueira, M.O.G. (2011). Energetic characterization of Matá-Matá wood from the Brazilian rainforest (*Eschweilera* Mart Ex Dc). *Scientia Forestalis*, Piracicaba, v. 39, n. 92, pp. 457-461. October. https://www.ipef.br/publicacoes/scientia/nr92/cap08.pdf

[28] Cavalcante, C.M.; Varejão, M.J.C.; Cruz, I.A. (2012). Poder calorífico de casca e madeira de espécies de *Eperua*: *E. falcata* Aubl., *E. leucantha* Benth., *E. purpurea* Benth. e. *schomburgkiana* Benth. In: *I Congresso de Iniciação Científica PIBIC/CNPq - PAIC/FAPEAM I*, 2012, Manaus. Anais. Manaus: INPA, pp.1-4. https://repositorio.inpa. gov.br/handle/1/4193

[29] Fengel, D.; Wegener, G. (2003). *Wood—Chemistry, ultrastructure, reactions*. New York: De Gruyter, 2003, 613 p.

[30] Printes, G.; Barbosa, A.P.; Varejão, M.J.C.; Silva, G.A. (2004). Determinação de constituintes químicos nos resíduos madeireiros da Amazônia Central. In: *XIII Jornada de iniciação cientifica – I Encontro de iniciação cientifica PIBIC-JR. CNPq - PAIC/FAPEAM*, 13, 2004, Manaus, Anais. Manaus: INPA, pp.1-4.

[31] Sjostron, E. (2013). *Wood chemistry. Fundamentals and applications*. 2nd ed. Finland: Academic Press, 293 p.

[32] Cunha, M.P.S.C.; Pontes, C.L.F.; Cruz, I. A.; Cabral, M. T. F. D.; Cunha Neto, Z.B.; Barbosa, A.P.R. (1989). Estudo químico de 55 espécies lenhosas para geração de energia em caldeiras. In: *Encontro brasileiro em madeiras e em estruturas de madeira,* 3, 1989, São Carlos. Anais. São Carlos: USP, pp.93-121.

[33] Mitchual, S.J.; Frimpong-Mensah, K.; Darkwa, N.A. (2014). Evaluation of fuel properties of six tropical hardwood timber species for briquettes. *Journal of Sustainable Bioenergy Systems*, v. 4, pp. 1-9. February. DOI: 10.4236/jsbs.2014.41001

[34] Pettersen, R.C. (1984). The chemical composition of wood. In: Rowell, R. (Ed), *The chemistry of solid wood*. Washington, D.C.: American Chemical Society, pp. 54-126.

[35] Martins, H. (1980). Madeira como fonte de energia. In: Penedo, W.R. (Ed). *Uso da madeira para fins energéticos*. Belo Horizonte: CETEC, pp. 9-26.

[36] Nascimento, C.C.; Brasil, M.M.; Nascimento, C.S.; Barros, S.V.S. (2017). Estimativa da densidade básica da madeira de *Eschweilera odora* (Poepp.) Miers por espectroscopia no infravermelho próximo. Ciência da Madeira, Pelotas, v. 8, pp. 42-53. October. DOI: 10.12953/2177-6830/rcm.v8n1p42-53

[37] Barros, S.V.S.; Nascimento, C.C.; Azevedo, C.P. (2012). Caracterização tecnológica da madeira de três espécies florestais cultivadas no Amazonas: Alternativa para produção de lenha. *Floresta*, Curitiba, v. 42, pp. 725-732. June. DOI: 10.5380/rf.v42i4.22514

[38] Quirino, W.F.; Pinha, I.V.O.; Moreira, A.C.O.; Souza, F.; Tomazello Filho, M. (2012). Densitometria de raios x na análise da qualidade de briquetes de resíduos de madeira. Scientia *Forestalis*, Piracicaba, v. 40, n. 96, pp. 525-536. April. http://www.ipef.br/publicacoes/scientia/nr96/cap 11.pdf

[39] Demirbas, A.; Sahin-Demirbas, A. (2006). Alternative & renewable energy industries; environmental engineering; gas industries. *Petroleum Oil Industries*, v. 26, n. 1, pp. 83-91. April.

[40] Deutsches Institut Fürnormung – DIN. (1996). *Testing of solid fuels – Compressed untreated wood - DIN 5173*. Berlin. 10 p.

[41] Ostrreiches Normungs Institut – ONORM. (2000). *Compressed wood or compressed bark in natural state – pellets and briquettes, Requirements and test specifications – ONORM M 7135*. Vienna. 4 p.

[42] Figueiredo Filho, D.B.; Silva Júnior, J.A. (2009). Desvendando os mistérios do coeficiente de correlação de Pearson (r). *Revista Política Hoje*, Recife, v. 18, n. 1, pp. 115-146. January/June. DOI: 10.11606/issn.2237-4485.lev.2014.132346

[43] Souza, F.; Vale, A.T. (2016). Densidade energética de briquetes de biomassa lignocelulósica e sua relação com os parâmetros de briquetagem. *Pesquisa florestal brasileira*, Colombo, v. 36, n. 88, pp. 405-413, October/December. DOI: 10.4336/2016.pfb.36.88.879

[44] Vale, A.T.; Bustamante, K.; Fortes, M.M.; Lima, M.B.O..; Josino, M.N. (2017). Análise energética de briquetes de resíduos de *Eucalyptus* spp., *Dipterix alata*, *Caryocar brasiliense* e *Musa* spp. *Enciclopédia biosfera, Centro Científico Conhecer*, Goiânia, v. 14 n. 25, pp. 102-113. June. DOI: 10.18677/EnciBio_2017A10

[45] Sette Junior, C.R.; Lima, P.A.F.; Lopes, D.M. M.; Barbosa, P.V.G.; Coneglian, A.; Almeida, R.A. (2017). Characterization of biomass, charcoal and briquette of *Phyllostachys aurea* Carr. ex A. & C. Rivière. *Scientia Forestalis*, Piracicaba, v. 45, n. 116, pp. 619-628. DOI: 10.18671/scifor.v45n116.03

[46] Zanoni, M.M.V.; Zanatta, J.A.; Dieckow, J.; Kan, A.; Reissmann, C.B. (2015). Emissão de metano por decomposição de resíduo florestal inundado. *Revista Brasileira de Engenharia Agrícola e Ambiental*, Campina Grande, v. 19, n. 2, pp. 173–179. February. https://doi.org/10.1590/1807-1929/agriambi.v19n2p173-179

# Analysis of Balneability Indicators in Urban Areas of Leisure and Tourism in the Brazilian Stepe

Anilton da Silva Estevam[1], Wnilma Silva de Souza[2], Dajana Gabriella Nóbrega Santos da Silva[3], Sérgio Luiz Malta de Azevedo[4], Adriana Maria Cunha da Silva[5]

[1]Master in Human Ecology and Social and Environmental Management / State University of Bahia - UNEB
Center for Studies in Traditional Communities and Peoples and Socio-Environmental Actions (NECTAS)
[2]Master in Human Ecology and Social and Environmental Management / State University of Bahia - UNEB
Center for Studies in Traditional Communities and Peoples and Socio-Environmental Actions (NECTAS)
[3]Master in Human Ecology and Social and Environmental Management / State University of Bahia - UNEB, BRAZIL
Center for Studies in Traditional Communities and Peoples and Socio-Environmental Actions (NECTAS)
[4]PhD in Geography, Federal University of Campina Grande - UFCG;
Teacher of the Master's Degree in Human Ecology and Socio-Environmental Management /PPGEcoH / DTCS, UNEB, BRAZIL
[5]PhD in Geosciences from the Federal University of Pernambuco - UFPE
Teacher of the Master's Degree in Human Ecology and Socio-Environmental Management /PPGEcoH / DTCS, UNEB, BRAZIL

*Abstract— The research analyzes the conditions of bathing in urban leisure areas in the Brazilian steppe, the object of the research was Prainha de Paulo Afonso-BA, Brazil, a place widely used for leisure and tourism by the population of the municipality and the neighboring cities of the states of Bahia , Pernambuco, Alagoas and Sergipe, and to a lesser extent by tourists from various parts of the country. It is observed the existence in the country of legal parameters that regulate the conditions of use of the waters for bathing purposes; yet accompanying the national reality is evident the fragility in the inspection of these norms, constituting this point, at risk the health of the people versus economic return through the generation of income, in a real area of interest of social-environmental management and human ecology. The methodology proposed for the research is the bibliographical research, the case study and the ethnographic research. The objective is to demonstrate, from the normative point of view, the bathing conditions of Prainha de Paulo Afonso. Obtaining as a result the verification of the real conditions of use (leisure and tourism) of that space of entertainment and the recognition of the service, or not, of the normative conditions required by the supervisory body.*

*Keywords— Socio-environmental management. Water quality. Public health. Semi-arid. Tourism.*

## I. INTRODUCTION

We initially refer to Pertille (2007) who teaches us that the process of human expansion meets economic rationalization, with nature being understood as a source of raw material for the satisfaction of human needs, and that this rationalization, in most cases ignores the limitations of existing natural resources and their time to regeneration.

Thus, water is a moving environmental resource, which is why the existence of an incessant hydrological cycle (MARTINS et al., 2017); standing out among the natural inputs necessary for the survival of living beings on the face of the earth, since these living beings, including humans, do not present themselves as self-sufficient to survive without the consumption of water (PAVAN et al., 2017) .

With regard to water potential, Brazil stands out on the international scene for having a considerable amount of this resource within its territory, approximately 12% of the existing total (MARTINS et al., 2017); however, this water resource is not symmetrically distributed throughout the national territory, with the Northeast formed in a large part of its territory by the Semiarid Region (SILVA, 2017), in

which there is a shortage of the mentioned resource.

According to Santos (2017) "the São Francisco River is characterized by being the main water resource in the Northeast region of the country, an important source of fresh water existing for riverside populations, occupying about 8% of the area of the national territory"; constituting, the presence of abundant water, a fundamental factor for regional development, including for the prehistoric peoples that occupied that area for thousands of years (SILVA, 2017).

Thus, the marks left in Velho Chico by human activities are old and profound; its waters are currently used for various activities, ranging from traditional fishing, passing through industry and agriculture (SILVA, 2017); the uses with aquaculture and the generation of electric energy also stand out, as can be seen in the complex operated by Companhia Hidrelétrica do São Francisco (CHESF) and tourism (REIS, 2004).

In this context, Reis (2004) points out that investments were made by the government in order to prevent the sanitary sewage of the city of Paulo Afonso from being thrown on the bed of Velho Chico, a condition that puts the municipality in prominence among the cities of the entire Northeast.

However, this author states that even with these investments the waters of Velho Chico that bathe this municipality:

> They are heavy waters, mixed with all types of pollutants and lastly, pesticide residues from areas that house irrigation projects installed in different municipalities such as Petrolina, Santa Maria da Boa vista, Tacaratu, Jatobá, Belém do São Francisco , Curaçá, Juazeiro, Glória, Rodelas, Chorrochó, among others. It is these waters that end up reaching us through the timid drainage network and the São Francisco. We also face issues of this type at the local level, as there are neighborhoods in Paulo Afonso, throwing sewage over some of the lakes in our city (REIS, 2004, p.261).

Pinto and Sampaio (2015), based on the literature, affirm that in the Lower São Francisco there is the promotion of aquaculture and tourist activities, which depend on the good environmental quality of the river; however, the negative environmental impacts observed in all their extension (hydroelectric, deforestation of the riparian forest, introduction of exotic species, etc.) are undeniable. The same author also affirms that to this reality is added the absence of inspection and urban planning and that the existence of contaminated water endangers the health of users, especially the elderly and children.

It should be noted that the accelerated population growth in this area coupled with the absence of efficient and effective public policies have turned cities into places that are not welcoming for human coexistence. In this context, among the possible uses of water is the recreation of primary contact, a posture that has always existed in human culture, with relevant social and economic prominence (JESUS; LOPES, 2017).

Jesus; Lopes (2017) state that bathing conditions acquire greater importance within non-consumptive and local uses, since in the context of primary contact (activities such as surfing, diving and swimming) there is a real possibility of ingestion and / or inhalation of significant water, or even its contact with parts of the human body that can absorb substances harmful to health.

For this reason, primary or direct contact imposes greater restriction on water quality, in view of prolonged exposure to pathogenic organisms, cyanotoxins, insect vectors, heavy metals, oils and greases, commonly present in contaminated water bodies.

In Brazil, resolution 274/00 of the National Environment Council - CONAMA establishes the criteria for bathing the use of waters in direct contact, be they sweet, brackish or saline. Thus, it can be said that in order to achieve adequate levels of bathing it is essential to monitor water quality, understood here as a sanitation policy that takes care of the environment, especially the competent performance of the institutions responsible for this sector; that is, "the quality of the waters is understood for the purpose of primary contact recreation, which is understood as a direct contact for a significant time with the water, where the possibility of ingesting appreciable quantities is high" (TORRES, 2015, p. 16).

The author, quoting Peleja (2015), further states that the purpose of bathing is to monitor water quality to analyze "the risk of contamination by bathers, and the relatively short time between contamination and bacterial decay". Thus, the quality of the water can be classified as excellent, very good, satisfactory (considered fit for use) or inappropriate, having as reference the quantity of fecal

coliforms, Escherichia coli and enterococci, in 80% of the samples collected in five consecutive weeks (CONAMA, 2000).

CONAMA resolution 274/00 also establishes that waters can be considered as inappropriate based on other criteria, such as; have the ability to offer risk to the health of society, through the presence of sanitary sewers, "in the open", as well as the presence of residues that make it unpleasant for recreation, algae blooming or other organisms, until it is proven that they do not offer risks to human health or other factors that temporarily or permanently contraindicate the exercise of primary contact recreation (CONAMA, 2000); it is in this context that Balneário Prainha will be observed.

Agreed with Harari (2017) when he states that the human being is not separated from the other animals that exist on the face of the land; in recent decades, within the human interest issues, the growing concern about the effects of human activities on the environment, especially those related to water pollution, has been highlighted (CAVALCANTI, 2016).

In this way, this research presents questions regarding the bathing conditions of urban areas of tourism and leisure in the Brazilian steppe, being used for the analysis Balneário Prainha, located in the city of Paulo Afonso-BA, Brazil, constituting a theme of social relevance due to the complexity and peculiarities that accompany this discussion; since, like other environments that have similar characteristics, the locality is widely used for leisure and tourism purposes of the local population and the surrounding municipalities located in the states of Bahia, Pernambuco, Alagoas and Sergipe; being a relevant tourist spot and consequently generating employment and income for part of the community that survives from service activities in the mentioned area.

## II. METHODOLOGY

The research was carried out at Balneário Prainha in the city of Paulo Afonso, "located in homogeneous micro-region nº 147 - Sertão de Paulo Afonso, in the territory of Itaparica" (SILVA, 2014, p.251), Northeast region of Bahia; located between the parallels of 9º39'e 27 "and 9º21'e 10" south latitude and between the meridians of 37º59 'and 52 "and 38º32' and 16" west longitude, 434.7 km away from the capital of Salvador (REIS , 2004), bordering the states of Sergipe, Alagoas and Pernambuco. One of its characteristics is the fact that,

> For the construction of Chesf's plants, large reservoirs were also created in the region, such as the Moxotó Dam, which accumulates 1.2 billion cubic meters of water. A channel 150 meters wide and 6 kilometers long carried water from this reservoir to the Lago da Usina Paulo Afonso 4, transforming the central area of the city of Paulo Afonso into a large island, the Island of Paulo Afonso (SILVA, 2014, p. 251).

According to data provided by the Brazilian Institute of Geography and Statistics (IBGE), it has an estimated population in 2018 of 117,014 people and an area of 1,545,192 km² (IBGE, 2018).

The chosen location originated from the flooding of areas for the creation of the reservoir of the Lago da Usina Paulo Afonso IV, being directly connected to the artificial channel that transformed the central area of Paulo Afonso into an island. It has appropriate characteristics for direct contact with the waters of the São Francisco River, being commercially explored by numerous bars and restaurants that receive tourists from all regions of the country, in addition to hosting nautical and momescos events.
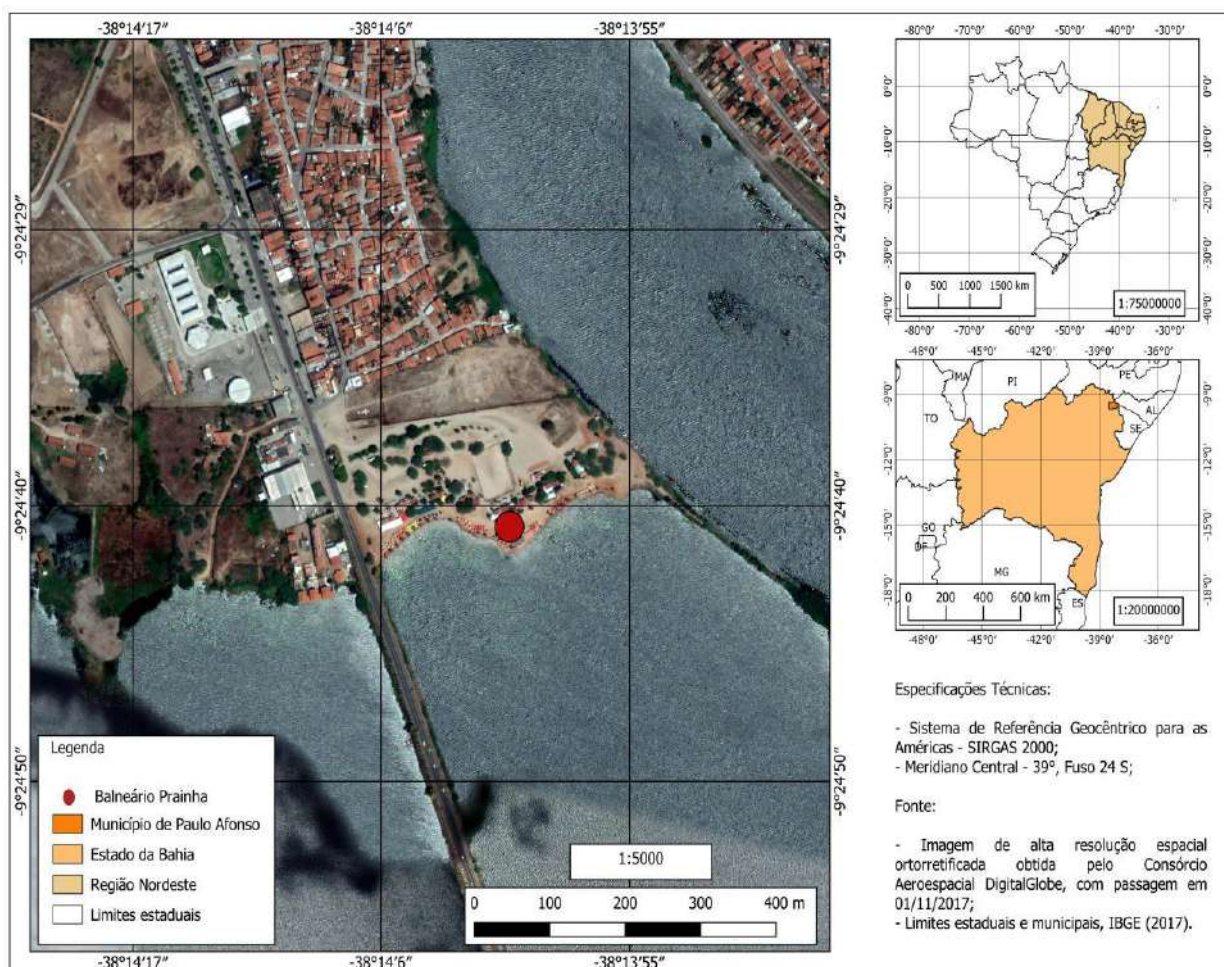
*Map of Prainha by Paulo Afonso - BA*

*Source: Authors*

For the present study, bibliographic and documentary research was used as the initial methodological proposal, which used several publications (articles, books and dissertations) and documents on the subject under analysis, with data collected during the months of August, September and October of the year 2018, photographic records of the location were added to this method.

As a parameter for assessing the bathing of the waters of Balneário Prainha, the indicators present in CONAMA Resolution 274/00 were used; having as exclusion criteria the need to perform laboratory tests or use of specialized equipment, so among these indicators, the following were selected for use in this research: existence of oils and greases; flowering of algae or other organisms, turbidity and existence of garbage or residential sewage discharged directly into the waters.

The analysis of the items above were carried out within the parameters proposed by Lopes; Magalhães Jr and Sperling (2015) as indicators for freshwater bathing in

Brazil.

## III.     RESULTS AND DISCUSSION

Tourist activities, especially those related to the use of bathing areas for the recreational practice of their waters, are important generators of income in small, medium and large cities. The resort under study is a reference in the city for the development of this practice, and guarantees the support of several families.

After data collection and field visits for on-site observation; as well as the raising of issues and analysis of the problem in the face of the literature and the observed observations, especially with regard to the questions of socio-environmental management regarding the bathing of the waters of Prainha de Paulo Afonso. Thus, the following parameters were considered for measuring the results of this research:

### Existence of oils and greases

Regarding the existence of oils and greases in the waters of the spa Prainha de Paulo Afonso, in the three visits made in the locality, the direct incidence of these tailings was not observed.

However, the areas adjacent to the spa, more specifically in other points of the channel of the lake of Usina Paulo Afonso 4 (inner margins of the channel, Bairro Barroca, Bico de Pedra; Prainha Airton Senna and Prainha do Candeeiro) are used for bathing and washing clothing and automotive vehicles (cars, motorcycles and trucks).

The weakness observed in the environmental monitoring of the area, as suggested by Silva. et al. (2015), for the purpose of leisure, it allows the existence, even in

specific moments and in a small amount, of oils and greases in the waters existing in the channel of the Lago da Usina Paulo Afonso 4.

Thus, even though CONAMA Resolution 274/200 does not have reference values for the tolerance of oils and greases in waters used for recreation, it allows the classification of water as inappropriate if the presence of these elements may endanger the health of people. people or generating water condition that displeases its use for recreational purposes (LOPES; MAGALHAES-JR; SPERLING, 2015).



*Source: http://www.pa4.com.br/noticias/22799*

### Flowering algae or other organisms

There is an evident blooming of algae or other organisms in the waters of Balneário Prainha by Paulo Afonso; situation that has already been verified in other researches, such as those developed by Silva et al (2015) and Cavalcanti (2016), which largely register the eutrophication of this recreation space, among other identified environmental management problems.

Thus, the proliferation of macrophytes in the water mirror and algae along the sand was found on the banks and / or in a place close to the spa; reality that as taught by Barbosa et al. (2015) represents a potential risk of contamination and degradation of water resources and soil; contributes to the qualitative unavailability of water resources; contributes to the occurrence of the eutrophication process; it increases costs for water

treatment, in addition to providing a favorable environment for the proliferation of disease vectors and causing loss of local biodiversity.

For Cavalcanti (2016) eutrophication occurs due to the excessive increase of nutrients in the aquatic environment and this increase occurs due to several factors, such as drainage of fertilizers; drainage of human waste. Among the species easily observed in the Lago Afina Paulo Afonso 4 channel, the following stand out: baronesas (Eichhornia crassipes), cattails (Thypha domingensis) and various types of algae; a finding that indicates the high eutrophication of the environment, which for Cavalcanti (2016) is linked to the economic and recreational activities developed on the site.

Corroborating with the one defended by the author, we understand that the presence of these aquatic plants in the

locality is recurrent and that the government and / or local businessmen; due to the high accumulated volume, the possibility of damage to public health and to the commercial enterprises existing on the site, they periodically clean and remove them; as well as carrying out intervention works in order to contain the advance / approach of these plants in the area of the bathhouse margins used by bathers.



*Source: http://www.pa4.com.br/noticias/baronesas-invadem-rio-e-mudam-paisagem-da-prainha-e-do-lago-da-pa4-em-paulo-afonso-fotos-e-videos*

### Turbidity

During the research, no signs of turbidity were observed in the waters, the approximate distance of 220 m from the margins of the area used for recreation in Balneário Prainha; however, it can be inferred that this phenomenon occurs due to the existence of a containment, placed by the City of Paulo Afonso this year, from the end of the peninsula to the BA 210 highway, an area that constitutes the main access of the channel waters to the banks used by bathers for recreation.

*Source: Authors*

Fact that could not be verified at the beginning of the year 2016, in the initial months of 2018 and in the initial six months of the year 2019, according to existing records and widely disseminated by the government and the local press that record that they were removed from the place "among on March 14, when the process started until April 4, 2,434 tipper trucks were removed from the São Francisco River, which represents approximately 20 thousand cubic meters of baroners. In weight, 9,800 tons "(PMBA, 2018).

A reality similar to the one previously mentioned is currently found in other points of the reservoir and in the place where the containment is installed; where the accumulation of baronets and various types of algae occurs, which, due to not being removed, rot and increase the amount of organic matter already in the water, contributing to the proliferation of younger plants; for the appearance of animals that adapt to that environment and for the appearance of odors and coloring do not favor its use for recreation.

*Source: http://www.pa4.com.br/noticias/o-antes-e-o-depois-mostram-o-tamanho-do-estrago-causado-pelas-baronesas-na-prainha-de-paulo-afonso*

**Existence of garbage or residential sewage discharged directly into the waters**

It is a fact that no changes have been observed since the conclusions presented as a result of the research carried out in the same place by Barbosa et al. (2015) and Cavalcanti (2016) who found the existence of fresh domestic sewage being discharged directly into the waters of the São Francisco River at different points in the Paulo Afonso Usina 4 reservoir channel. The same reasoning can be used regarding the existence and garbage deposit along the banks of this same channel.

The data collected in the field visits of this research ratify what was observed by the mentioned researchers, confirming that along the channel of the reservoir of Usina Paulo Afonso 4, numerous points of discharge of domestic sewage and garbage deposits are found. In contrast, the existence of active pipelines that discharge residential or commercial sewage directly into the waters of the resort were not found, specifically in the area known as Prainha Beach Resort.

However, with regard to domestic and commercial garbage, several accumulation points were found, in the vicinity or on the margins of the area used for direct contact by bathers in Prainha de Paulo Afonso, a condition that allows easy contamination of the water by these polluting agents , being only necessary, for that, the existence of light breeze or rain in the place.

*Source: Authors*

## IV.     FINAL CONSIDERATIONS

In order to comply with CONAMA resolution 274/2000, it is necessary to carry out laboratory tests to verify the real classification of the waters of Balneário Prainha as improper or appropriate for use in activities of direct contact by human beings; it is worth mentioning the need for scientific research related to the socio-environmental impacts resulting from the tons of feed launched to feed fish in the dozens of fish farms that have existed since the source of the São Francisco River.

From the data examined, it is concluded that there are environmental impacts in the locality known as Prainha de Paulo Afonso, which undergoes a sensitive eutrophication process, as a result of the high amount of organic matter in the São Francisco riverbed, the height of the reservoir channel. Usina Paulo Afonso 4; impacts that are continuous and result from anthropic activities, with the existence of several types of algae and a large volume of baronesas (CAVALCANTI, 2016).

The environmental impacts existing at the site interfere with the environmental quality (BARBOSA et al., 2015) and consequently its bathing; which demonstrates a

risk factor, since the location is widely used by the local population (traders and bathers) and tourists for recreational activities that require direct contact with the waters.

As a solution proposal, there is an urgent need for strong investment in environmental education in all municipalities bathed by the waters of Velho Chico; in addition to the elaboration of public policies aimed at mitigating the existing environmental impacts in the São Francisco River, since the population of the city of Paulo Afonso contributes to the present scenario, but it is not its only cause, since the Usina Paulo channel Afonso 4 is formed by "heavy waters, mixed with all types of pollutants and finally, by pesticide residues" (REIS, 2004, p. 261).

Thus, instituting the practice of continuous monitoring is an important mechanism to enhance the chances of ensuring the environmental quality of the Prainha spa and its effective bathing.

## REFERENCES

[1] AGÊNCIA NACIONAL DAS ÁGUAS – ANA. **Cadernos de recursos hídrico: turismo e o lazer e sua interface com o setor de recursos hídricos**. Brasília/DF: Ministério do Meio Ambiente (MMA), 2005. 79p. Available in: <http://livros01.livrosgratis.com.br/an000007.pdf> Access in: 20 out. 2018

[2] ANDRADE, M. M.; OLIVEIRA, L. W.; VIEIRA, A. G. **Avaliação da balneabilidade e identificação da ictiofauna do balneário da Amizade de Presidente Prudente - SP**. Periódico Eletrônico Fórum Ambiental da Alta Paulista, Alta Paulista/SP, v.11, n.1, p.88-99, 2015. Available in: <http://www.amigosdanatureza.org.br/publicacoes/index.php/forum_ambiental/article/view/1075/1098> Access in: 21 out. 2018

[3] BARBOSA *et al*. **Levantamento e Avalição dos Impactos Ambientais na Prainha de Paulo Afonso, Bahia, Área de Uso Recreacional das Águas na Bacia do Rio São Francisco**. Anais do 8º Encontro Internacional das Águas Tema: Tratamento de água: Qualidade, Economia e Sustentabilidade, Recife/PE, n.1, p.1-11, 2015. Available in: <https://www.researchgate.net/publication/276270081_LEVANTAMENTO_E_AVALIACAO_DOS_IMPACTOS_AMBIENTAIS_NA_PRAINHA_DE_PAULO_AFONSO_BAHIA_AREA_DE_USO_RECREACIONAL_DAS_AGUAS_NA_BACIA_DO_RIO_SAO_FRANCISCO> Access in: 21 out. 2018

[4] CAVALCANTI, L. A. P. **Avaliação do Processo de Eutrofização no Balneário da Prainha - Paulo Afonso/BA**. Anais do Congresso Brasileiro de Gestão Ambiental e Sustentabilidade - Vol. 4: Congestas 2016, João Pessoa/PB, v.4, n.1, p.856-860, 2016. Available in: <http://eventos.ecogestaobrasil.net/congestas/> Access in: 21 out. 2018

[5] HARARI, Y. N. **Sapiens: uma breve história da humanidade**. 30ª. ed. Porto Alegre: L&PM, 2017. 464p.. HARARI, Y. N. **Sapiens: uma breve história da humanidade**. Porto Alegre, RS: L&PM, 2017.

[6] JESUS, C. R.; LOPES, F. W. A. **Lazer e balneabilidade: uma abordagem histórica sobre o uso recreacional das águas na sociedade**. Revista Caderno de Geografia, Belo Horizonte/MG, v.27, n.50, p.557-572, 2017. Available in: <http://periodicos.pucminas.br/index.php/geografia/article/view/p.2318-2962.2017v27n50p557/11765> Access in: 17 out. 2018

[7] LOPES, F. A.; MAGALHAES-JR, A. P.; SPERLING, E. V. **Indicadores para balneabilidade em águas doces no Brasil**. Revista Geografias, Belo Horizonte/MG, v.11, n.1, p.6-22, 2015.. Belo Horizonte, Janeiro - Junho Vol.11 nº1 2015 Available in: <http://www.igc.ufmg.br/portaldeperiodicos/index.php/geografias/article/view/648/501> Access in: 17 out. 2018

[8] MARTINS *et al*. **Análise dos paramêtros de balneabilidade: um estudo de caso sobre as praias dos municípios de joão pessoa e cabedelo/pb**. Revista InterScientia, João Pessoa/PB, v.5, n.1, p.116-, 2017. Available in: <https://periodicos.unipe.br/index.php/interscientia/article/view/452/413> Access in: 17 out. 2018

[9] PAVAN *et al*. **Diagnóstico e análise da balneabilidade da área de proteção ambiental da lagos de cima, localizada no município de campos dos goytacazes/RJ**. Revista Perspectivas Online: Ciências Exatas & Engenharias, Campos dos Goytacazes/RJ, v.7, n.18, p.41-51, 2017. Available in: <http://seer.perspectivasonline.com.br/index.php/exatas_e_engenharia/article/view/1190/916> Access in: 18 out. 2018

[10] PERTILLE, I. **o uso turístico dos reservatórios de hidrelétricas: estudo dos terminais turísticos no lago de itaipu, paraná, brasil**. 2007. 145f. Dissertação (Mestrado em Turismo) - Universidade de Caxias do Sul, Caxias do Sul, 2007.

[11] PINTO, T. K.; SAMPAIO, C. L. S. **Poluição por resíduos sólidos no baixo São Francisco, Nordeste Brasil**. Revista de Desenvolvimento Econômico – RDE, Salvador/BA, v.XVII, n.1, p.431-442, 2015. Available in: <https://revistas.unifacs.br/index.php/rde/article/view/4015/2737> Access in: 18 out. 2018

[12] REIS, R. R. A. **Paulo Afonso e o Sertão baiano: sua geografia e seu povo**. Paulo Afonso/BA: Fonte Viva, 2004. 308p.

[13] SANTOS, C. A. B.; SANTOS, K. S. S. **Aspectos socioambientais da pesca artesanal no submédio são francisco**. In: II CONGRESSO INTERNACIONAL DA DIVERSIDADE DO SEMIARIDO, Campina Grande/PB, v. ISSN 2526-186X, n.1, p.1, 2017. Available in: <http://www.editorarealize.com.br/revistas/conidis/trabalhos/TRABALHO_EV074_MD1_SA2_ID2287_23102017235039.pdf> Access in: 16 out. 2018

[14] SILVA, F. J. R. **Povos indígenas  atingidos pelo projeto de transposição das águas do são francisco. In: História ambiental: recursos naturais e povos tradicionais no semiárido nordestino / Edson Hely Silva; Carlos Alberto Batista Santos; Edivania Granja da Silva Oliveira (Org.)**. Curitiba/: Appris, 2017. 313p.

[15] SILVA, A. G. **De Forquilha a Paulo Afonso: histórias e memórias de pioneiros**. Paulo Afonso/BA: Fonte Viva, 2014. 456p.

[16] TORRES, A. D. M. **Avaliação da qualidade e balneabilidade da água da Barragem de Santa Cruz - Apodi/RN**. 2015. 89f. Dissertação (Mestrado em Ambiente, tecnologia e sociedade) - Universidade Federal Rural do Semiárido (UFERSA), Mossoró, 2015.

[17] **Baronesas no balneário Prainha de Paulo Afonso em 14/03/18**. Available in: <http://www.pa4.com.br/noticias/baronesas-invadem-rio-e-mudam-paisagem-da-prainha-e-do-lago-da-pa4-em-paulo-afonso-fotos-e-videos> Access in: 21 out. 2018

[18] **CONAMA. Ministério do Meio Ambiente. Resolução CONAMA Nº 274/2000**. Available in: <http://www.mma.gov.br/port/conama/res/res00/res27400.html> Access in: 18 out. 2018

[19] **IBGE. Cidades Paulo Afonso (2018)**. Available in: <https://cidades.ibge.gov.br/brasil/ba/paulo-afonso/panorama> Access in: 18 out. 2018

[20] **PMBA. Nota sobre retirada de baronesas nos lagos de paulo afonso (2018)**. Available in: <http://www.pauloafonso.ba.gov.br/novo/?p=noticias&i=6759#> Access in: 21 out. 2018

[21] **Lavagem de veículos no Lago da PA IV**. Disponivel em: <http://www.pa4.com.br/noticias/22799> Access in: 09 jun. 2019

[22] **Baronesas na Prainha de Paulo Afonso**. Available in: <http://www.pa4.com.br/noticias/baronesas-invadem-rio-e-mudam-paisagem-da-prainha-e-do-lago-da-pa4-em-paulo-afonso-fotos-e-videos> Access in: 09 jun. 2019

[23] **Antes e depois das baronesas na Prainha de Paulo Afonso**. Available in: <http://www.pa4.com.br/noticias/o-antes-e-o-depois-mostram-o-tamanho-do-estrago-causado-pelas-baronesas-na-prainha-de-paulo-afonso> Access in: 09 jun. 2019

# Influence of the coefficient of thermal expansion on the stress distribution in ceramic veneers after thermal simulation

Marco Aurélio de Carvalho[1], Mariane de Castro Boaventura[2], Tainah Costa Firmiano[3], Naysa Wink Neris[2], Adna Alvez Rocha[2], Priscilla Cardoso Lazari-Carvalho[1]*

[1]Professor, School of Dentistry, University of Anápolis, Anápolis, Brazil.
[2]Master student, School of Dentistry, University of Anápolis, Anápolis, Brazil.
[3]PhD student, School of Dentistry, University of Goiás, Anápolis, Brazil.
*Corresponding author:

*Abstract— The aim of the study was to evaluate the stress distribution in the ceramic veneers in a full prosthetic crown with different framework after the sintering and cooling cycle through the thermal analysis by three-dimensional finite element analysis. Using images from a computerized microtomography of a central incisor, an anterior crown was constructed. The models were composed of 2mm thickness ceramics (feldspathic ceramics) and 0.4mm thickness frameworks(zirconia, alumina, lithium-disilicate, or metal). Ansys Workbench finite element software was used for analysis and mesh generation through a 5% convergence. The thermal loading was performed in 2 stages simulating the heating and cooling of the ceramic veneer sintering cycle: stage 1 - 403 to 750 degrees C; stage 2 - from 750 to 25 degrees C. The von Mises equivalent strain($\sigma vM$) was used for the quantitative and qualitative evaluation of the framework. The maximum ($\sigma max$) and minimum ($\sigma min$) stresses were used to evaluate the ceramic veneer and zirconia, alumina, and lithium-disilicate frameworks. The highest values of compressive stress (294,58 MPa) were found in the ceramic veneer in the models with alumina framework, followed by models with zirconia (253,65 MPa), palladium silver (239,74 MPa), and lithium disilicate (205,43MPa). The tensile stresses followed the same behavior presenting the highest values in the alumina prostheses (Al: 93,977 MPa, Zr: 76,358 MPa, Ps:68,193 MPa and Ld: 56,573 MPa). The ceramic framework alumina and zirconia cause a higher stress concentration in the ceramic veneers. The stress concentration in the ceramic veneers was affected not only by the coefficient of thermal expansion but also for the mechanical properties of the framework materials.*

*Keywords— ceramic crown, finite element analysis, thermal analysis.*

## I. INTRODUCTION

Metal-free prosthetic crowns have been highly appreciated in the dentistry, mainly in the anterior region, due to its ideal aesthetic characteristics, translucency close to the dental structure, and absence of the metal collar in the cervical region[1].

Besides these characteristics, the high resistance of the ceramic framework (lithium disilicate, alumina, and zirconia) associated with the feldspathic ceramic has become a relevant alternative for thin kind of restoration[2,3]. The zirconia, widely used as a framework material due to the high biocompatibility[4]and excellent mechanical properties, has an excellent tensile (1200 MPa) and compressive strength (2000 MPa)[5]. However, the zirconia frameworks present a high prevalence of ceramic veneer chippings[5–8].In this way, this failure is statistically higher when compared to the metal-ceramic crowns[9,10].

The incompatibility of the properties related to the thermal expansion between the framework and the ceramic veneer can induce the formation of residual stresses in these materials[11]. These residual stresses influence the fracture resistance of the ceramics used as aesthetic cover

material[12]. Therefore, understand the possible contribution of the Coefficient of Thermal Expansion (CTE) in the development of the residual stresses in the ceramic veneer is crucial to avoid fractures and chipping after the heating and cooling cycles[13].

It is believed that the predisposition to long-term failures is related to thermal mismatch between zirconia and ceramic veneer, and not to the intrinsic characteristics, that are inherent to each material[14,15].Another point to take into account is the fracture propagation, which begins and expands in ceramics veneer and not in the framework[16].

During the preparation of prosthetic crowns, they are submitted to heating, firing, and cooling process. The concept of veneer ceramic application advocates that this has a CTE slightly lower (10% or less) then the CTE of the framework used to the metal-ceramic restorations and for all the ceramic materials, promoting a positive thermal mismatch, thus leading to compressive stresses between the two materials, avoiding in this way the ceramic veneer fracture during the cooling process[17–20].If the CTE of the ceramic veneer is significantly higher than that of the framework, tensile stresses are generated and the chipping of the ceramic veneer may occur[21]. Thereby, due to the differences in thermal behavior between the framework and ceramic veneer materials, its physical-chemical properties are adapted to expand and contract proportionately[22].

So then, it is important to emphasize that the literature is scarce about studies that quantify the stresses generated in the ceramic veneer after de complete sintering cycles of the materials addressed in this research. The finite element analysis can help the evaluation of the site where the stresses begin, thus allowing the comprehension of the CTE effects on the generated stresses in the ceramic veneer when using different materials as a framework. Therefore, this study aimed to evaluate the effect of the differences between the coefficients of thermal expansion of some materials used as a framework (alumina, zirconia, metal, and lithium disilicate) in the stress distribution of the ceramic veneers using the thermal simulation in a three-dimensional finite element analysis.

## II.    MATERIAL AND METHODS

### Experimental Design

Three 3D models of an incisive single crown were virtually constructed. For these models, the crowns were divided into a framework and ceramic veneer. The framework materials were varied between Zirconia - Zr,

Palladium-silver – Ps, Lithium-disilicate – Ld, and Alumina - Al. The models were thermally loaded assuming two conditions: a) firing rate: raging from 403°C to 750°C and b) cooling rate: raging from 750°C to 25°C. The finite element software was used to determine the tensile and compressive stress areas for the framework and ceramic veneer.

### 3D Models Construction

A 3D model of a maxillary central incisor was used for constructed a single crown using the SolidWorks 2013 software (Dassault Systèmes SolidWorks Corp, Waltham, Massachusetts, USA). The maxillary central incisor was prepared to receive a full prosthetic crown with 2mm of thickness, following the natural anatomy of the dental surfaces. The incisal edge was reduced 2.5mm and the margin designed was defined as a chamfer. After that, the prosthetic crown was obtained using boolean operations. The boolean subtraction operation was performed for the framework and ceramic veneer construction, which was defined with 0.4- and 1.6-mm thickness, respectively[23] (Figure 1).
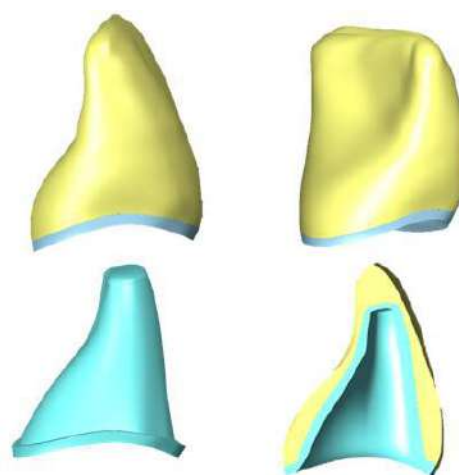


*Fig.1: The 3D solid model of an incisor crown with a framework and ceramic veneer.*

### Numerical Analysis

The models were exported to Ansys Workbench 14.0 FEA software (Swanson Analysis Inc, Canonsburg, Pennsylvania, USA) for the finite element analysis. All structures were considered linear, isotropic, and homogeneous and its properties.

A convergence of analysis (5%) in all models was achieved using a tetrahedral mesh containing 0.5 mm elements and the final mesh for the models resulted in approximately 5300 elements and 10300 nodes for both solids (Figure 2).
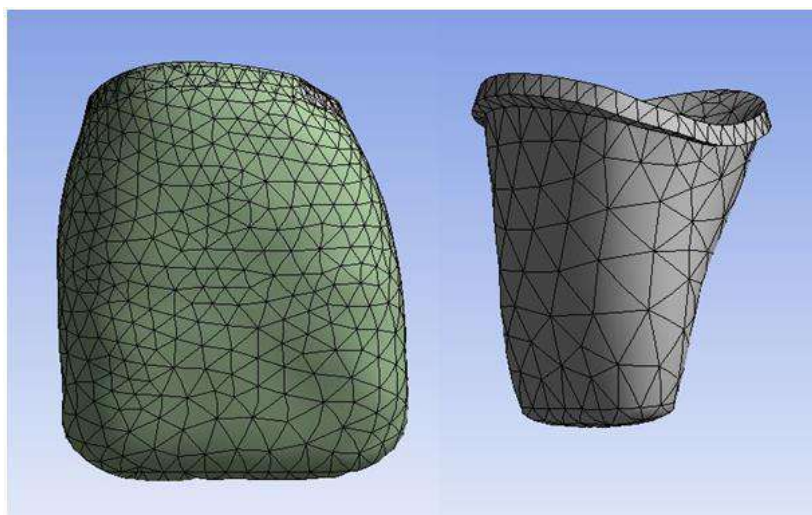
*Fig.2: Tetrahedral 0,5mm elements mesh.*

The models were thermally loaded in 2 steps simulating the firing and cooling process. The firing temperature was varied from 403° to 750°C and the cooling temperature was varied from 750° to 25°C. The CTE of each material was obtained from the manufacturer and is also demonstrated in Table 1.

*Table 1: Mechanical properties of materials used.*

| MATERIAL | Young's Modulus (Gpa) | Poisson's ratio | Coefficient of thermal expansion (10-6/K) |
|---|---|---|---|
| Ceramic veneer | 70 | 0.24 | 9,5 |
| Zirconia | 205 | 0.22 | 11 |
| Palladium-silver | 150 | 0.33 | 13,5 |
| Alumina | 370 | 0.22 | 8 |
| Litium-dissilicate | 95 | 0,30 | 10,2 |

The results were evaluated using maximum and minimum principal stress for the ceramic veneer.

## III. RESULTS

The results were obtained using the maximum (tension) and minimum principal stress criteria for ceramic veneers, the quantitative analysis of which is shown in Figure 3. The highest values of compressive stress (294,58 MPa) were found in the ceramic veneer in the models with alumina framework, followed by models with zirconia (253,65 MPa), palladium-silver (239,74 MPa), and lithium-disilicate (205,43MPa). The tensile stresses followed the same behavior presenting the highest values in the alumina prostheses (Al: 93,977 MPa, Zr: 76,358 MPa, Ps:68,193 MPa and Ld: 56,573 MPa).
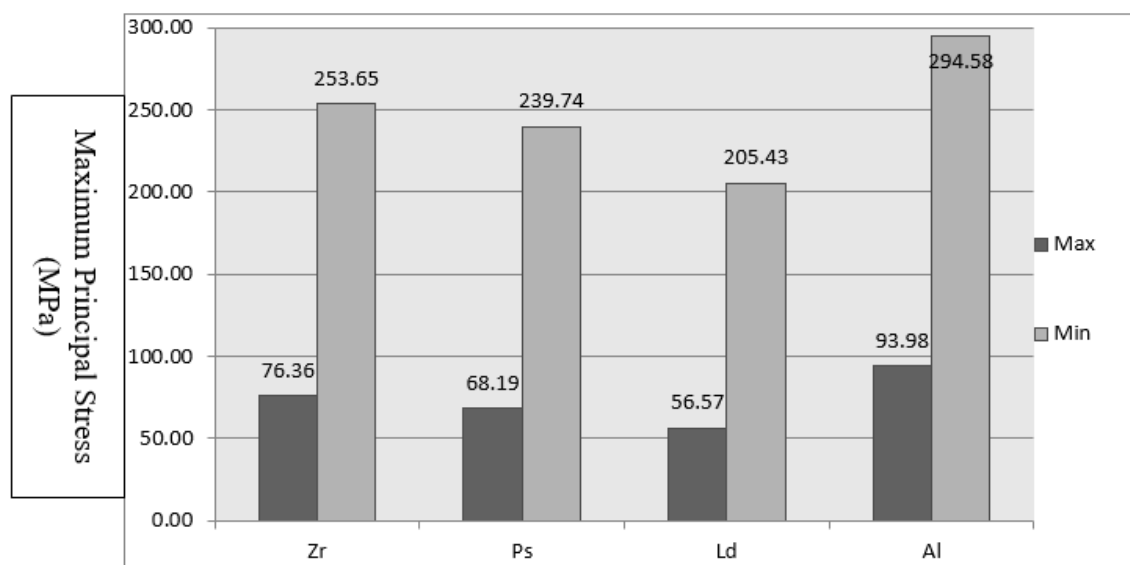
*Fig.3: Maximum and Minimum Principal Stress in the ceramic veneer for the different core materials.*

The maximum tension and compression were located on the external lingual face of the ceramic veneers in all models. The pattern of stress distribution did not change with the use of different materials (Figure 4,5 and 6). It was observed that the peak stress was located in the area of the lowest volume of the ceramic veneer, indicating that the thickness of the restorative material may influence the stress distribution.
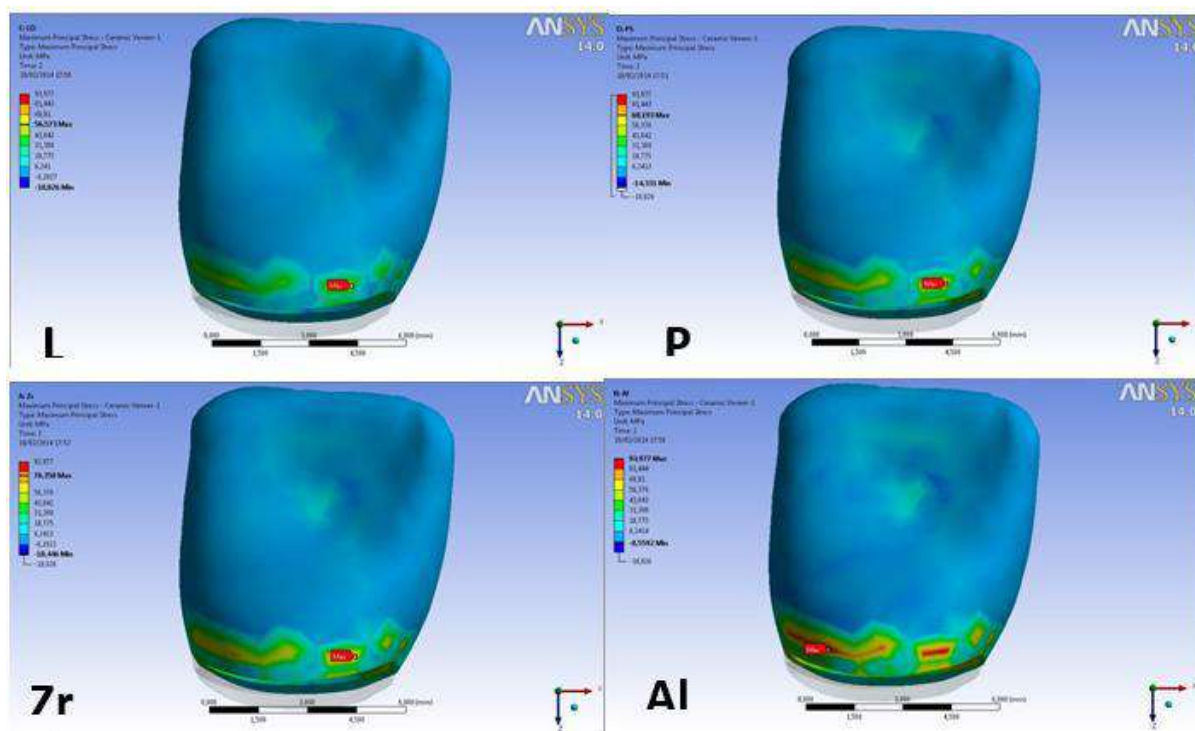


*Fig.4: Maximum Principal Stress for the ceramic veneer in the lingual view.*
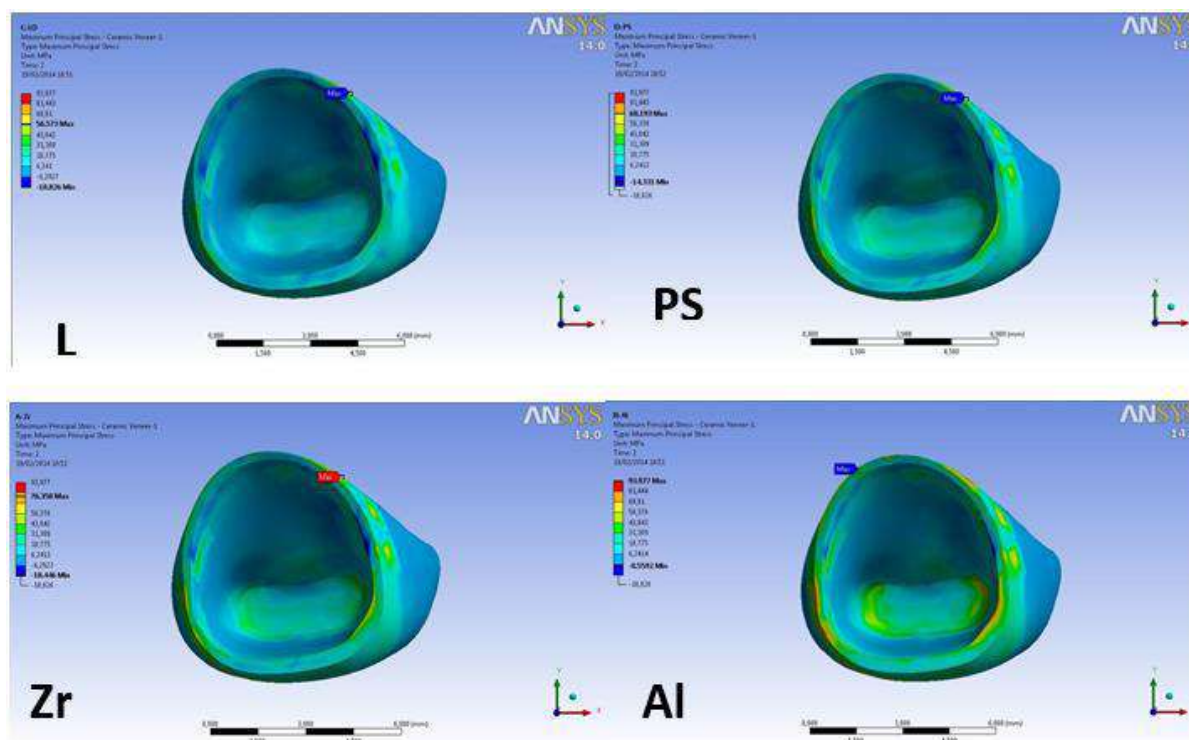
*Fig.5: Maximum Principal Stress for the ceramic veneer in the intaglio surface.*
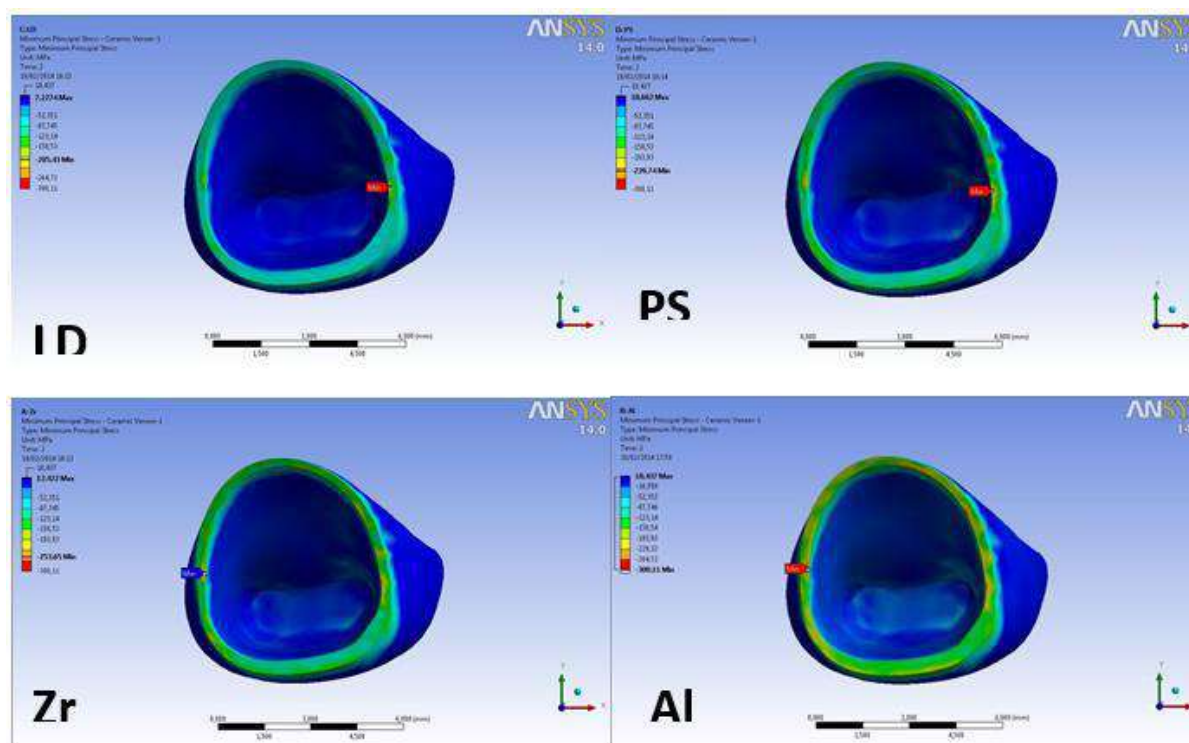


*Fig.6: Minimum Principal Stress for the ceramic veneer in the intaglio surface.*

## IV.   DISCUSSION

The contribution of the cooling rate, differences in CTE between the core and veneer material, and a complex tooth geometry need to be considered as potential sources of residual stresses causing the fracture of ceramic veneers. The present study evaluated the stress generated in the ceramic veneer of the full crown using four different core materials. The results indicate that core material with

a high difference with ceramic veneer material can induce stress in the cervical area of the ceramic veneers. The greater the incompatibility of the CTE, the greater was the tensile and compression stress observed in the ceramic veneer.

All-ceramic systems are widely used to achieve excellent esthetic restorations. Especially for zirconia and alumina restorations, they need to be covered by feldspathic ceramic to decrease the opacity of the framework[24].If the core/ceramic veneer interface exhibits an incomplete bond, chipping or fracture is expected to initiate in the veneer margins[25]. The literature reports that the interface between the ceramic veneer and the framework affects the mechanical performance of the ceramic veneer [24], showing the importance of this interface in the integrity of the restorations.

The framework/veneer interface may suffer from many variables that can affect the bond strength, such as the surface of the core. The surface can affect the mechanical retention and residual stresses generated by the mismatch of the CTE between the ceramic and framework structures[25].

The CTE mismatch variation and the cooling rate had a greater impact on the failure of the ceramic veneer [16]. Sebastiani in 2015 observed that the cooling rate and the thickness of the ceramic veneer influence the thermal gradient during the cooling process and residual stress, however, the study did not use crowns, due to this fact, the anatomical conformation it was suggested as a reason for the change in the distribution of residual stress[26]. This study presents a three-dimensional model simulating a crown in its anatomical aspects and the distribution of residual stress was better elucidated. The hypothesis that the thickness of the ceramic veneer influences the thermal gradient during the cooling was confirmed since the higher stress was observed in the cervical area of the crown, where the ceramic had lower thickness.

The residual stress generated can be modulated by the slow cooling protocol [8,27,28] but this factor has been controversial in the related literature. Some studies show less resistance to fracture when the ceramic was cooled quickly, suggesting that tensile stress is generated as a consequence of a high-temperature gradient during solidification and that residual stress develops on the surface of the quickly cooled ceramic[12]. Another study found no significant differences between fast and slow cooling protocols[9,19,29]. In this study, the cooling process was simulated as a fast cooling process, since this process appears to be the most challenging to the ceramic veneer. The results prove that the fast cooling process produces

high stress in the ceramic veneer and can be harmful to the success of the restoration, especially on crowns with alumina or zirconia frameworks. Bonfante et al. evaluated the cooling process using finite element analysis and found that the all-porcelain system presented high-stress concentration compared with metal ones. However, in the study, the authors did not compare the residual stress generated between the firing and cooling process [21].

When evaluating the results of this present study with the CTE of the materials, the alumina crown showed a negative mismatch between the veneer and framework material and present high stress in the ceramic veneer. The palladium-silver material a greater mismatch and presents lower stress that zirconia material. This can be explained that not only the CTE but also elastic modulus and Poisson's ratio of the material can influence the stress distribution.

Fatigue, different framework designs, and different veneer layer thicknesses were not considered in the present study. These factors should be evaluated in future investigations. Therefore, although further virtual simulations are required to gain a better understanding of the mechanical behavior of the zirconia core/ceramic veneer interface, the results of the present study add useful data to previous in vitro findings.

## V. CONCLUSION

The differences between the CTEs influence the mechanical behavior of the ceramic veneers. The differences between the systems indicate that the compatibility between the CTEs is fundamental, but also the mechanical properties (elastic modulus) to maintain a mechanical performance of the veneering ceramics. The lithium disilicate frameworks cause lower stress in the ceramic veneers, while the alumina the higher stress.

## REFERENCES

[1] Schmitter M, Lotze G, Bömicke W, Rues S. Influence of surface treatment on the in-vitro fracture resistance of zirconia-based all-ceramic anterior crowns. Dent Mater 2015;31(12):1552–60.

[2] Cattell MJ, Palumbo RP, Knowles JC, Clarke RL, Samarawickrama DYD. The effect of veneering and heat treatment on the flexural strength of Empress 2 ceramics. J Dent 2002;30(4):161–9.

[3] Guazzato M, Proos K, Quach L, Swain MV. Strength, reliability and mode of fracture of bilayered porcelain/zirconia (Y-TZP) dental ceramics. Biomaterials 2004;25(20):5045–52.

[4] Fischer J, Stawarczyk B, Tomic M, Strub JR, Hämmerle CHF. Effect of thermal misfit between different veneering

ceramics and zirconia frameworks on in vitro fracture load of single crowns. Dent Mater J 2007;26(6):766–72.

[5] Piconi C, Maccauro G. Zirconia as a ceramic biomaterial. Biomaterials 1999;20(1):1–25.

[6] Denry I, Kelly JR. State of the art of zirconia for dental applications. Dent Mater 2008;24(3):299–307.

[7] Mainjot AK, Schajer GS, Vanheusden AJ, Sadoun MJ. Influence of cooling rate on residual stress profile in veneering ceramic: measurement by hole-drilling. Dent Mater 2011;27(9):906–14.

[8] Belli R, Wendler M, Zorzin JI, Petschelt A, Tanaka CB, Meira J, et al. ScienceDirect Descriptions of crack growth behaviors in glass–ZrO 2 bilayers under thermal residual stresses. Dent Mater 2016;32:1165–76.

[9] Wendler M, Belli R, Petschelt A, Lohbauer U. Spatial distribution of residual stresses in glass-ZrO2 sphero-cylindrical bilayers. J Mech Behav Biomed Mater 2016;535–546.

[10] Heintze SD, Rousson V. Survival of Zirconia- and Metal-Supported Fixed Dental Prostheses: A Systematic Review. 2010;23(6):493–503.

[11] Göstemeyer G, Jendras M, Dittmer MP, Bach F-W, Stiesch M, Kohorst P. Influence of cooling rate on zirconia/veneer interfacial adhesion. Acta Biomater 2010;6(12):4532–8.

[12] Belli R, Wendler M, Zorzin JI, Petschelt A, Tanaka CB, Meira J, et al. Descriptions of crack growth behaviors in glass–ZrO2 bilayers under thermal residual stresses. Dent Mater 2016;32(9):1165–76.

[13] Swain M V. Unstable cracking (chipping) of veneering porcelain on all-ceramic dental crowns and fixed partial dentures. Acta Biomater 2009;5(5):1668–77.

[14] Aboushelib MN, Kleverlaan CJ, Feilzer AJ. Microtensile bond strength of different components of core veneered all-ceramic restorations. Part II: Zirconia veneering ceramics. Dent Mater 2006;22(9):857–63.

[15] Fischer J, Stawarzcyk B, Trottmann A, Hämmerle CHF. Impact of thermal misfit on shear strength of veneering ceramic/zirconia composites. Dent Mater 2009;25(4):419–23.

[16] Belli R, Petschelt A, Lohbauer U. Thermal-induced residual stresses affect the fractographic patterns of zirconia-veneer dental prostheses. J Mech Behav Biomed Mater 2013;21:167–77.

[17] Coffey JP, Anusavice KJ, DeHoff PH, Lee RB, Hojjatie B. Influence of contraction mismatch and cooling rate on flexural failure of PFM systems. J Dent Res 1988;67(1):61–5.

[18] De Jager N, De Kler M, Van Der Zel JM. The influence of different core material on the FEA-determined stress distribution in dental crowns. Dent Mater 2006;22(3):234–42.

[19] Wendler M, Belli R, Petschelt A, Lohbauer U. Characterization of residual stresses in zirconia veneered bilayers assessed via sharp and blunt indentation. Dent Mater 2015;31(8):948–57.

[20] Inokoshi M, Yoshihara K, Nagaoka N, Nakanishi M, De Munck J, Minakuchi S, et al. Structural and Chemical Analysis of the Zirconia–Veneering Ceramic Interface. J Dent Res 2016;95(1):102–9.

[21] Bonfante E a, Rafferty BT, Silva NRF a, Hanan JC, Rekow ED, Thompson VP, et al. Residual thermal stress simulation in three-dimensional molar crown systems: a finite element analysis. J Prosthodont 2012;21(7):529–34.

[22] Quinn JB, Sundar V, Parry EE, Quinn GD. Comparison of edge chipping resistance of PFM and veneered zirconia specimens. Dent Mater 2010;26(1):13–20.

[23] Camargos GDV, Lazari-Carvalho PC, Carvalho MA de, Castro MB, Neris NW, Del Bel Cury AA. 3D finite element model based on CT images of tooth. Brazilian J Oral Sci 2020;19:e208910.

[24] Lazari PCPC, Sotto-Maior BSBS, Rocha EPEP, de Villa Camargos G, Del Bel Cury AAAA. Influence of the veneer-framework interface on the mechanical behavior of ceramic veneers: a nonlinear finite element analysis. J Prosthet Dent 2014;112(4):857–63.

[25] Rocha EP, Anchieta RB, Freitas AC, de Almeida EO, Cattaneo PM, Chang Ko C, et al. Mechanical behavior of ceramic veneer in zirconia-based restorations: a 3-dimensional finite element analysis using microcomputed tomography data. J Prosthet Dent 2011;105(1):14–20.

[26] Sebastiani M, Massimi F, Merlati G, Bemporad E. Residual micro-stress distributions in heat-pressed ceramic on zirconia and porcelain-fused to metal systems: Analysis by FIB-DIC ring-core method and correlation with fracture toughness. Dent Mater 2015;31(11):1396–405.

[27] Benetti P, Kelly JR, Sanchez M, Della Bona A. Influence of thermal gradients on stress state of veneered restorations. Dent Mater 2014;30(5):554–63.

[28] Göstemeyer G, Jendras M, Borchers L, Bach F-W, Stiesch M, Kohorst P. Effect of thermal expansion mismatch on the Y-TZP/veneer interfacial adhesion determined by strain energy release rate. J Prosthodont Res 2012;56(2):93–101.

[29] Longhini D, Rocha CO de M, Medeiros IS, Fonseca RG, Adabo GL. Effect of glaze cooling rate on mechanical properties of conventional and pressed porcelain on zirconia. Braz Dent J 2016;27(5):524–31.

# Perception of the Nursing Team in Relation to Oncologic Patient Assistance in Palliative Care in the Intensive Care Unit

Caliupe Fernandes de Jesus[1], Fernando Augusto Pinheiro[2], Angela Antunes de Morais Lima[3], Jessica dos Santos Souza[4]

[1]Nurse. Graduated by Cacoal Biomedical Sciences College– FACIMED(2018) and post graduate student in Intensive Care by the Multi-professional Health Residency Program at *Hospital Regional de Cacoal*[Cacoal Regional Hospital].

[2]Nurse. Graduated by Cacoal Biomedical Sciences College – FACIMED (2008). Specialist in Adult and Pediatric Intensive Care by Cacoal Biomedical Sciences College (FACIMED, 2017). Specialist in Urgency and Emergency with emphasis on ICU by GrupoAthenas, (2011). Tutor in the Multi-professional Health Residency Program at the Regional Hospital of Cacoal. Lecturer at the Pimenta Bueno College – FAP.

[3]Nurse. Graduated by Mato Grosso do Sul Federal University (UFMS, 1999) and specialist in Family Health from the University of Rondônia (UNIR, 2002) and in health surveillance by SírioLibanês (2017). Tutor in the Multi-professional Health Residency Program at the Regional Hospital of Cacoal.

[4]Nurse. Graduated by São Paulo College – FSP (2018). Intensive Care Resident – ICU by the Health's Secretary of the State of Rondônia. SESAU/RO under intermediate of the Multi-professional Residence Committee – COREMU in the Cacoal Regional Hospital Complex – COHREC.

*Abstract*— *Introduction: The palliative care in general should retake the possibility of perceiving death as a natural and expected process, facing a life threatening disease. Even if there are efforts aiming toward Palliative Care in the ICU, there are still difficulties that hinder such practice, by the fact that it demands individual activities toward the patient. Objectives: describe the perception of the nursing team in relation to oncologic patient assistance in palliative care admitted to the ICU. Methodology: Descriptive, transversal, quali-quantitative study, with field data collection, in which 29 nursing professionals were interviewed through an individual questionnaire, made by the researcher herself in a hospital from Rondônia countryside in 2020. Results: it was possible to prove that the Palliative Care theme is still not widespread and lot of professionals don't know its principles, such reality hinders the care in relation to these oncologic patients admitted to the ICU. Conclusions: It stands out, then, that there is a need for the nursing team to be ready to attend oncologic patients, just as it becomes evident the team's interest over the presented theme. To offer continuing education about intensive care is essential, just as providing an emotional support to these professionals who deal everyday with pain, suffering and death.*

*Keywords*— *Oncologic Care. Nursing. Intensive Care Unit.*

## I. INTRODUCTION

The concept of Palliative Care (PC) was initially developed in the 50's by the English doctor Cicely Saunders, pioneer of the modern PC movement, on of her lines that circulates to the present day is: "Suffering is only intolerable when nobody cares." (Health, 2014).

In the 90's the World Health Organization (WHO) first defined the Palliative Care as total and active care towards terminally ill patients, where their social, spiritual, psychic and pain relief issues are put first(Forte *et al*., 2018).

Palliative Care are based in principles, according to the World Health Organization they are; to provide relief from the pain and other unpleasant symptoms, to assure life and consider death as a normal process of life, do not accelerate or postpone death, integrate psychological and spiritual aspects in the patient care, offer a supporting system that enables the patient to live as actively as possible until the moment of death, assist family members through the patient's disease and also through mourning, grant a multi-professional approach to focus the needs of the patients and their relatives, including support through

mourning, improve the quality of life and positively influence the course of the disease, starting as soon as possible, along other therapeutic measures(WHO, 2017).

In the 21st century the palliative care became attributions of health professionals, under the responsibility to offer the necessary support to the patient and his relatives. There are randomized studies showing that patients who receive cares such as: pain and fatigue management, nausea and shortness of breath control, had their life span prolonged. These care require not only the treatment of physical symptoms but also the emotional symptoms, such as fear, anxiety and depression, symptoms that are common on relatives and severely ill patients (Forte *et al*., 2018).

In general they should retake the possibility to perceive death as a natural and expected process, facing a life threatening disease. Some more severe patients end up needing specialized care such as the intensive care at some point of their illness process(SAÚDE, 2018).

The focus on palliative care has been more and more debated, also receiving more evidence and even worldwide prominence, a conference about ethics gathered 21 care doctors in the World Congress of WFSICCM in Durban in South Africa, where the main debated subject was the care at the end of life in Intensive Care Unit (ICU), in the multidisciplinary team everyone must be engaged so the use of the technology that we have nowadays do not end up inadequately prolonging the lives of those patients in the ICU(Myburgh *et al*., 2016).

The WHO through the World Palliative Care Alliance published the Global Atlas of Palliative Care at the End of Life, in order to emphasize the subject and bring more enlightenment on the theme (Myburgh *et al*., 2016).

However the multidimensional discussions toward the improvement of the nursing work and the health team aims toward quality in assistance. Some international epidemiological data about cancer still define it as a public health problem justifying the constant investment in research to subsidize diagnostic and therapeutic technologies that become more and more efficient, for diagnosis, treatment and also to raise the survival rate of the patients stroke by this illness (Mendonça *et al*., 2012).

In order to improve treatment during dying in the ICUs of Brazil, the I Forum of the End of Life Study Group of the Southern Cone happened in the year 2009 at Porto Alegre city. With the presence of members from the Brazilian (AMIB), Uruguayan, (SUMI) and Argentine (SATI) Society of Intensive Medicine, with the objective of elaborate appropriate recommendations to diagnostic and treatment of terminally ill patients under PC. In 2010

the IIº Forum of the End of Life Study Group of the Southern Cone happened. In the XV Brazilian Congress of Intensive Medicine, at Brasilia city. Aiming to elaborate actions to be offered to palliative patients in critical condition. In this forum the flow chart for providing palliative care in the ICU was elaborated, containing recommendations toward the palliative care to be offered to critically ill patients. In this delicate moment the patient's family should be privileged with communication, for them to accompany the patient and prepare for his death(Moritz *et al.*, 2011).

Furthermore the lack of specialized professionals is also evident. There are few training centers for Palliative Care in Brazil, most of them are located in state of São Paulo. Another great obstacle is society's reluctance about discussing death and terminality (Health, 2014).

In the ICUs is where we find the largest number of critical patients, some of them in end of life situation, surrounded by technological and specialized devices, even with so much availability of technologies present in ICUs, there are still evidences related to the unpreparedness of professionals in order to develop care actions to patients that are dying. "The academic background of the health professionals does not contemplate deeper theoretical approaches directed to death and dying, and there are few discussions on the subject among the undergraduates" (N. C. B. Barros *et al.*, 2013).

Now with the exposed data, the improvement of communication among the members of the multi-professional team and an in-depth knowledge about palliative care in the ICUs can avoid conflicts and grant the improvement in diagnostic, treatment and raise the survival rate of those patients(Tiengo, 2017). Thus this study aims to identify the knowledge of the nursing team about intensive care in relation to the specialized assistance to the oncologic patient under palliative care, as well as its comprehension and the main feelings experienced by the team when providing such care.

Considering that in Brazil the PC is still little diffused even with the presence of relevant forums addressing the topic, one of the main obstacles is the lack of discipline in the professional resumes, they are trained for life maintenance at all cost (Health, 2014).

Therefore this research aims at verifying the knowledge that those nursing professionals who act inside the ICU, have about palliative oncologic patients, checking out their possible qualification for that. Pointing the frailties of the provided assistance and describing the feelings experienced by the team.

In this manner this study has full relevance for a better understanding about what is palliative care and in which way the nursing team can properly provide such care to terminally ill patients admitted in an Intensive Care Unit (ICU). So they can experience a dignified death with less suffering as possible.

## II.       METHODS

It is a descriptive study of transversal character and qualitative nature, carried out in two Intensive Care Units with a total of 18 beds in a Regional Hospital in Rondônia. The sample is probabilistic for convenience, composed by 29 professionals, counting with 50% plus one from each category, in which 05 nurses, 03 nursing residents and 21 nursing technicians are defined. For selecting the participants; being both technical and academically graduated in nursing and be an effective member of the team was utilized as criteria for inclusion, and also to accept participating in the research and the criteria for exclusion was applied to the workers who had less than 3 months acting in ICU, for such time be defined as minimum period of adaptation and engagement.

The data was collected in January 2020 through a semi-structured mixed questionnaire, applied individually according to the professional's availability, in the ICU itself, with an average duration of 15 minutes each.

For the data analysis, the objective and essay answers were submitted to analysis of content and thematic modality. In a set of techniques which allows interference from the obtained content composed by three phases: 1) pre-analysis, 2) data exploration; 3) treatment of the results, interference and interpretation. Then the categories were identified and named as: "The perception of the nursing team about what is palliative care" and "The knowledge about what are the principles of palliative care".

The development of the studies met the requirements and ethical precepts in effect in the country and the project was approved by the Ethical Committee in Researches on Human Beings from the Cacoal College of Biomedical Sciences under the number 3.778.295. All the participants signed a two-way Informed Consent Form. For differentiation and preservation of their identities the professionals were identified with page numbering, only indicating the options: "N: nurse, NT: nursing technician and R: nursing resident.

## III.       RESULTS

The total number of professionals was 29, 24 female (82,8%) and 5 male (17.2%), aged between 23 and 53 years old, with an average of 34 years old. The female predominance is explained by Donoso (2000), evidencing that the English word nurse has its origin in Latin, from the name nutrix, which means "mother who creates". The time of performance in nursing among the researched subjects ranged from 03 months up to 18 years, with the average of 07 complete years, now the performance time in hospital was between 03 months up to 10 years, with the average of 03 full years, and the performance time in the ICU sector varying between 03 months up to 09 years, with the average of 03 full years, knowing that this percentage was calculated from the answers of 27 questionnaires, 02 interviewees did not answered about their respective performance time. About the degree of training, 21 of technical training (72,4%), 5 graduated (17,3%) and 3 with *latusensu* specialization (10,3%).

A category came after a careful analysis of the collected data, one that deals on the nursing team's perception about what is palliative care, the most mentioned data in this category was "to promote relief from pain and suffering, in order to promote comfort and a more humane care" this can be detailed by the following quotes:

> *"...care offered to the patient without physical healing ends, only to promote comfort and well-being within the conditions of the patient and the pathology (R 01)".*
>
> *"...palliative care on my point of view is about the multidisciplinary care which provides comfort and well-being to the patient, the being treated as a whole, the reduction of pain, the mental and spiritual peace; all of those care not restricted only to the patient, but may extend to his relatives (N 04)".*
>
> *"... it's humanized care, making it possible to the patient an end of life quality, offering a humane and compassionate assistance facing an incurable disease, always having in mind that palliative care deals with the person and not the disease, easing symptoms without physical healing purposes, just dignified and high on quality (NT 06)".*
>
> *"... to offer a dignified assistance to the patient in process of terminal and/or incurable disease in cases where there are no possible means to reverse the clinical*

*picture, with treatments or means that don't extend his suffering (R 02)".*

Still on this category of the perception of the nursing team about what is palliative care, it is evident that palliative care aims to promote relief from pain, suffering and a more humane care to those terminally ill patients, as stated below:

*"... promote more comfort to the patient in the end of his life, not only physical comfort, but also psychological, offering a treatment that nullify or at least reduce the pain as much as possible and giver him peace and safety in a more humane treatment as much as it is possible (NT 07)".*

This thought that palliative care are to promote comfort measures to the patient at the end of his life can also be observed in the lines described below:

*"... palliative care are comfort measures to the patients diagnosed with terminal illness. It's when the professional provides care so that the patient fell less pain and discomfort as possible, measures which won't make the patient to get better so he can be discharged, but instead to provide him with a "less painful" death (N 05).*

*"... they are the basic and humane care with the patient in order to promote comfort to his body and mind. In order to minimize the suffering from the patient and his relatives (NT 08)".*

*"... it's a multi-professional approach towards the patient who needs such care, with the objective to improve the quality of life, comfort easing the suffering and pain, all accomplished in a humanized way (NT 09)".*

About the category related to "The knowledge about what are the principles of palliative care". A quantitative of 11 (37,9%) from the interviewed professionals who did not know the principles of palliative care was obtained, and 18 (62,1%) of the professionals who said they knew

which principles are those, have their speeches illustrated below:

*"... to ease the patient's symptoms not in search of cure, if that's the diagnostics. Accept that death is a natural process and part of daily life, neither postponing life nor delaying death, natural cycle. Respecting the psycho-social and spiritual aspects of the patient, and provide an ending of life as natural as possible, keeping the patient and his relatives aware of that (NT 06)".*

We can also observe on the next speeches other opinions about what are the principles of palliative care

*"... comfort, pain reduction and understand death as a natural process (N 04)".*

*"...pain relief, helping on acknowledging death as a natural process, offering support and guidance to the relatives so they participate in the best way possible in taking care of the patient (N 13)".*

*"...the main care are related to the pain so there is no suffering and also to the psychological conditions with professional guidance depending on the case (NT 11)".*

*"... they are actions aiming toward improving the life quality of the patients and their relatives who face problems associated to life threatening illness, which are: prevention of pain and suffering relief with pain control and relief of other symptoms such as psycho-spiritual and social ones (NT 12)".*

The theme, training and specific information in the palliative care field presented two requirements mentioned by the team, in the first requirement when questioned if they had already received training on palliative care 10,3% of them answered yes. While 89,7% have never received this kind of information or training. Now about if they would like to receive training on palliative care; 100% of the interviewed has shown interest about continuing education in the palliative care field.

*Chart 1 – Found results about factors on the matter of frailties from the team and the main feelings experienced by those professionals into adult ICU from Cacoal Regional Hospital, 2020.*

| FRAILTIES | % |
|---|---|
| Lack of Understanding of the Disease by the Professionals | 37,93 |
| Insecurity of professionals | 34,48 |
| Lack of Communications among Health Professionals | 55,17 |
| Emotional Wear of the Team | 68,96 |
| Inadequate Physical Structure | 58,62 |
| Not Knowing how to Deal with the Patient's Demands and Expectations | 31,03 |
| **FEELINGS** | **%** |
| Compassion | 58,62 |
| Valuation of Life | 68,96 |
| Humanity | 79,31 |
| Anguish | 37,93 |
| Pain; Frustration; Anxiety | 24,13 |
| Solidarity | 65,5 |
| Mourning | 13,79 |
| Sadness | 34,48 |
| Palpitation; Throat Lump | 17,24 |
| Sense of Dutty Fulfilled | 44,82 |
| Happy about Helping | 51,72 |

**Font:** Jesus, Pinheiro and Lima, 2020

## IV.

## V.    DISCUSSION

According to Gomes and Othero (2016), palliative care are complex and reality challenging, presenting itself as an innovative way of assistance in the health field and it is gaining space in Brazil, it is different from healing medicine, it is focused on comprehensive care, through its principles which are related to prevention and control of the symptoms, aiming toward the well-being of all patients who face a terminal and life threatening illness.

The therm "palliate", originates from the Latin *palliare,* meaning, to make it more bearable, mitigate, remedy on a provisional basis. Palliative Care basically

consists in a philosophy that can be used in many different contexts, highlighting the relief of symptoms, pain and the suffering from those who are facing chronic-degenerative diseases or terminal stage, they treat the patient as a whole, aiming for improving his quality of life (Pessini & Bertachini, 2006).

In view that disease and suffering always come together, when the disease is grave and the suffering is intense, the palliative care offer intensive treatment which then demands for Intensive Care Unit. It is therefore objected that while there is progression of the illness, the treatment of the patient changes from healing to palliative,

thus generating comfort and relief of his symptoms (Oliveira et al., 2008). In view that in the ICU, the integration between the palliative and curative care since the moment of admission has been more and more highlighted to a greater relevance, searching for quality attendance (N. Barros et al., 2013).

When the interviewed were asked about what would be palliative care, many of them answered that it aims to provide relief from suffering and to offer comfort to terminally ill patients. In palliative care the interrelationship among all the involved ones is essential, which are, the patient, his relatives and the multi-disciplinary team. A wide approach allows the inclusion of this practice in both the health system and into society (Moritz et al., 2012).

Moritz (2012) also portrays that PC can and should be offered along the palliative care, since they are necessary for prevention and treatment of patients and their relatives. Thus he also brings some of the fundamental principles of PC into ICU which are: accept death as a natural process, always prioritize the best interest and wishes of the patient, reject diagnostic and therapeutic futility, neither shorten life, nor prolong the process of death, grant quality of life and death, relief pain and other associated symptoms, take car of the clinical, psychological, social and spiritual aspects of both the patients and their relatives, respect the autonomy of the patient and their legal representatives.

In relation to the principles of Palliative Care, it was clear that the participants have somewhat limited knowledge, although they exhibit values compatible with some principles of those care. The participants related it to death and to comfort measures, although, none of the participants conceptualized it as the treatment proposed by WHO. This finding is also pointed by other study stating that in Brazil the PC are still not very widespread by most of the population and also by health professionals (Freitas & Pereira, 2013).

In terms of training in palliative care, in Brazil, there are many different challenges to overcome and, among them, lies the difficulty in the education of health professionals about the terminality and quality of death matters (Dias et al., 2007).

To offer PC with quality means to implement innovative actions and among them; changes in attitude and education of all professionals involved with chronic ill patients or with an expectation of near death. Therefore, in order to act into the perspective of palliative care, it is relevant to invest in training the professionals. Educating

not only the nurses, but all the nursing team (Vicensi et al., 2016).

When asked about training in specific information in the PC field, it was almost unanimous the number of interviewees who have never received training or any other kind of course about this matter. It also became evident that everybody would like to receive more information about this content, The National Policy for Permanent Education (PNEP) was instituted in February 2004 to make it easier to access those information and training, it has the objective to change the institutional practices, to improve the quality of attention and health assistance, to compromise the team with its work process and improve the relation among the work teams (Ministry of Health BRAZIL, 2004). Considering that PC implies a trans-disciplinary approach with psychology, religion, effective communication, philosophy, ethics and atransversality toward the patients' answers, their suffering, anxiety and fears, in the midst of therapeutic strategies (Silva & Guimarães, 2012).

Studies by Silva *et al.* (2015) show that the deficiency in the field of training make it harder for the development of the PC and also they highlight the difficulty of the professionals about dealing with the death subject, with the necessities from the end of life and that it can even take to dehumanized care. Such characteristics can compromise the quality of care given, in a way that can provide negative experiences. Thus one of the methods to change this practice, they suggest changes in training and more developments from the permanent education.

Studies shows that palliate is a dimension of care in health and all of the professionals should know when the palliative care will be necessary, considering that the challenges to the multi-professional team in palliative care were described as frailties when adressing the tearminality process. Throguth the reports, the participants mentioned the lack of comprehension of the illness, insecurity, emotional distress, inadequate physical structure and lack of communication in relation to the palliative care, being this fact a trigger of conflicts. It is known that the communication skill is essential to the multi-professional work, this thinking was also observed in another study, in which the excellent and the respect among the team contribute towards an high quality assistance. This study shows that; assisting people in terminality mobilize emotions in the health team members, because death becomes part of their daily life, creating conflicts and need for consideration, making necessary for a support (Cardoso et al., 2013).

When related to feelings and perceptions, the results show both the diversity and the extremes of the emotions. Thus it is considered essential that the findings be regarded into permanent education since the professional, besides knowledge, needs emotional support, since the ICU environment itself generates a great amount of emotional distress and other factors that make the professional feel undermined, as the same finds himself daily in contact with death. Knowledge enables a positive attitude, not only to help others, but also for self-care. However, some professional in certain situations will need psychological support, that can be offered by the work team itself. Studies show that when it occurs in an organized and planned way, the results are more evident, benefiting the professionals, teams, patients and relatives, in a complex cycle of relation and also technical, scientific and humane improvement (Honório, 2016).

The author brings some strategies for the technical-scientific improvement and also for psycho-emotional support, highlighting; professional education towards learning, acceptance and management of emotions and existential confrontation, rebuild and update the beliefs related to life and death, development of the studies about PC sharing results among the various work teams, education to self-care, offer training such as forums and workshops to improve the communications of professionals, offer professional counseling to take care of the patients in palliative situation, use of standardized protocols in the care practices in order to avoid unnecessary and conflict trigger interventions (Honório, 2016).

In end-of-life situations due to numerous terminal illness where the patient is considered out of healing possibilities, the role of the multidisciplinary team in the ICU is to commit to change this utterly technical scenery by implementing less aggressive care, searching for quality of life or quality of death, if it occurs, offering more humane care to those patients. Thus, to know the conceptions related to implementation of palliative care, and also the end-of-life process would allow this health team a better understanding of its values and beliefs when facing such process, feeling ready at the moment of acting on patients and relatives on such situations. In this manner the professionals categorized the nursing assistance and innervation to be given to the oncologic patients as highly important, this fact is also verified in many different studies (Silveira et al., 2016).

## VI. CONCLUSION

It was verified in this study that the aging of the population and the occurrence of chronic and degenerative diseases has been occurring more frequently, a lot of those disease cause the patient to need an Intensive Care Unit - ICU admission, thus requiring the nursing team to be prepared both in practice/evidence based knowledge, and psychologically/emotionally.

The Palliative Care presents itself as a new way of assistance, with an approach toward the human being in his integrity and the need for intervention in consequence of symptoms of physical, social, emotional and spiritual nature granting the terminality process to be as good as possible.

It is possible to observe that the nursing team shows interest in the proposed theme, and that one of the greater obstacles to overcome be the communication among the teams and the understanding of the patient's pathology, thus causing hasty and generally unnecessary conducts, at the end causing even more suffering to the patient.

It was also evidenced in the study the fact that it is necessary to offer continuous education, just as training and access to information to the referred them thus preparing those professionals for the direct attention to the patients in palliative care.

It is important that there is some kind of psychological support to the professional who deal directly with terminal ill patients, because they are dealing directly with death everyday and also with the intense suffering of such patients, thus generating a lot of emotional distress on the professionals and the lack of such support can directly affect this kind of support.

"Death, you are brave, Your power is great, When I arrived in this world, You were already killing people. I kept inside my mind, This great accuracy of yours, However I ask you a favor, To go to the holy field, Don't make me suffer too much, Death, kill me painless!"

(*Patativa do Assaré*)

### REFERENCES

[1] Barros, N., Alves, E., Oliveira, C., Dias, M., França, I., & Freire, M. E. (2013). Palliative Care in the Uti: Nurses' Understanding. *Revista de Pesquisa: Cuidado é Fundamental Online*, 3293–3301. https://doi.org/10.9789/2175-5361.2013v5n1p3293

[2] Barros, N. C. B., Oliveira, C. D. B., Alves, E. R. P., França, I. S. X. de, Nascimento, R. M., & Freire, M. E. M. (2013). Cuidados paliativos na UTI: compreensão, limites e possibilidades por enfermeiros. *Revista de Enfermagem da*

*UFSM*, *2*(3), 630–640. https://doi.org/10.5902/217976925857

[3] Cardoso, D. H., Muniz, R. M., Schwartz, E., & de Oliveira Arrieira, I. C. (2013). Hospice care in a hospital setting: The experience of a multidisciplinary team. *Texto e Contexto Enfermagem*, *22*(4), 1134–1141. https://doi.org/10.1590/S0104-07072013000400032

[4] Dias, K., Machado, G., Pessini, L., & Hossne, W. S. (2007). *A formação em cuidados paliativos da equipe que atua em unidade de terapia intensiva : um olhar da bioética*. *1*(1), 34–42.

[5] Donoso, M. T. V. (2000). the Genus and Its Implications in Nursing Management. *Reme: Revista Mineira de Enfermagem*, *4*(1/2), 67–69.

[6] Forte, D. N., Santos, A. F. J. dos, Crispim, D., Souza, M. dos R. B. de, Lago, P., & Rodrigues, C. (2018). Panorama dos Cuidados Paliativos no Brasil. *Academia Nacional de Cuidados Paliativos Outubro de 2018*, *4*, 15. https://paliativo.org.br/wp-content/uploads/2018/10/Panorama-dos-Cuidados-Paliativos-no-Brasil-2018.pdf

[7] Freitas, N. D. O., & Pereira, M. V. G. (2013). Percepção dos enfermeiros sobre cuidados paliativos e o manejo da dor na UTI # Nurses ' perception on palliative care and management of pain. *O mundo da saúde*, *37*(4), 450–457. http://bvsms.saude.gov.br/bvs/artigos/mundo_saude/percepcao_enfermeiros_sobre_cuidados_paliativos.pdf

[8] Gomes, A. L. Z., & Othero, M. B. (2016). Cuidados paliativos. *Estudos Avançados*, *30*(88), 155–166. https://doi.org/10.1590/S0103-40142016.30880011

[9] Health, O. (2014). Vamos falar de Cuidados Paliativos. *Sociedade Brasileira de Geriatria e Gerontologia*, 17.

[10] Honório, F. G. (2016). Instrumento de controle intensivo: contribuições da enfermagem e da filosofia dos cuidados paliativos. *BIBLIOTECA UNIVERSITARIA DA UFSC*, 147.

[11] Mendonça, A. C. A., Moreira, M. C., & Carvalho, V. de. (2012). Atenção paliativa oncológica em Unidade de Terapia Intensiva: um estudo da produção científica da enfermagem. *Escola Anna Nery*, *16*(4), 817–823. https://doi.org/10.1590/s1414-81452012000400025

[12] Ministério da Saúde, Secretaria de Gestão do Trabalho e da Educação na Saúde, & Departamento de Gestão da Educação na Saúde. (2004). *Política de Educação e Desenvolvimento para o SUS: caminhos para a educação permanente em saúde: pólos de educação permanente em saúde*. 68.

[13] Moritz, R. D., Deicas, A., Capalbo, M., Forte, D. N., Kretzer, L. P., Lago, P., Pusch, R., Othero, J., Piva, J., Silva, N. B. da, Azeredo, N., & Ropelato, R. (2011). II Fórum do "Grupo de Estudos do Fim da Vida do Cone Sul": definições, recomendações e ações integradas para cuidados paliativos na unidade de terapia intensiva de adultos e pediátrica. *Revista Brasileira de Terapia Intensiva*, *23*(1), 24–29. https://doi.org/10.1590/s0103-507x2011000100005

[14] Moritz, R. D. Cuidados paliativos nas Unidades de Terapia Intensiva. São Paulo: Editora Atheneu, 2012

[15] Myburgh, J., Abillama, F., Chiumello, D., Dobb, G., Jacobe, S., Kleinpell, R., Koh, Y., Martin, C., Michalsen, A., Pelosi, P., Torra, L. B., Vincent, J. L., Yeager, S., & Zimmerman, J. (2016). End-of-life care in the intensive care unit: Report from the Task Force of World Federation of Societies of Intensive and Critical Care Medicine. *Journal of Critical Care*, *34*, 125–130. https://doi.org/10.1016/j.jcrc.2016.04.017

[16] Oliveira, R. A. de, Carvalho, R. T. de, & Arantes, A. C. de L. Q. (2008). Cuidados Paliativos. In *Cuidado Paliativo / Coordenação Institucional de Reinaldo Ayer de Oliveira*.

[17] Pessini, L., & Bertachini, L. (2006). Nuevas Perspectivas En Cuidados Paliativos. *Acta bioethica*, *12*(2), 231–242. https://doi.org/10.4067/s1726-569x2006000200012

[18] SAÚDE, C. P. D. P. D. A. À. (2018). *Governo Do Distrito Federal Secretaria De Estado De Saúde Subsecretaria De Atenção Integral À Saúde Diretriz para Cuidados Paliativos em pacientes críticos adultos admitidos em UTI*. 1–61.

[19] Silva, A. E., & Guimarães, E. A. A. (2012). Palliative Care Nursing : Prospects for Technical and Auxiliary. *Revista de Enfermagem do Centro Oeste Mineiro*, *2*(3), 376–393. http://www.seer.ufsj.edu.br/index.php/recom/article/viewFile/256/352

[20] Silva, M. M. da, Santanda, N. G. M. de, Santos, M. C., Cirilo, J. D., Barrocas, D. L. R., & Moreira, M. C. (2015). Palliative care in highly complex oncology care: perceptions of nurses. *Escola Anna Nery - Revista de Enfermagem*, *19*(3), 460–466. https://doi.org/10.5935/1414-8145.20150061

[21] Silveira, N. R., Nascimento, E. R. P. do, Rosa, L. M. da, Jung, W., Martins, S. R., & Fontes, M. dos S. (2016). Cuidado paliativo e enfermeiros de terapia intensiva: sentimentos que ficam. *Revista Brasileira de Enfermagem*, *69*(6), 1074–1081. https://doi.org/10.1590/0034-7167-2016-0267

[22] Tiengo, T. (2017). A Percepção Dos Profissionais De Terapia Intensiva Sobre Pacientes Em Cuidados Paliativos Internados Em Unidade De Terapia Intensiva. *Biblioteca da Fundação Antônio Prudente*, 72.

[23] Vicensi, M. do C., Maciel, A. P. da S., Erdtmann, B. K., Schneider, D. G., Andrade, E. F., Poetini, G. M. B., Schmitz, J., Rosa, L. M. da, Vargas, M. A. de O., Vicensi, M. do C., Santos, M. J. dos, Andrade, M. de S., Bresciani, H. R., & Caprario, S. (2016). Enfermagem em Cuidados Paliativos. In *Conselho Regional de Enfermagem de Santa Catarina* (Vol. 04). http://www.corensc.gov.br/wp-content/uploads/2016/11/Cuidados-Paliativos-Parte-1-Site.pdf

[24] WORLD HEALTH ORGANIZATION - WHO. (2017) Cancer Definition of Palliative Care. Available in: <http://www.who.int/cancer/palliative/definition/en/>. Accessed in: June 17, 2019.

# Computational modeling of atmospheric dispersion applied to a small modular reactor

Rodrigo Carneiro Curzio[1], Bruno da Silva Moura[2], Pedro Luiz da Cruz Saldanha[3], Sergio Gavazza[4]

[1,2,4]Department of Nuclear Engineering, Military Institute of Engineering (IME), Rio de Janeiro-RJ, Brazil

[3]Pos Graduate Program in Administration - ICHS, Fluminense Federal University (UFF), Volta Redonda-RJ, Brazil

*Abstract— This study describes the computational modeling of the atmospheric dispersion resulting from a postulated radiological accident in a small modular reactor (SMR), with a power of 16 MWe (50 MWt), and containing three fuel enrichment regions, at 4%, 5 % and 20%. Among the hypothetical inventory radionuclides, derived from nuclear reactions during fuel burnup after 2 years of operation, the contribution of Cs-137 was considered for simulation, using the HotSpot code, of the concentration and total effective doses (TEDE) received, both depending on the distance from the event. A locality in the interior of Brazil was chosen to install the SMR, where information on meteorological conditions was collected to identify the predominant atmospheric stability class. The results suggest that the maximum calculated TEDE was 3.6 Sv, 34 m from the reactor, decreasing with time and distance, and following the Gaussian dispersion model, and that the contamination plume is dependent on the Pasquill-Gifford criteria and Cs-137 activity. For doses between 1 mSv and 10 mSv and between 10 mSv and 50 mSv, it is suggested that the population be housed in existing buildings in the locality, and for values above 50 mSv, shelter in these conditions or the evacuation of people close to the reactor in movement contrary to the spread of the plume. The relevance of this investigation shows the importance of emergency response planning and the influence of meteorological conditions, considering the data assumed in the simulation.*

*Keywords — SMR, Modeling, Dispersion, HotSpot.*

## I. INTRODUCTION

The study presents a computational modeling of the atmospheric dispersion resulting from a hypothetical radiological accident, in a small modular reactor (SMR), whose power is 16 MWe (50 MWt). SMRs are defined as small nuclear power reactors, capable of generating up to 300 MWe of electrical power [1]. Because it is manufactured in modules, its versatility allows transportation and installation in places less likely to build a conventional nuclear reactor (PWR), which can be a solution for places where energy supply or access is necessary, such as in Northern Brazil [2].

By hypothesis, and within in this context, a situation analysis for study, by computational modeling, becomes relevant, seeking to evaluate the implementation of protection measures in emergency situations, proposals to avoid or reduce the population's exposure to radiation, in the case of an accident with a reactor of this size, installed in a distant area. This analysis would allow to verify with more detail the appropriate selection of the site for the execution of nuclear activities and practices with this type of modular reactor [1,3].

The objective of the research is to perform a computational simulation of the atmospheric dispersion of radionuclides, using the HotSpot Health Physics code (version 3.1.2) [4], released during a hypothetical accident in the SMR, and to analyze the data obtained, in order to verify the adoption the immediate protective measures in the initial phase of this postulated radiological event, as well as the influence of weather conditions on the contamination plume.

## II. MATERIALS AND METHODS

### 2.1 Description of the SMR reactor

For this study, it is assumed that the SMR, whose power is 16 MWe (50 MWt), has been operating continuously for 2 years (720 days), at maximum power [5], and that the atmospheric dispersion of radionuclides was generated by the burning of fuel from this reactor.

The core of this SMR has three fuel enrichment regions,
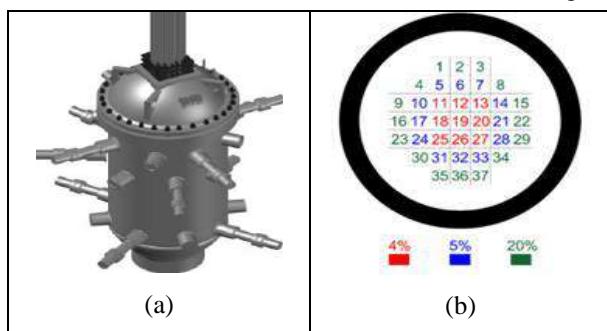


*Fig. 1: Nuclear installation illustration: a) on the left, the SMR pressure vessel; b) on the right, the top view of the core.*

*Source: AUTOCAD,2019.*

In this context, for the analysis of the average activities of the radionuclides resulting from the nuclear reactions occurred during the burning, Table 1 presents a hypothetical inventory, containing possible radionuclides accumulated in the reactor, after 2 years of uninterrupted operation, with their respective masses, average activity and fraction of release to the atmosphere, considering the fuel enrichment adopted for the SMR of this study [6,7].

Among the radionuclides from the SMR inventory, the atmospheric dispersion modeling and the doses

4%, 5% and 20%, as shown in Fig. 1. calculation were conducted based on the contribution of Cs-137.

This isotope is important in the analysis of the consequences of radiological accidents, as it is extremely toxic and has a long half-life (30 years) [3]. Several records in the literature indicate the main risks of exposure, internal and external, to this radioisotope, which can be seen, for example, in the reports of the accident in Goiania, in 1987 [8].

In addition, the choice for Cs-137 can also be justified by the innovative character of this proposal, in allowing an analysis by computational simulation of possible situations of radiological accident involving atmospheric dispersion, favoring the adoption of immediate protective measures in its initial phase. Such situations could not be analyzed using experimental methods, due to the high risk associated with exposure to ionizing radiation. Thus, the option for a radionuclide of relevance in the area of radiological protection [3], for application in this study, gives support to the use of the same methodology for more general situations as in the case of the reactor inventory in question, in its entirety, for example.

*Table 1: Hypothetical inventory of radionuclides in the SMR after 2 years of operation [6].*

| Radionuclide | Mass (*g*) | Activity (Bq) in the core | Release fraction | Activity (Bq) released into the atmosphere |
|---|---|---|---|---|
| Ba-140 | 3,409E+01 | 9,228E+16 | 0,02 | 1,846E+15 |
| Cs-137 | 1,337E+03 | 4,295E+15 | 0,30 | 1,289E+15 |
| I-131 | 1,032E+01 | 4,746E+16 | 0,40 | 1,898E+16 |
| Kr-85 | 4,252E+01 | 6,153E+14 | 1,00 | 6,153E+14 |
| Kr-85m | 5,700E-02 | 1,735E+16 | 1,00 | 1,735E+16 |
| Rn-220 | 6,839E-13 | 2,334E+07 | 1,00 | 2,334E+07 |
| Sr-89 | 5,757E+01 | 6,185E+16 | 0,02 | 1,237E+15 |
| Sr-90 | 7,325E+02 | 3,739E+15 | 0,02 | 7,479E+13 |
| Te-132 | 6,049E+00 | 6,911E+16 | 0,05 | 3,455E+15 |
| Xe-133 | 1,443E+01 | 1,000E+17 | 1,00 | 1,000E+17 |

*Source: Research Data*

## 2.2 Modeling of radiological accident simulation

For the occurrence of radiological accident in the SMR, the following premises were considered: a) the reactor was operating at maximum power for 2 uninterrupted years; b) the cladding, based on Zircaloy-4, reached temperature

values beyond its design specifications; c) the limit of 340ºC [9] led to the creation of cavities. This rise in temperature was motivated by an supposed failure of the control bar locks (cadmium-based neutron absorbers) and the delay in the insertion of borated

water, which caused, not only the insertion of positive reactivity in the core, i.e, the reactor in the supercritical condition, but also a substantial loss of fluid, characterizing the *Loss of Cooling Accident* (LOCA) [10].

With this cladding failure scenario, it was assumed that the gaseous fission products were released into the water in the reactor pressure vessel and collected at its top, continuing to operate without any replacement of the elements in a failure condition. Consequently, the radionuclides in question were dispersed, instantly, into the atmosphere, for a period of 10 min, in a single release. This release occurred through the venting system in the reactor building, located 10 m above the ground, as described in Fig. 2.
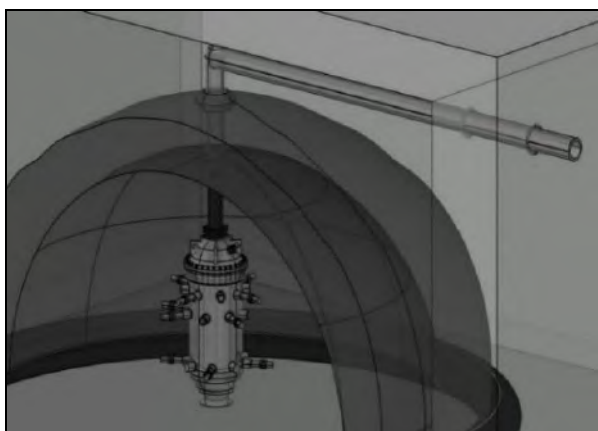


*Fig. 2: Simplified illustration (out of scale) of the vent pipe system of the nuclear installation.*

*Source: AUTOCAD, 2019*

## 2.3 Modeling of radiological accident simulation

The Atmospheric dispersion was calculated using the Gaussian plume dispersion model, using the HotSpot code, a Health Physics code from Lawrence Livermore National Laboratory used as a computational tool to perform the atmospheric transport modeling [4]. This software takes into account the wind speed for calculating the transport of the radioactive material released into the environment and the local atmospheric stability, named A (extremely unstable) to F (moderately stable), according to the Pasquill-Gifford stability classes [4].

The HotSpot allows to determine the atmospheric concentration of the radiological agents dispersed in any point of space, where the origin of the coordinate system is located at ground level (x = 0, y = 0, z = 0), with the release coordinates of the radionuclides in (x = H, y = 0, z = 0), using the following equation [4]:

$$C(x,y,z,H) = \frac{Q}{2\pi U \sigma_y \sigma_z} \exp\left(\frac{-y^2}{2\sigma_y^2}\right) \left\{ \exp\left[\frac{-(z-H)^2}{2\sigma_z^2}\right] + \exp\left[\frac{-(z+H)^2}{2\sigma_z^2}\right] \right\} e^{\left(\frac{-\lambda x}{u}\right)} DF(x) \quad (1)$$

where $C(x,y,z,H)$, consists of the atmospheric concentration (*Bq.s/m³*); $Q$, the source activity (*Bq*); $\sigma_y$, the standard deviation of the concentration distribution in the direction perpendicular to the wind (m); $\sigma_z$, the standard deviation of the concentration distribution in the vertical direction (*m*); y, the distance perpendicular to the wind direction (*m*); z, the distance from the vertical axis (*m*); H, the effective[1] release height (*m*); λ, the radioactive decay constant ($s^{-1}$); x, u, the average wind speed at the effective release height of the material (*m/s*); *DF(x)*, in the plume depletion factor, calculated by the following equation [4]:

$$DF(x) = \left\{ \exp \int_0^x \frac{1}{\sigma_z \exp\left[\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]} \right\}^{-\frac{v}{u}\sqrt{\frac{2}{\pi}}} \quad (2)$$

where *v* is the deposition speed (*m/s*) of the radioactive material, and the other variables are in accordance with equation (1). Fig. 3 schematically illustrates the radionuclide dispersion process based on the Gaussian model.
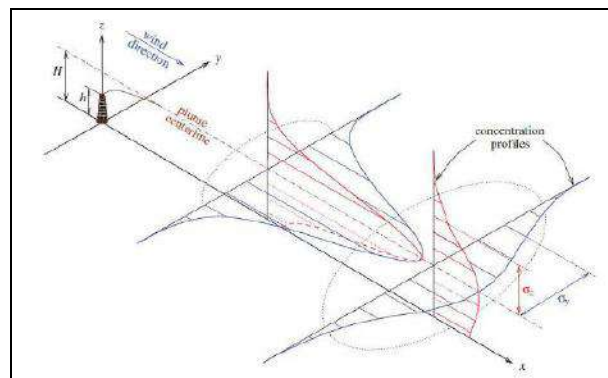


*Fig. 3: Representation of the radiological plume dispersion, from a continuous point source, with the wind direction aligned with the x axis* [12].

*Source: Adapted from STOKIE, 2011*

---

[1]For this work, it was assumed, by hypothesis, that the effective release height is the physical height of the release of the radioactive material into the atmosphere (in this case, the height of the venting system, located at 10 *m* in relation to the ground).

For the simulation of the total effective dose (TEDE[2]), The HotSpot code uses the radiation dosimetry methodologies recommended by the International Commission on Radiological Protection (ICRP), to convert the concentration provided by equation (1) into the dose to which individuals who remain in the same location and in the direction of the wind will be exposed. For this case, the code uses the values of dose coefficients from the documents Federal Guidance Report (FGR) 11, 12 and 13, which provide the factors of dose conversion by inhalation, submersion and ingestion [3,4].

The chosen area for the simulations is located in the interior of the State of Amazonas, in Brazil, 700 km from Manaus-AM and 200 km from Porto-Velho-RO, with geographical coordinates 7º 32 '60"(S) and 63º 04' 48" (O). The justification for this location is due to the fact that this region has been identified as one of the places in the country where many Brazilians live without access to the electricity service [13]. This location also presents peculiarities because it has a flat surface in most areas, including the critical direction to be studied (the atmospheric dispersion models fit well in this type of terrain), it has rural and urban areas, lakes and rivers, highways, in addition to being close to public establishments, like the Brazilian Army and the Highway Police, which may favor the physical security aspect of the nuclear installation of this study. This entire region and geographical characteristics can be seen in Fig. 4.

According to Fig. 4, the reactor is located at an approximate distance of: 250 m from the Highway Police Station; 1 km from the Federal Institute of Education, Science and Technology; 1.2 km from the Brazilian Army Unit; 1.5 km from the Regional Airport of the locality under study; 1.4 km from the set of residences shown in that figure. Such information aims to subsidize the analysis of atmospheric dispersion in the initial phase of response to the postulated radiological event, in which immediate protective actions, such as shelter and evacuation, in addition to the application of its generic levels of intervention, will be considered [14].

For the simulation, information about meteorological conditions was collected in order to identify the possible classes of atmospheric stability existing in the region under study.

---

[2]TEDE (Total Effective Dose Equivalent) is the sum between the effective dose for external exposures (submersion, resuspension and deposition) and the compromised absorbed dose for internal exposures (inhalation) [11].
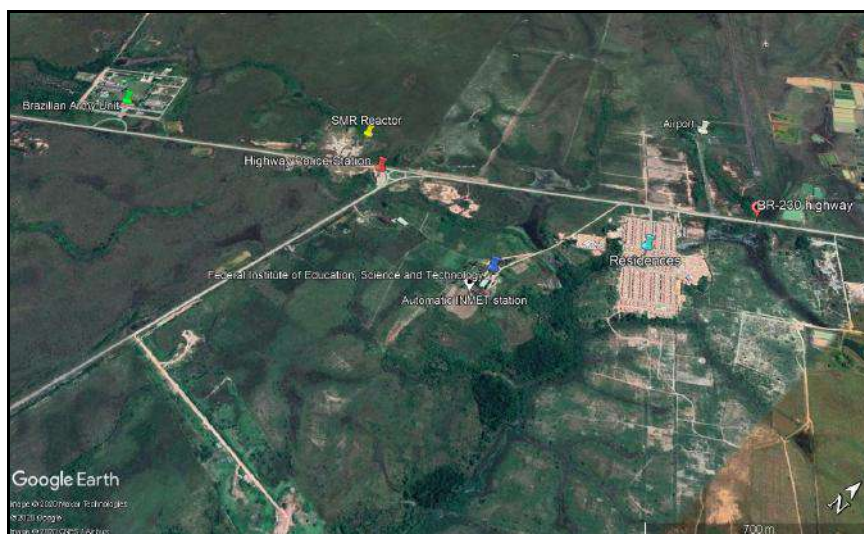
*Fig. 4: Visualization of the SMR installation location, showing adjacent areas.*

*Source: Google Earth, 2020*

The data were obtained from the database of the National Institute of Meteorology (INMET), the National Institute for Space Research (INPE) and the literature, considering an observation period for the last 5 years.

Based on meteorological information, the direction and speed of the wind in this locality were defined, throughout the year. It was found that the wind speed in the region oscillates in the range of 0 and 4 *m/s*, with the highest recorded speed being 6 *m/s*. The period of day when this maximum speed can occur is between 12 noon to 6 pm. The preferred wind direction is most frequent between 0 to 90º, although other directions may occur throughout the year. In addition, the average obtained for the intensity of solar radiation, with the data for the period considered, was greater than 700 *W/m²* [15-17].

Based on the meteorological data of that place and assuming a plausible scenario, it was assumed that, at the moment of the postulated accident, the wind speed was 3 *m/s*, the release of radionuclides into the atmosphere occurred during the day, there were no precipitations and the solar radiation was 700 *W/m²*, which allows to classify atmospheric stability, for the present study, in Pasquill-Gifford's Class A (extremely unstable) [4]. In addition, considering the areas adjacent to the SMR operation site, the analysis of the atmospheric dispersion of the Cs-137 was carried out based on the wind direction coming from the West (270º), a situation in which the greatest negative effects will be caused, due to the existence of relevant points (university center, Highlight Police Station and residences) in the region of incidence and displacement of

the winds, according to the legend in Fig. 4, justifying its use in this study.

Thus, considering the dispersion model, the type of terrain, the characteristics of the reactor of this study and the meteorological information, these data were analyzed and entered as input parameters in the HotSpot software. All calculations were performed considering the Pasquill-Gifford stability class A. Table 1 presents these parameters for the simulation of the radiological accident caused by an assumed failure in the SMR cladding.

*Table 2: Parameters for HotSpot simulation.*

| Parameters | Input |
|---|---|
| Radioactive material | Cs-137 |
| Activity | 4,295E+15 *Bq* |
| Wind speed | 3,0 *m/s* |
| Wind direction | 270º West |
| Distance coordinates | Distance from plume centerline |
| Stability class (standard terrain) | A (extremely unstable) |
| Receptor height | 1,5 *m* |
| Sampling time | 10 *min* |
| Factors of dose conversion | FGR nº11 [18] |
| Exposure time | 24h |
| Effective release height | 10 *m* |

*Source: Research Data*

Under the boundary conditions defined in Table 1, the study zones were delimited in isodoses curves, according to the TEDE values received, depending on the distance to the origin of the dispersion. These curves are organized as internal, intermediate and external, assuming the limits of 50 mSv, 10 mSv and 1 mSv, respectively. The first two values refer to the dose avoided by the evacuation (50 mSv) and shelter (10 mSv) actions [14] and the third (1 mSv), only as a reference for the third curve, in reference to the annual limit of dose for an individual of the public (1 *mSv/year*), expected for a normal exposure situation, before the accident [19].

The results obtained, in terms of the TEDE received and the concentration of Cs-137, at different distances downwind, due to atmospheric dispersion, were analyzed and compared with the normative thresholds stipulated by the regulatory authorities for radioprotection, in order to verify the influence of weather conditions on the contamination plume, the population potentially affected during this radiological event and also the protective measures to be taken in the initial phase of the accident described in this study.

## III. RESULTS AND DISCUSSION

After the data in Tables 1 and 2 (referring to Cs-137) are entered in the HotSpot code, the TEDE values and the concentration profile are shown in Table 3, considering a maximum distance of 100 km from the origin of the dispersion. The data refer to the period of one day (24 hours) of exposure.

Table 4 presents other important information for the analysis of atmospheric dispersion, considering the assumptions adopted in the simulation.

In this way, Fig. 5 and 6 show the isodoses curves, representing the TEDE of 50 mSv, 10 mSv and 1 mSv, respectively, generated over the terrain, showing the affected area, in which the extremely unstable stability class (Class A) was considered acting in the SMR's operating region.

The calculation of the atmospheric transport of the Cs-137 was also carried out for comparison with other stability classes, in the hypothesis that there are different atmospheric classes operating in the region where the reactor is operating, relating the dose values received at different distances from the origin of the dispersion, as well as the maximum TEDE value achieved, in the different stability classes, as described in Fig. 7 and presented in Table 5.

*Table 3: Dispersion data of the Cs-137 from the SMR accident.*

| Distance (km) | TEDE (Sv) | Air concentration [(Bq.s)/m³] | arrival time of plume (hora:min) |
|---|---|---|---|
| 0,03 | 3,50E+00 | 1,80E+11 | <00:01 |
| 0,1 | 9,90E-01 | 5,50E+10 | <00:01 |
| 0,5 | 4,00E-02 | 2,50E+09 | 00:02 |
| 1 | 9,70E-03 | 6,40E+08 | 00:05 |
| 2 | 2,40E-03 | 1,70E+08 | 00:11 |
| 3 | 1,10E-03 | 7,70E+07 | 00:16 |
| 4 | 6,10E-04 | 4,50E+07 | 00:22 |
| 5 | 3,90E-04 | 3,00E+07 | 00:27 |
| 10 | 1,10E-04 | 8,60E+06 | 00:55 |
| 15 | 5,10E-05 | 4,30E+06 | 01:23 |
| 20 | 3,10E-05 | 2,60E+06 | 01:51 |
| 30 | 1,50E-05 | 1,30E+06 | 02:46 |
| 40 | 9,50E-06 | 8,50E+05 | 03:42 |
| 50 | 6,60E-06 | 5,90E+05 | 04:37 |
| 60 | 4,90E-06 | 4,40E+05 | 05:33 |
| 70 | 3,80E-06 | 3,50E+05 | 06:28 |

| 80 | 3,10E-06 | 2,80E+05 | 07:24 |
| 90 | 2,60E-06 | 2,40E+05 | 08:20 |
| 100 | 2,20E-06 | 2,00E+05 | 09:15 |

*Source: Research Data*

*Table 4: Data obtained from computational simulation in HotSpot code regarding the dispersion of Cs-137.*

| Information | Observation |
|---|---|
| Maximum TEDE Value | 3,6 Sv |
| SMR distance the TEDE is maximum | 0,034 *km* |
| Distance from the SMR at which the TEDE exceeds the internal isodose | 0,45 *km* |
| Distance from the SMR at which the TEDE exceeds the intermediate isodose | 0,98 *km* |
| Distance from the SMR at which the TEDE exceeds the external isodose | 3,1 *km* |

*Source: Research Data*
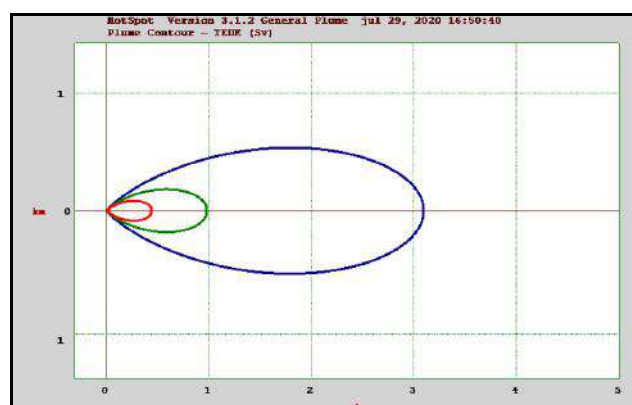


*Fig. 5: Isodose curves due to Cs-137, obtained from HotSpot code, considering stability class A. Internal isodose (red color): 50 mSv (0.055 km²); Intermediate isodose (green color): 10 mSv (0.26 km²); External isodose (blue color): 1 mSv (2.4 km²).*

*Source: HOMANN, 2019*
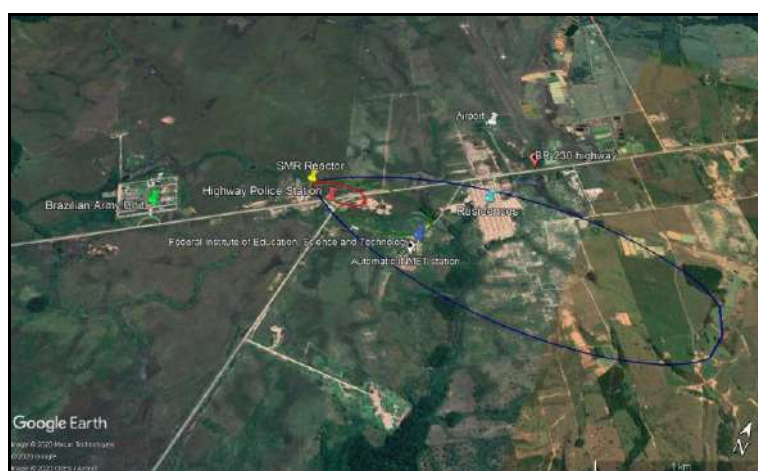


*Fig. 6: Contour limit of the isodoses referring to the contamination plume with Cs-137.*

*Source: Google Earth, 2020*
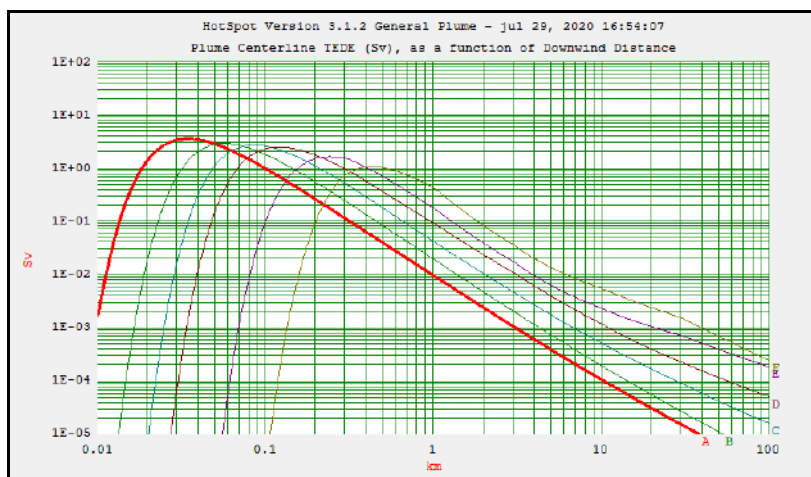
*Fig. 7: TEDE values received at different distances downwind, considering all stability classes.*

*Source: HOMANN, 2019*

*Table 5: Maximum values of TEDE for different stability classes.*

| Atmospheric stability class | Dispersion data for Cs-137 | | |
|---|---|---|---|
| | Description | Maximum TEDE (Sv) | Distance (km) from SMR |
| A | Extremely unstable | 3,6 | 0,034 |
| B | Moderately unstable | 2,9 | 0,057 |
| C | Slightly unstable | 2,8 | 0,085 |
| D | Neutral conditions | 2,5 | 0,120 |
| E | Slightly stable | 1,7 | 0,240 |
| F | Moderately stable | 1,1 | 0,430 |

*Source: Research Data*

From the origin of the dispersion, the calculated values showed that the maximum TEDE, due to Cs-137, is obtained at 34 m, with a value of 3.6 Sv, decreasing with time and distance. These results are obtained at different times, as this radioactive material reaches designated receiving points in downwind locations [3], as shown in Table 3. Such behavior is shown to be acceptable from the theoretical point of view, since the release of this radionuclide into the atmosphere follows the Gaussian model of dispersion, shown in Fig. 3 [4,12].

Fig. 5 and 6 show that the highest dose values, above 50 mSv, are found in the area between zero point and 0.45 km, followed by the intermediate dose value, greater than 10 mSv and smaller than 50 mSv, within the distance of 0.45 km to 0.98 km, and the last curve in the distance from 0.98 km to 3.1 km, representing values above 1 mSv and less than 10 mSv. The curves cover an area of 0.055 km², 0.26 km² and 2.4 km², respectively.

Regarding the influence of weather conditions on atmospheric dispersion, the results showed that the more unstable these conditions prevail in the location, the greater the TEDE values at a shorter distance from the origin of the Cs-137 dispersion, as shown in Table 5. This can also be seen in Fig. 7, which shows the decrease in maximum TEDE values when atmospheric stability conditions become more stable. In addition, due to the curves presented in this same figure, there is also an increase in TEDE value for greater distances when considering the most stable classes. These observations suggest that situations of high turbulence in the atmosphere favor the mixture of pollutants, increasing the rate of deposition of radioactive material in the soil and decreasing the transport of this radionuclide over greater distances, i.e, generating lower dose values from submersion to the cloud of Cs-137. In addition, the results also denote the dependence of the plume on radioactive

contamination with the criteria of atmospheric stability, proposed by Pasquill-Gifford [3,4].

Furthermore, according to the calculated data, for doses above 50 mSv, the intervention may occur in the direction of evacuation of people from the vicinity of the reactor, in a movement contrary to the propagation of the plume. According to the geographical characteristics presented in Fig. 4, and according to the assumed atmospheric dispersion scenario (daytime, main wind direction coming from the West and without rain at the moment of the postulated accident), there are locations in this region, such as the Airport and also the Brazilian Army unit, which besides being close to the reactor site, are not being influenced by the preferential displacement of the plume, which would allow the execution of this protective action. In addition, the existence of the BR-230 highway would facilitate the transportation and removal of the population to the designated locations, provided that this measure occurs for a period of up to 1 (one) week, as recommended by regulatory agencies [14].

For doses in the range between 10 mSv and below 50 mSv, the results suggest the adoption of shelter as a protective measure. As seen in the isodoses curves in Fig. 6, the Highway Police Station, the Federal Institute of Education, Science and Technology and the set of existing residences are receiving exposures below 10 mSv. The same procedure can also be adopted for the population that is submitted to doses ranging from 1 mSv to 10 mSv, since in emergency situations, the pre-established levels of intervention can be reassessed, when implemented, in depending on the conditions existing at the time of the accident, as long as the dose levels are not exceeded (foreseen, in this case, for the shelter, in 10 mSv) [14]. This measure would considerably reduce the doses due to irradiation from the cloud, irradiation from contaminated soil and inhalation of Cs-137, due to the reduction factor inherent in these constructions.

However, even in the case where the doses are above 50 mSv, the shelter, under the conditions mentioned above, can be applied, as long as the dose limits imposed for this action (10 mSv) are respected. The ideal time to implement the evacuation would be before the passage of the plume, which may not be possible given the results achieved in this study, since the radioactive cloud reaches the points closest to the reactor in less than 5 min. If the evacuation was performed during the passage of the plume, it would be possible that higher doses would be received by the evacuees than by those who remained sheltered. In addition, depending on weather conditions, the number of people to be evacuated and the means of transport available, evacuation could take a long time,

corroborating the option for shelters, so as not to put the population potentially involved in the accident at risk. It should be noted that the shelter period should not exceed two days of exposure [14], when evacuation, in a later stage, i.e, after the passage of the plume, could be more effective.

From the distance of 3.1 km from the origin of the accident in the SMR, the TEDE values, at different points, are below 1 mSv. The results suggest that Cs-137 can be transported over long distances, however, the dose values due to the contribution of this radionuclide, in the amount in which it was released into the atmosphere (Table 1), will be below the intervention levels proposed for the shelter and evacuation, therefore, it is not necessary to adopt these protective measures, under simulated conditions [3]. These values, in fact, are in the same order of magnitude as those allowed for normal operation situations, before the accident moment, in which the dose limit is 1 *mSv/year* for the individual of the public [19].

## IV. CONCLUSION

The objective of the research was achieved through simulation by computational modeling of atmospheric dispersion resulting from a hypothetical radiological accident in a small modular reactor (50 MWt), in a region where electricity is scarce, to analyze the adoption of immediate protective measures in the initial phase of the postulated radiological event, as well as the influence of weather conditions on the contamination plume.

The main results of this research showed that, for stability class A, assumed at the time of the hypothetical accident, a maximum TEDE value of 3.6 Sv was obtained, at a distance of 34 m from the origin of the dispersion, as a contribution of a radionuclide with significant importance in radiological protection, the Cs-137, which was obtained from of a hypothetical SMR inventory, considering the condition of total burnup of this reactor. From this result achieved, the present study allowed to verify that the other calculated concentration and dose values decrease with time and distance, following the Gaussian dispersion model [4,9].

The research also allowed to verify the influence of the meteorological conditions in the atmospheric dispersion, showing the dependence of the plume of radioactive contamination with the criteria proposed by Pasquill-Gifford. The results showed that the more unstable these conditions prevail in the place, the greater the TEDE value at a shorter distance from the origin of the Cs-137 dispersion, and that an increase in doses occurs, for greater

distances, when considering the classes more stable atmospheric stability.

Another relevant finding from this study, is that, for doses above 50 mSv, the intervention may occur in the sense of evacuating of population from the vicinity of the reactor, in a period of less than a week, both for the region's Airport, as well as for the Brazilian Army Unit, featuring a movement contrary to the preferential direction of the plume. For doses in the range between 10 mSv and below 50 mSv and between 1 mSv and 10 mSv, the results suggest the adoption of the shelter as a protective measure, considering that in the reactor location there are the Highway Police Station, the Federal Institute of Education, Science and Technology and residences, which are receiving exposure below 10 mSv. In addition, for all these cases, depending on the time of arrival of the plume, the climatic conditions, the amount of people to be removed and the existing means of transport, the option for shelters may be the most relevant, as long as it does not exceed two days of exposure, when evacuation is the most effective option.

Therefore, the research shows that, for studies of atmospheric dispersion, with a well-defined characterization of the source of ionizing radiation, the methodology applied in the computational modeling resulting from a radiological accident in an SMR allows to verify the compliance with the standards regarding the planning of emergency responses and the influence of weather conditions.

## ACKNOWLEDGEMENTS

## REFERENCES

[1] FISCHER, G., RIPLEY, C. Improving Air-Cooled Condenser Performance and Availability Through Innovative Cleaning, Inspection and In-Situ Sleeving. In: 2012 20th International Conference on Nuclear Engineering and the ASME 2012 Power Conference. American Society of Mechanical Engineers Digital Collection, 2012. p. 777-782.

[2] UNITED STATES DEPARTMENT OF ENERGY - DOE (2019). Reactor Technology: Benefits of Small Modular Reactors (SMRs). Disponível em: <https://www.energy.gov/ne/benefits-small-modular-reactors-smrs>. Acesso em: 10/02/2020.

[3] MUSWEMA, J. L. et al. Atmospheric dispersion modeling and radiological safety analysis for a hypothetical accident of Ghana Research Reactor-1 (GHARR-1). Annals of Nuclear Energy, v. 68, p. 239-246, 2014.

[4] HOMANN, S. G. Hotspot Health Physics Codes Version 3.1 User's Guide. CA, USA: Lawrence Livermore National Laboratory, 2019.

[5] NETO A. T., DUARTE, G.M., TALON, J.D., LOPES, T.J., OLIVEIRA, C.L., FIEL, J.C.B., FONTES, G.S., CABRAL, R.G., VELLOZO, S.O., BARROSO, D.E.G. Multilaminated shielding applied to a hypothetical small modular reactor. BJRS, 2019.

[6] S. M. BOWMAN (2011). SCALE 6: Comprehensive Nuclear Safety Analysis Code System, Nuclear Technology, 174:2, 126-148, DOI: 10.13182/NT10-163;

[7] US NUCLEAR REGULATORY COMMISSION et al. Regulatory Guide 1.183 (draft was Issuedas DG-1081): Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors. US Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, 2000.

[8] INTERNATIONAL ATOMIC ENERGY AGENCY (1988), The Radiological Accident in Goiânia. IAEA, Vienna.

[9] DUDERSTADT, James J. Nuclear reactor analysis. Wiley, 1976.

[10] SMITH, Matthew C.; WRIGHT, Richard F. Westinghouse small modular reactor passive safety system response to postulated events. Proc. of ICAPP'12, 2012.

[11] US.NRC. Basics References, Glossary. Disponível em: <https://www.nrc.gov/reading-rm/basic-ref/glossary/total-effective-dose-equivalent-tede.html>. Acesso em: 03/03/2020.

[12] STOCKIE, John M. The mathematics of atmospheric dispersion modeling. Siam Review, v. 53, n. 2, p. 349-372, 2011.

[13] IEMA. Clean and inclusive electrical matrix. Available in: <http://energiaeambiente.org.br/um-milhao-estao-sem-energia-eletrica-na-amazonia-20191125>. Access in: 05/03/2020.

[14] NATIONAL NUCLEAR ENERGY COMMISSION (CNEN). Regulatory position 3.01/006. Protection Measures and Criteria for Intervention in Emergency Situations. Rio de Janeiro, 2011.

[15] INPE. National Institute for Space Research. Available in: <http://clima1.cptec.inpe.br/monitoramentobrasil/pt>. Access in: 25/07/2020.

[16] INMET. National Meteorological Institute. Available in: <https://portal.inmet.gov.br/dadoshistoricos>. Access in: 25/07/2020.

[17] Average weather in Humaitá. Weather Spark, 2020. Available in: <https://pt.weatherspark.com/y/28384/Clima-caracter%C3%ADstico-em-Humait%C3%A1-Brasil-

durante-o-
ano#:~:text=Em%20Humait%C3%A1%2C%20a%20esta%
C3%A7%C3%A3o%20com,superior%20a%2036%20%C2
%B0C.>. Access in: 25/07/2020.

[18] ECKERMAN, K. F.; WOLBARST, A. B.; RICHARDSON, A. C. B. Federal Guidance Report No. 11: Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. EPA, 1988.

[19] NATIONAL NUCLEAR ENERGY COMMISSION (CNEN). Basic Radiation Protection Guidelines. CNEN NN 3.01 Rule. Rio de Janeiro, 2014.

# Challenges for Innovation in Small Businesses: The Local Innovation Agent Program in Brazil

Laura Tavares Ferraz[1], Paulo Gammaro Gândara Rabello Alves[2], Cleidson Nogueira Dias[3], Raimundo Otávio Nogueira Dias[4]

[1]M.B.A. in Business Management. Fundação Getúlio Vargas, São Paulo, Brazil
[2]Lawer and leader of the sales team at Galpão SIA - Casa em Movimento), DF, Brasília, Brazil
[3]DSc. in Business, Department for Innovation and Business, Brazilian Research Agricultural Corporation (Embrapa) and professor at University of Brasília (UnB), DF, Brasília, Brazil
[4] MSc. in Mechanical Engineering, Intern Quality Engineer at Faurecia Clean Mobility na Gödöllő, Pest, Hungary, USA

*Abstract— The Local Innovation Agent Program (ALI-Agentes Locais de Inovação) in Brazil is a national action that has invested billions of reais in the last decade supporting small businesses to face the various barriers to innovate. Thus, this article aims to identify the perception of micro and small companies in Brasília-DF about the challenges to innovate while participating in the ALI Program. To this end, the present work made use of the descriptive methodology and the qualitative analysis method. As for the means, it used bibliographic research, case study and field research, as described by Vergara (2007). The results showed the perception of two different audiences, first, of the Local Innovation Agents, who helped to identify the stages with the greatest degree of difficulty; second, from the participating entrepreneurs themselves, who contributed, with their perceptions of difficulties, positive points and learnings when applying the ALI methodology for the innovation of their businesses.*

*Keywords— Innovation. Micro and small business. Local Innovation Agent Program. Retail.*

## I. INTRODUCTION

The effects of technology, in a global trade, especially impact the small business. Therefore, this type of enterprise needs to keep itself updated and constantly innovate its own products, services and processes in order to survive. On the one hand, large corporations have high bargaining power, scale and investment; on the other hand, they are hierarchical and procedural. In addition, they have difficulties in identifying the need for changes and also in implementing new management paradigms.

Plunged in a framed panorama of economic uncertainties and significant changes in the employment relationship, Brazil has been presenting successive records of formalization of companies (Varella, 2019), thus showing the exponential increase in the offer of products and services, while at the same time the great level consumer demand and broad market competition.

Less than 20% of people involved in entrepreneurial activities in the country create new products for the market (Bizzotto, 2008). The culture of commodities is still a reality that harms and weakens mainly the small retail entrepreneur, subjecting him to a

true "guerrilla" for the most competitive price, destining his business to stagnation (Bogmans & Retrepo, 2019).

In this context, it is clear that smaller companies are in a good position to innovate, either because of their lean structure, which favors proximity to the end customer; possibility of making decisions and identifying opportunities to innovate faster, even within the limitations of strategic vision, financial and human resources.

Therefore, it is necessary that these companies have access to tools that help them on this path towards innovation. To that end, a wide portfolio of products and services promoting technology and innovation were developed by Sebrae to support the sustainable development of small businesses (Sebrae, 2017).

Among these products, the projects "Sebraetec", "Capital Empreendedor" and "Agentes Locais de Inovação" (ALI) stand out. In this second case, the program was developed nationwide, more than ten years ago, in conjunction with the National Council for Scientific and Technological Development (CNPq). (Sebrae, 2019a)

In 2019, Sebrae reformulated the ALI methodology, using more advanced and current innovation methods, including concepts and tools applied by large innovation companies and fast growing startups. Thus, allowing to validate innovation with potential customers, scale the business and reduce innovation risks in a shorter period of time. (Sebrae, 2019b)

The present study seeks to identify how was the experience of participating companies with the new methodology applied in the Federal District in 2019, from the perspective of difficulties, positive points and learnings experienced by them during this first cycle of the program. Understanding these empirical experiences will allow future participating companies to better understand the benefits, prepare for obstacles and develop strategies to mitigate challenges, thus contributing to the generation of expected results (increase in revenue, productivity and cost reduction), with fewer errors in the process towards innovation. In this sense, how can management tools help innovation processes for small business owners?

Therefore, this article has the general objective of identifying the perception of micro and small companies in Brasilia about the challenges to innovate while participating in the ALI Program. As a specific objective, a comparative approach was made to the contents worked on in the theoretical framework with the identification of the standards experienced by entrepreneurs in the process of business innovations, as well as to describe the behavior that retailers in the region of Brasília / DF have in the theme of innovation.

According to (Gil, 1999), the delimitation of the research refers to the establishment of limits for the investigation, given that not all aspects of the problem can be researched simultaneously. Thus, the focus of this work will be restricted to the universe of Local Innovation Agents and entrepreneurs approved in the selection process of the Local Innovation Agents Program (ALI), which concluded the ten meetings predicted in the methodology.

The Brazilian Micro and Small Business Support Service (SEBRAE-Serviço Brasileiro de Apoio às Micro e Pequenas Empresas) together with the National Council for Scientific and Technological Development (CNPq-Conselho Nacional de Desenvolvimento Científico e Tecnológico) disseminate innovation to the small business owner through the ALI Program, in which there will be a final stage focusing on four small retail companies through the Innovation Radar by Bachmann and Destefani (2008), by observing the aspects of Culture of Innovation, Customer Experience, Productivity and Cost Reduction,

through which the evolution of retail companies will be investigated regarding their sales processes in commercial points.

The methodology used to carry out the diagnosis in the companies was based, mainly, on the understanding of the type of research by Vergara (2007). Thus, the basic criteria that will considered for the purposes are the descriptive and the method of qualitative analysis. Descriptive, since it exposes characteristics of a certain group of companies and their correlation with the object of study and qualitative, since the researcher is a direct source of the data collected. As for the means, it is characterized as field and bibliographic research, since it is intended to make a study from the reality experienced in the ALI Program and a systematic study, using books, articles, magazines and electronic networks in general.

This article is structured, in addition to this introduction, into four other topics. In the second, there is a review of the literature and the insertion of three case studies on the subject addressed. In the third one, the methodological aspects used for the development of this article will be highlighted. The fourth topic will present the analysis and discussion of the results. Finally, in the final considerations, a brief discussion of the results is promoted based on the conceptual references used.

## II. THEORETICAL BACKGROUND

### 2.1 Innovation as a driver for Competitiveness

Considering that Brazilian companies are inserted in a global environment where the competitiveness of the markets is increasingly fierce, they must seek innovation to differentiate themselves from competitors, improve their performance and, consequently, gain a competitive advantage over others.

Before discussing the importance of innovation for the greater competitiveness of Micro and Small Companies (MSC), it is worth understanding what innovation is. According to the Oslo Manual, innovation can occur in four areas of the company: a) the introduction of a new or significantly improved product (good or service); b) a process; c) a new marketing method or d) a new organizational method in business practices, in the organization of the workplace or in external relations. (OECD & FIEP, 2005).

Innovation can also be seen as a business management strategy that has the function of breaking a balanced state of economic forces, through the insertion of new products, goods or services in a certain segment or market. Shumpeter (1934) states that "innovation is the

crucial source of effective competition, economic development and the transformation of society". As a result, Kupfer and Hasenclever (2002) consider that innovations can provide cost reduction, productivity gains, increase in the quality of products or services, competitive asymmetry and, often, temporary monopolization of a market opportunity, earning greater profits.

In line with the other authors, Vasconcelos and Cyrino (2000) understand that competitive advantage is related to the occurrence of levels of economic performance above the market average from the strategies implemented by companies. In this sense, investment in innovation can provide differentiation from competition, achieve competitive advantage and, consequently, provide the conditions for superior financial performance and perpetuity in the market.

Oliveira (2013) considers that traditional organizations have faced difficulties in maintaining their business when faced with some types of market and technology changes, especially in the face of technological disruptions. In his opinion, they fail not because of their deficient management, but because they follow a management guideline resulting from express attention to their customers, a study of trends and the allocation of resources for innovations that pointed out the best return. However, they failed to consider disruptive innovations that created new customers and markets for products with lower margins and greater appeal.

Schumpeter (1939) introduces the concept that innovation can be incremental - significant improvements from something that already existed before - or radical - by totally revolutionizing a market or creating a totally new market. This same concept is used by Oliveira (2013), who also believes that radical innovation becomes mandatory even in traditional companies that are willing to innovate, since purely incremental innovation can become obsolete with exponential speed with which technology grows, with a population that is seven times greater than that of the 18th century. After all, disruptive innovations, when exploring unknown territories, present original proposals that can generate competitive differential and, consequently, allow to explore those that were not their consumers, to open new niches and non-existent markets. Oliveira (2013) also contributes with the perspective of how to identify the needs of consumers to deliver value and an orientation of the effort required to invest in incremental and radical innovation:

Innovation must offer its consumers the possibility of doing something that it was previously unable to accomplish, either due to the lack of resources or the complexity of the product. Thus, the best way to think about innovation is to identify the gaps left by products and services until then offered to the market, in terms of their functions. In general, it is proposed that organizations dedicate 90% of their efforts to incremental innovation and 10% to radical innovation, both essential to organizations. (Oliveira, 2013).

This suggested percentage will depend on the sector in which they operate, the dynamics, the influence of external factors and even the culture of the company, but it is very important that both initiatives are considered together and, whenever possible, are conducted separately in the company because different processes are needed for each type of innovation.

It is worth mentioning that it is not enough that the innovative proposal is creative and interesting, if the market is not willing to pay for it. Therefore, radical innovation is often accompanied by innovation in the business model. On the one hand, radical innovation seeks to solve consumer needs, while innovation in the business model proposes to analyze how the organization should structure itself and adapt its processes to innovate, in terms of distribution channels, revenue generation and processes and operations. Due to their complementary nature, both types of innovation must be applied simultaneously.

**2.2 Retail Sales and Innovation**

When analyzing Brazilian retail, there are a number of inherences within the management behavior of companies that directly affect their sales processes. In particular, the difficulty in interpreting the performance indicators and the absence of the development of the value proposition in the offers aimed at the customer are factors that trigger in the sales team an inhospitable environment for their work. As a result, this environment generates a high rate of employee turnover in the company, a direct impact on productivity, sales conversion and, subsequently, on the company's revenue, as noted below:

> (i) Few retailers make use of performance indicators that allow them to assess the cost of their operations (sic.) And that provide a better management of their human and material resources; (ii) In general, the store team is fixed, with a constant number of employees, scaled by the average, which creates idleness during low-traffic hours (sic.) poor service and eventual loss of customers during peak hours, as on Saturdays; (iii) It remains to develop a value proposition for the client, covering among others (sic.) services, store image, layout, logistics and communication; (iv) Retail work is seen as "beak", employee

dissatisfaction is high and the annual turnover is large. Retail companies, in general, are concerned with creating marketing strategies to try to bring customers into the store, but few seek to design and implement service strategies to keep them loyal. (Nascimento, 2005, pp. 22)

In this scenario, Bizzoto (2008) points out that professionals try to fit into the vacancies opened by companies, that is, "no matter what we like to do, we have to adapt to what the company needs". This has serious consequences, causing 74% of the economically active population in Brazil to dislike the work they do. On the other hand, Many small and medium-sized businesses fail because they do not see or recognize the need for change. They are introspective, very busy with putting out their own fires and dealing with the current crisis to worry about possible storms that may arise (Bessant, 2009).

The competitive environment within the retail universe requires companies to find alternatives to remain in the market, whether by launching new products, new processes or new business models.

Innovation is a fundamental element of business competitiveness, since it allows organizations to increase their market share by adding value to the product or service better than other companies (PORTO, 2013). In a categorical tone, if we do not change what we offer to the world (goods and services) and how we create and offer, we run the risk of being overcome by others who do. Microsoft - one of the largest and most successful companies in the world - takes the view that it is always two years from its extinction (Bessant, 2009).

The sales team can contribute to retailers' offerings to conquer the market, but this is in fact not the basic reason for consumers to buy our solutions. We know that on a daily basis, we, as buyers, need to perform certain tasks and in that circumstance we look for products or services that can be "hired" in order to solve them. In this logic, Bizzoto (2008) highlights that the companies that direct their products in the circumstances in which customers find themselves, and not in the profile of consumers, are those that create successful products.

In this context, Nascimento (2005) asserts that proximity and the focus on the customer to deliver value to the market is seen as a prerequisite and an imperative for high performance companies. Companies understand, serve, exceed the needs and interests of customers, plan targeted actions aimed at speed and effectiveness of responses in a competitive context, maintain ethical relationships with customers ensuring that they know what to expect from them and keeping all stakeholders

(controllers) , community, government, employees, users), exceeding their expectations.

The focus on the customer is the source of fundamental ideas for creating value that aims to offer innovative solutions, since innovation only reaches concreteness when it is accepted and valued by the market:

> [...] What these customers say and think weighs heavily as a source of ideas - hence its high concreteness. Market research is an efficient way to reach them. Among its various techniques, it is deserved to be mentioned the focus group, a qualitative research modality carried out directly with small groups of people with knowledge or experience in relation to the good or service that is intended to be analyzed in depth. (Barbieri, 2009, pp. 32)

Helping the company team to format a questionnaire that will be used as a basis for the interview with the client (when it was defined that only one type would be interviewed) or clients (when the company understood that it needs to interview more than one type of client) is essential to find out what the client is wanting to do and is not getting, that is, what is the progress the client wants in the circumstance he is experiencing (Soares; Bezerra, 2018).

As it is considered that it is always a risky and uncertain process, many retailers and small businessmen choose not to innovate, even though the possible rewards seem attractive, however in the panorama that we experience today - it is rarely an option - especially in turbulent sectors of the economy. of sudden changes. Some companies need to change dramatically to survive in the business. A company founded in the early 19th century, for example, that had Wellington boots and toilet paper on its list of products today is one of the largest and most successful in the world of the telecommunications field. Nokia started its activities as a lumber and sawmill, manufacturing equipment for cutting trees in Finland. He started to explore the paper industry and from there he reached TI's "paperless" office - and at that point he reached cell phones(TIDD, 2008, p. 60).

As important when understanding the benefits that innovation provides for the business to perpetuate itself over time, it is to understand the challenges that the small business has to survive. Thus, in 2007, Deloitte Brasil, an Audit and Business Consulting company, carried out a study that seeks to understand the factors of innovation for the survival of micro and small companies in Brazil. (Deloitte, 2007)

According to the survey, entrepreneurs associate innovation more with a new business model than with the differentiation process (significant improvement) of this product and | or service. They associate innovation with the ability to expand their business inside and outside their own markets, with 2/3 of the interviewees saying that innovation was able to make their businesses more profitable. This study also reinforces that innovation is a decisive factor for the survival of the business, since more than 80% of the interviewees stated that innovation is important to grow faster than the competition.

Fleck (2003) reinforces that the measure of success of an organization is its ability to survive and self-perpetuate the business, linked to an intense search for innovation in solutions that respond to market needs.

However, according to the survey carried out by Deloitte, the great challenge for entrepreneurs is to raise funds in the long term, few existing lines with reasonable rates to finance innovation and the excessive bureaucracy to release resources.

In 2016, MJV, a technology-based company focused on innovation, developed a survey of 288 business leaders and managers to verify how they see and plan innovation in their corporations (MJV, 2016).

In this study, despite half of the companies claiming not to have a structured process, the motivation to innovate is explicit, and for 62% of the interviewees, the main motivators for the development of innovation projects are:

- Improving the quality of existing services or products

- Meeting customer expectations

- The development of new products or services

- Business expansion to new customers and / or segments

- Improving operational efficiency.

It is observed that, in this study carried out by MJV there is a more timid behavior for radical innovation and a tendency to make incremental innovations, in comparison to the study carried out by Deloitte. The study carried out by Sebrae-SP considers both scenarios, but focuses on the need to know how to control the management of your business well in order to survive. Therefore, this latest survey shows that leaders are more attracted to the improvement in the current solution (improving the quality of existing services or products and meeting customer expectations) than investing in a new business model (developing new products, services and business expansion to new customers and segments).

## III. METHODOLOGY

This work has a qualitative approach. As for the research methodology, it was based on the taxonomy presented by Vergara (2007), which qualifies the research under two aspects: as to the means and as to the ends.

As for the means, the research was field, bibliographic and case study. It is classified as field research since it empirically investigates the place where the phenomenon occurred from interviews conducted with Local Innovation Agents and participating entrepreneurs. Bibliographic, because the information contained in books, magazines, technical and academic publications was used. In addition, the case study was adopted as a means of investigation because it investigates the contribution of the Local Innovation Agents Program (ALI) in the sales processes of participating micro and small retail companies, with character of depth and detail of information.

As for the purposes, the research was descriptive. According to Godoy (1995), in his qualitative analysis descriptions, "the researcher is a key instrument, the environment is a direct source of data, does not require the use of statistical techniques and methods. They are descriptive, the result is not the focus of the approach , but rather the process and its meaning, that is, the main objective is to understand the main difficulties, positive points and learning experienced by entrepreneurs during the first cycle of the new ALI methodology and its correlation with the studies published by solid institutions regarding the thematic studied.

In order to identify which were the main difficulties, learning and benefits experienced by entrepreneurs in applying the ALI Project in their companies, the interview was conducted with two different audiences. The first corresponds to Local Innovation Agents who participated in the entire first cycle and to those entrepreneurs (participants in the ALI / DF Project - Local Innovation Agents of Cycle 1 of 2019) who also completed all the tools of the cycle. In this way, an initial portrait was made, with the eight Local Innovation Agents to understand their perceptions regarding the investigated theme.

Then, a sample of 20 companies assisted in the first cycle of the ALI Program in 2019 in the city of Brasília / DF was selected, in which the companies located in the Plano Piloto, that is, the Asa Norte neighborhood and,

later, in the In step 2, eight interviews were selected and conducted with the entrepreneurs who completed all ten stages of the project to check how the practice experienced by these entrepreneurs was based on the initial identification made with the Local Innovation Agents.

As can be seen in Appendix I, Local Innovation Agents were asked only one open question: from their empirical perceptions, what were the three biggest challenges faced by entrepreneurs in applying the ALI methodology? Following the analysis of the result above, questions were also asked to the entrepreneurs. These questions consisted of four open questions, with the aim of allowing them to express their opinion on the challenges raised by the ALIs; a question with five options to measure the practical effectiveness of the tools and content worked to apply innovation in the business, and, finally, a sixth open, generic and optional question, seeking to identify some other point that the interviewees would like to explore.

Finally, among the eight selected micro and small companies that completed all stages of the cycle, as a last step, we sought to deepen the research in the cases of four (04) participating micro and small retail companies, that is, those that presented better performance regarding the delivery of innovative solutions to the market at the end of the program, using physical points of sale (PPS) as the purchase channel and having a sales team to assist the customer during the retail experience.

## IV. ANALYSIS AND DISCUSSION OF RESULTS

Before actually starting to analyze the results found in the field research, it is necessary to explore an overview of the new ALI methodology, since the questions are linked to this experience. An overview of the tool will then be discussed, making a dialogue with the study objects covered in the theoretical framework.

### 4.1 Phases of the Local Agent Innovation Program.

This topic intends to make a relation with the points treated in the case studies presented in this article, while briefly explaining the methodology applied to the companies that participated in the first cycle.

The ALI Innovation Management Methodology was structured so that any company, regardless of its size and structure, can generate successful innovations, in a systematic way. This methodology is based on the most advanced and current methods of innovation, using concepts and tools that are applied by large innovative companies, as well as fast growing startups, thus allowing

to validate the innovation with potential customers, scale the business and reduce risks (SEBRAE , 2019).

The ALI program has free monitoring for the micro and small companies (MSEs) served. It has regular face-to-face meetings, with a methodology aimed at generating concrete results for the participating companies, whether with increased revenue, reduced costs and / or increased productivity. However, in order to arrive at the value proposal described and the expected results, the work must be carried out jointly and collaboratively in the company, in addition to being supported by different actors, namely: the Local Innovation Agent, the advisor, the consultant, the state manager and the innovation ecosystem.

The first phase seeks to identify the entrepreneur's innovative profile and assess whether he has a market problem that is worth solving. In line with the research carried out by Sebrae-SP (2014), it was identified that entrepreneurial behavior makes all the difference to the success of the business, so the Innovation Radar was developed, a tool applied in the selection process, to help identify entrepreneurs with an innovative profile.

Still in the first phase, the Potential Problems Prioritization Framework works on the importance of the entrepreneur and his team to put themselves in the role of a client, to generate insights of problems experienced by these clients in order to later select the problem with the greatest potential to be worked on terms of market and level of stress experienced by the client. This dynamic works on several points brought along in the theoretical framework, such as: the Sebrae-SP (2014) survey highlights that 38% of the companies did not identify needs met by the market, that is, there is no immersion work in the experienced reality by the customer. MVJ's research also identifies the difficulty of finding internal leaders and staff to support initiatives linked to strategic direction and risks inherent to innovation. As the ALI project encourages team participation, it automatically contributes to fostering a culture of innovation, training the team - so that it can constantly identify improvements in the quality of existing services or products - with meeting customer expectations | market, as well as the empowerment of the solution, since it was built collectively.

The second and third phases work with a series of tools that aim to validate whether the hypothesis of the identified problem is a real market|customer need, as well as what is the progress, the value proposal contained in the product, good or service to be created in addition to the identification of possible gaps not satisfactorily addressed by the current market.

During these phases, we apply the Job to be Done concept that was created by Clayton Christensen (1997), which provides a change of paradigms about the possibilities of innovation for small businesses, in order to encourage them to think about more radical solutions, either with the development of new products, goods or services or with the expansion of business to new customers and / or segments. This stimulus increases the chance of the small business detaching itself from the competition, delivering more value to these markets, increasing revenue and the chance of self-perpetuating the business over time. In the third phase, they also introduce the concept of MVP (minimum viable product), popularized by Eric Reis (2011), which seeks to test the market potential of a given innovation without depending on large investments.

In the fourth phase, we arrive at the modeling of the business, where we work on the importance of management planning for the implementation of the new solution. At that moment, possible costs, expenses, expected revenue and sales conversion necessary to tangible the expected results with innovation are identified. At this stage, strategic planning is also developed in the Canvas Business Model, by stimulating the development of networks and partnerships, exposing the company to various offer channels, exploring new revenue models for the reality of the new solution in the market that small business proposes to explore.

It is noted that all these points were worked on in different perspectives throughout the theoretical framework, thus reinforcing the importance of the Innovation Management Methodology of the ALI Project.

## 4.2 Analysis of the results found in steps I and II

Based on the consolidation of the data collected with the Local Innovation Agents, the biggest barriers that entrepreneurs faced to put the ALI project into practice in the company were identified. In the first place, the Agents considered that interactions with customers - validation processes provided in the tool - were the most difficult steps for entrepreneurs. Second was the difficulty in dedicating itself to the project as a whole, followed by the difficulty of implementing the MVP.

From the above survey, we sought to understand the positive points, difficulties and their learning with the entrepreneurs. The compilation of the interviews generated the analyzes that will be presented below.

As can be seen in Appendix 1, the first question asked sought to understand the positive points, difficulties and learning experienced in the interaction | validation phase with customers. Entrepreneurs considered the tool

to be positive to encourage greater contact with their customers based on an open and structured conversation, favoring attentive listening to their real intentions, to identify their genuine and indirect needs. At the same time, it was considered difficult to extract this information, either due to the lack of practice in asking open and indirect questions, the lack of time for customers to answer the structured questionnaire, the difficulty of the entrepreneurs themselves in dedicating themselves to collecting information. according to the instructions of the methodology, or for the period of fifteen days suggested for completion of the stage, it was considered short for the achievement of the proposed objectives. This whole experience also generated important learnings in their opinion, as it allowed them to be aware that it is necessary to make a good approach with the customer, learn to manage the interaction time and carefully interpret the progress that the customer wants, to then develop a product , good or service suited to their needs.

The second question sought to understand the strengths, difficulties and learnings that entrepreneurs faced when dedicating themselves to the ALI project. Being part of this project, allowed the company to make adjustments to the product according to the market need, expand its horizons of possibilities for innovation, better plan its actions, test hypotheses and quickly identify difficulties, model and | or remodel before launching something new on the market, in addition to better understanding the value that the product provides and the innovation applied in it.

On the other hand, difficulties also accompany this trajectory. Entrepreneurs reported that it is not easy to launch the product in practice. The difficulties were justified because they involved a certain cost of implementation, time, application of unconventional remuneration models and fear of the project failing. It was also considered very difficult to get the engagement of other people (employees, partners, etc.) to contribute, execute and run the project together with them.

After participating in the ALI project, the interviewees also reported that the methodology provided a logical construction of thought that is fundamental to any business, stimulates the expansion of the mindset towards new solutions, new market options, new ideas and even, the improvement of what was already being thought by the company, so that the construction of an MVP did not present itself as something so complicated and that it seemed to meet the market's desires.

The third question sought to identify how companies experienced the implementation of MVP and |

or solution of the product (good or service found), following the same criteria of the previous questions, that is, the presentation of positive points, difficulties and learnings. According to the understanding expressed in the responses, this phase was the moment when ideas materialized in the stimulus when looking at areas that normally would not receive attention and focus on the solution (instead of focusing on problems). It was also reported that this moment was conducive to the maturation of new ideas - from the assimilation of new techniques - generating renewed enthusiasm to run the business.

On the other hand, this step demanded even more dedication from the entrepreneur to the project and the report of additional efforts was repeated, in addition to the day-to-day demands, which made the solution difficult to implement. Also in this line, the lack of financial resources and the engagement of other team members also contributed negatively to putting the developed solution into practice. Given the experience of completing all stages of the project, learning was reported that it is important to set and manage time to dedicate to innovation in the company, focus on creating a single product and better understand the value proposition that this product has aims to deliver to its customers and the market.

The fourth question aimed to compare the perception of ALIs with that of entrepreneurs. It was sought, then, to understand which of the aspects addressed in the questions was the most challenging. The time to dedicate to the project as a whole, represented 62.5% of the interviewed sample and the reasons presented by the entrepreneurs were: lean team, difficulty to engage in the project, excessive operational, managerial or personal demands, in addition to the cases when the company was going through moments of internal adjustments - not necessarily related to the program. All of these aspects were related to the difficulty in placing the innovation project as a central element of the business.

The interaction with the customer - which was identified by the ALIs as one of the greatest difficulties of entrepreneurs - was reported as the biggest challenge by only 25% of the sample among entrepreneurs, who considered that this interaction forced them to look outside and leave comfort zone. Finally, 12.5% of entrepreneurs pointed out the development of MVP as the greatest challenge encountered. In these cases, it was reported that the process of selecting a single idea, as well as, advancing the feasibility and modeling of the new product was difficult due to the lack of knowledge of the chosen segment, lack of partnerships and little knowledge about its target audience.

The penultimate question had the objective of measuring with the entrepreneurs, the real usefulness of the contents and tools used in the ALI project, so that 88.9% of the sample considered the contents and tools used "extremely useful" to put into practice the innovation of their business , followed by the "partially useful" option, which accounted for 11.1% of responses.
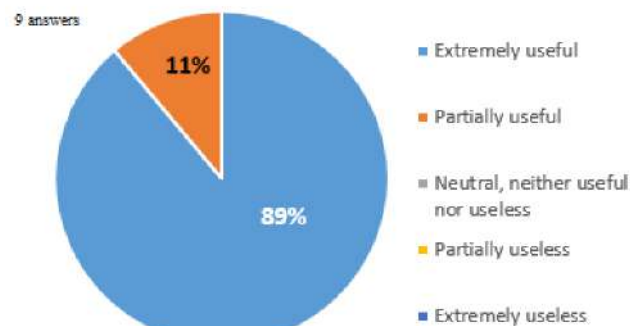


*Fig.1: Results of Question 5*

Source: Prepared by the Author.

The last question was open and optional for those who wanted to contribute with an unexplored point. Those who spoke up showed a lot of satisfaction with the project, expressing that the tools are simple, allow use in different scenarios, in addition to being reusable. It was also highlighted that the dedication and motivating vision of the Local Innovation Agent made a difference in enriching the process, insights and reflections generated throughout the project. An interesting contribution was also made by one of the interviewees, who highlighted that the methodology could have fewer tools, but encourage more discipline in their implementation.

It is observed that from the responses collected it is possible to make good connections with the theoretical framework worked on. In the case study carried out by Sebrae-SP, the tool helped and enabled entrepreneurs and their staff to know their customer's consumption habits, to identify the real market needs, to know their competitors, as well as to think and plan the actions, dividing tasks and defining responsibilities.

Most of these elements were also brought up in other words, in the MVJ case study (2016), in the case study by Delloite (2007) and de Oliveira (2013). In all of these sources, the importance of working to meet customer needs, improving quality, possible development of new products, as well as expanding business to new customers and / or segments is emphasized. The references are also

strong when it comes to the difficulties with day-to-day operational management, lack of resources to finance innovation projects, lack of financial management, in addition to issues related to human resources, such as less engaged and resistant professionals to changes and innovation initiatives.

**4.3 Analysis of the results found in stages III**

The last stage focused on four cases of micro and small retail companies. Thus, the interview was adopted as the form of analysis for this work and we submitted the interviewees to judge the following statements to the values of "totally agree" to "totally disagree" based on their participation in the ALI Program:

Implementation of innovative solutions in management processes that made the operation more efficient;

Delivery of new innovative products and / or services to the market that positively impacted current revenue

Understanding of new innovation concepts that, when applied, reduced the costs of operating in the business

Implementation of new strategies that helped in the sales processes and contributed to a better work environment

Increase and-or improvement in the business presence points

Understanding of productivity indicators giving rise to more assertive strategies for the business

As a result of applied research, we show in Figure 1, the results measured according to the cutouts to be analyzed:

*Table 1: Evaluation template answered by the four companies covered. Source: data obtained from the survey*

| Evaluate below the statements presented according to the company's participation in the ALI Program: | | | | | | |
|---|---|---|---|---|---|---|
| Attitude object to be measured | AFIRMATION | Completely agree (5) | Agree (4) | Do not agree, nor disagree (3) | disagree (2) | Completely disagree (1) |
| Management processes | Implementation of innovative solutions in management processes that have made operation more efficient | 4 | | | | |
| Supply | Delivery of new innovative products and / or services to markets that positively impacted annual sales | 2 | 1 | 1 | | |
| Cost reduction | Understanding of new innovation concepts that, when applied, reduced operating costs in the business | | 1 | 3 | | |
| Sales processes | Implementation of new strategies that helped in the sales processes and contributed to a better work environment | 1 | 2 | 1 | | |
| Presence | increase and / or improvement in business presence points | 1 | 2 | | 1 | |

| Produtivity | Understanding of productivity indicators giving rise to more assertive strategies for the business | | 2 | 2 | | |

Source: Prepared by the Author.


In red, we quantify the number of companies that marked the value gaps, judging the statements presented.


*Table 2: Score assigned by participating companies per statement. Sum of the assessment, considering the maximum score of 30 points (maximum of 5 in each statement).*

| COMPANY | Afirmation 1 | Afirmation 2 | Afirmation 3 | Afirmation 4 | Afirmation 5 | Afirmation 6 | Total |
|---|---|---|---|---|---|---|---|
| DOC VINHOS | 5 | 4 | 3 | 5 | 2 | 3 | 22 |
| ARCO-ÍRIS LIVROS | 5 | 3 | 3 | 4 | 4 | 4 | 23 |
| MEU CLOSET | 5 | 5 | 3 | 4 | 4 | 4 | 25 |
| GRÃO GRAAL | 5 | 5 | 1 | 3 | 5 | 3 | 22 |

Source: Prepared by the Author.


Given the first statement, it is unanimous to say that the participating companies succeeded in implementing innovative solutions in management processes that made operation more efficient through the methodology applied by the ALI program. When justifying the evaluation in this regard, the 4 (four) companies fully agree that the learning conceived in the meetings generated insights, new ideas and strategies that were applied in parallel with the meetings.

Regarding the second statement, two of the four companies fully agreed that through the ALI Program they were able to offer new innovative products and / or services that positively impacted their current earnings; a company agrees with the statement while a company has indicated that it neither agrees nor disagrees. When justifying the answered assessment, the excerpt from the speech of one of the entrepreneurs who was successful in this regard:

[...] We are still in the launch phase of our new service, of course we need to improve it as the customer uses and immerses himself in this new experience, but the acceptance has been very positive.

An interesting point of analysis for this research is the observation of the third statement. Three of the four companies considered neither agreeing nor disagreeing that participation in the ALI Program brought an understanding of new concepts of innovation that, when applied, reduced the costs of operating in the business, while one company agreed with the statement.

In answering the "why" of the assessment, the three companies that positioned themselves as the majority share that they already applied some strategies of their own in this sense because of the current economic scenario that they experienced, in which they needed to reduce the costs of their operations in order to continue supporting themselves in the market and that because of these actions, these indicators are stable.

In order to elucidate in a more direct way the measurement of the results investigated by this work, the fourth statement is provided: The ALI Program contributed to the implementation of new strategies that helped in the sales processes and contributed to a better

work environment. Two companies agree with the statement, one company fully agrees, while one company neither agrees nor disagrees.

The company that scored neither disagree nor agree with the statement, asserts that the gains obtained in the methodology came from other attributes such as productivity (more precisely the optimization of the company's management processes) and that its sales processes remained unchanged.

Highlighted, the company that considered to fully agree with the statement expressed in its testimony the following actions:

With the focus on the customer, we had gains that changed the way we approach our product presentation, the survey of consumers and even the organization of the store, so we started signaling through punctuation measured by the customer experience the most requested products and we molded the store window with these offers to save the customer's effort in finding what he wants [...]

The fifth statement can be pointed out by companies as one of the possible solutions in the sales processes in order to make the offer more comprehensive and reduce the effort of the potential customer, thus triggering a greater assertiveness of the sales team when succeeding in selling. Two companies agree that the ALI Program contributed to the increase and / or improvement of the business's points of presence, one company fully agrees and one company disagrees with the statement.

When investigating the only statement of disagreement considered in the research, the entrepreneur justified that to improve or increase his points of presence he would have to invest in actions and innovation projects which would cause the raising of financial resources, in which the company does not have and does not captures external resources. The companies that considered to agree with the statement, said that they made small improvements in their points of presence, looking for solutions that did not need external financial investments, in the last case, having as their own, often derived from their working capital as a source of resources.

Finally, the sixth statement seeks to understand whether the ALI Program contributed to the entrepreneurs' greater understanding of productivity indicators, giving rise to more assertive strategies for the business. Two companies agreed with the statement, while, likewise, two companies neither agree nor disagree. On this case we obtained the following lines:

"[...] As I offer services, it is very difficult to understand and quantify productivity indicators for my business. I know the company's total results but I can't control the performance of the employees "

"I believe that it (the program) contributed to see what I need to be better for my company (sic.) I think I will reap these results in the medium term, but it is good to be able to see how productive I am"

In addition to the statements submitted to the judgment of values by companies, at a later time, companies were qualitatively asked to answer the categorical question: "How did participation in the ALI Program influence the sales process? Was there any impact? "

One of the companies replied that bringing together the entire sales team and managers during the program meetings provided the good habit of allocating a moment in the week to build strategies, evaluate opportunities that can improve the company's sales and efficiency processes in general.

Another company replied that its team started to observe the client's behavior more due to the meetings of the ALI Program and that, due to this circumstance, the managers began to remodel the team and the service script, highlighting what allows the client's progress to obtain more correct communication as they offer new products and services.

During the cycle of the Program, one of the analyzed companies increased its presence, recently opening a physical store in the Asa Norte neighborhood, where until then it marketed its products on stands at fairs in the region. The businesswoman sees this action as an opportunity to enhance customer access, maintaining the existing points of presence and investing in the sales process to generate greater impact on her sales.

## V. CONCLUSION

It was possible to identify in this article the difficulties, learnings and benefits of innovation experienced by entrepreneurs when participating in the ALI 2019 Program promoted by Sebrae-DF, as well as establishing a dialogue between these points with the selected theoretical framework.

From the points of benefits and difficulty raised throughout the theoretical framework for innovation, it is possible to note that the ALI Project proposes to be a way for the small business to face the challenges of the highly competitive environment, with an innovative solution,

which allow the small to deliver value to the market, differentiate itself from the competition and achieve concrete financial results.

The need to validate ideas, the value proposition and the solution with customers before actually investing in the product. This trajectory brings more confidence, not only for the company that proposes to innovate, but also for possible investors interested in financing the solution. In addition, it increases the chances of participating in calls for innovation and minimizes the risk of failure in the innovation process. In a way, the financial issue was raised as a limiter of small business in every selected theoretical framework and also appeared in the field study carried out.

The result of the interviews carried out showed the following aspects:

- Difficulty: entrepreneurs end up interacting little with their customers, market, partners and competitors, due to the diverse demands explored in this article;

- Limiter: there is a need for innovation, but in practice, the small business owner is unable to devote efforts in this direction;

- Learning: the tool provides a paradigm shift that allows the entrepreneur to shift the focus from the inside out (from the company to the customer);

- Benefit: the ALI methodology follows a logical and simple structure for innovation, with more ownership, as well as using tools and transferring useful content to put innovation focused on small businesses into practice.

When the entrepreneurs highlighted that the greatest difficulty faced in the project was the dedication, in a way, they approach the vision of Local Innovation Agents, when they highlight their difficulty in interacting with their customers in the validations, as these are the steps that demand the greater dedication of time, apprehension of the transferred content and its applicability.

In addition, the contribution for companies was to improve the sales and communication processes of these solutions offered to the market by the guidelines of the ALI methodology, for customers to become more fluidly convinced and sales to occur more assertively. Innovative strategies for more and / or better revenue streams and points of presence helped to "drain" the pressure exerted on the sales team, providing a healthier and more sustainable environment within MSCs.

The verification of the topic under review, considering the analysis of results and its theoretical basis and empirical results, serve as an encouragement for other companies in the retail business that wish to differentiate themselves in the delivery of their solutions, relieving market pain and making the environment of sales, a space that inspires its professionals to work more efficiently, more results with less effort.

In the same vein, the study suggests that a higher level of awareness about the turbulence of the path to be followed, has the potential to result in a higher level of engagement and a reduction in the evasion of the program, consequently reducing the waste of human resources. and financial investments in the innovation ecosystem.

This is, precisely, the objective of this article, which aims to provide a greater awareness of the challenges, benefits and turbulences that small entrepreneurs may encounter on the path towards innovation. It is expected that, anticipating obstacles ahead, will result in greater engagement and, consequently, in a greater result or reduction in the program's dropout rate, avoiding waste of energy and public resources.

Despite the ALI program proposing to be a tool that helps the entrepreneur to revolutionize small business through innovation, it was observed that there are still difficulties that remained and prevented the participating companies from being able to dedicate themselves more to the project. This may have happened due to flaws in the selection process, with the possible participation of companies that were not properly framed and expected. This point, however, requires further investigation so that, in other cycles, the results are more effective for companies and the market.

Other elements present in the interviews were not addressed in this article - because they escape the proposed objectives - but have the potential to be explored in future studies, such as: from the feedback given by one of the entrepreneurs, a study would be relevant to identify possible improvements on the applicability of the tools used in the ALI project. It is also necessary to reinforce that, as it was not possible to measure concrete financial results within this first cycle, a study is needed to identify the factors that led companies participating in this new methodology to have, or not, results with their application.

## ACKNOWLEDGEMENTS

(CNPq) and Brazilian Service of Support for Micro and Small Enterprises (SEBRAE).

## REFERENCES

[1] Barbieri, José Carlos, Antonio Carlos Teixeira Álvares, Jorge Emanuel Reis Cajazeira (2009). Gestão de ideias para inovação. Ed. Bookman. Porto Alegre, 2009.

[2] Bessant, John (2009). Inovação e empreendedorismo / John Bessant, JoeTidd; Ed. Bookman. Porto Alegre.

[3] Bizzotto, Carlos Eduardo Negrão (2008). Plano de negócios para empreendimentos inovadores. São Paulo: Atlas, 2008.

[4] Bogmans, Christian; Restrepo, Jorge (2019). O Desafio dos preços moderados das commodities na América Latina. Valor Econômico, Available in <https://valor.globo.com/mundo/blog-do-fmi/noticia/2019/03/25/o-desafio-dos-precos-moderados-das-commodities-na-america-latina.ghtml>. Access in 16.01.2020.

[5] Christensen, C. M. (1997). The Innovator's Dilemma. Boston: Harvard Business School Press.

[6] DELOITTE (2007). As pequenas e medias empresas que mais crescem no brasil: uma pesquisa sobre visões e práticas que aceleram o ritmo de expansão dos negócios. Deloitte. São Paulo, pp. 36.

[7] Fleck, D (2003). Desafios do crescimento corporativo e suas consequências para a perenidade da empresa. Economia & Conjuntura, Rio de Janeiro, 3(39), pp. 26-31.

[8] Gil, A. C (1999). Métodos e técnicas de pesquisa social. São Paulo: Atlas.

[9] Godoy, A. S. (1995). Introdução à pesquisa qualitativa e as possibilidades. Revista de Administração de Empresas, São Paulo, 35(2), pp. 57-63, Mar./Abr. Available in: <http://www.scielo.br/pdf/rae/v35n2/a08v35n2.pdf>. Access in: 15 dez. 2019.

[10] Kolko, Jon (2018). Do Design Thinking ao Design Doing. São Paulo: M.Books do Brasil Editora Ltda..

[11] Kupfer, D.; Hasenclever, L . (2002). Economia industrial: fundamentos teóricos e práticos no Brasil. Rio de Janeiro: Campus.

[12] MJV (2016). 3 Principais barreiras à inovação no Brasil. Available in: <https://blog.mjv.com.br/principais-barreiras-a-inovacao-no-brasil>. Access in: 15 dez. 2019.

[13] Nascimento, Luiz Otávio da Silva (2005). Êxodo: da visão a ação, uma proposta para o varejo brasileiro. São Paulo, Ed. SENAC.

[14] OCDE (2005). Manual de Oslo: Proposta de Diretrizes para Coleta e Interpretação de Dados sobre Inovação Tecnológica. 3ª. ed.. Available in: <oei.es/historico/salactsi/oslo4.htm>. Access in: 15 dez. 2019.

[15] Oliveira, J. P. L (2013). Oportunidades para inovação. In: PORTO, G. S. Gestão da Inovação e Empreededorismo. Rio de Janeiro: Elsevier.

[16] Oliveira, Nielmar (2018). Número de pontos comerciais volta a crescer no 1º semestre, diz CNC. Agência EBS Brasil. Available in <http://agenciabrasil.ebc.com.br/economia/noticia/2018-08/numero-de-pontos-comerciais-volta-a-crescer-no-semestre-diz-CNC>. Access in 29.09.2019.

[17] Porto, Geciane (2013). Gestão da inovação e empreendedorismo. Rio de Janeiro: Elsevier.

[18] Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Nova Iorque: Crown Business Publisher, 77 p. ISBN 978-0-307-88789-4.

[19] Schumpeter, J. A (1939). Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process. Nova Iorque e Londres: McGraw – Hill Book Company Inc, v. I e II.

[20] Schumpeter, J. A. (1934). The theory of economic development. Cambridge (EUA): Harvard University Press.

[21] SEBRAE - Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (2017). Pequenos negócios com potencial de alto impacto. Brasília: Sebrae. 48 p. p.

[22] SEBRAE-SP - Serviço Brasileiro de Apoio às Micro e Pequenas Empresas. Guia do empresário, metodologia de Gestão da Inovação do projeto ALI. Brasília-DF.

[23] SEBRAE (2019a). Agentes Locais de Inovação: receba o Sebrae na sua empresa. Brasília: [s.n.]. Available in: <https://www.sebrae.com.br/sites/PortalSebrae/Programas/agentes-locais-de-inovacao-receba-o-sebrae-na-sua-empresa,8f51d53342603410VgnVCM100000b272010aRCRD>. Access in: 15 dez. 2019.

[24] SEBRAE (2019b). Guia ALI do Empresário. Metodologia de Gestão da Inovação do Projeto ALI. Brasília: [s.n.], 2019b. ISBN 978-65-5021-035-9.

[25] SEBRAE (2014). Causa Mortis: o sucesso e o fracasso das empresas nos primeiros 5 anos de vida. Brasília.

[26] SEBRAE (2017). Pequenos negócios com potencial de alto impacto. Brasília: Sebra. 48 p. p. Available in: <http://www.bibliotecas.sebrae.com.br/chronus/ARQUIVOS_CHRONUS/bds/bds.nsf/ea939504f8fba7a982d13c4ce90a3f93/$File/7605.pdf>. Access in: 15 dez. 2019.

[27] Varella, Claudia (2019). BRASIL bate recorde, com 2,5 milhões de novas empresas formalizadas em 2018. Uol notícias. Available in <https://economia.uol.com.br/empreendedorismo/noticias/redacao/2019/03/26/brasil-bate-recorde-empresas-formalizadas.html>. Access in: 29.09.2019

[28] Vasconcelos, F. C. E. C. Á. B (2000). Vantagem competitiva: os modelos teóricos atuais e a convergência entre estratégia e teoria organizacional. Revista de Administração de Empresas, 40, pp. 20-37.

[29] Vergara, S. C (2007). Projetos e Relatórios de Pesquisa em Administração. 9ª. ed. São Paulo.

## APPENDIX I

Interview script 1

Field research applied to local innovation agents

- Difficulties encountered when applying the ALI methodology

Therefore, the question asked to Local Innovation Agents was: From your perceptions, what were the 3 biggest bottlenecks that entrepreneurs had to apply the ALI methodology?

Interview script 2

Field Research applied to entrepreneurs participating in the First cycle of the ALI Pro-gram 2019

How was the company's experience in the:

1.  Interaction phases | validation with customers. Briefly highlight the following:

    - Strengths
    - Difficulties
    - Learnings

2.  About your dedication as an entrepreneur to the ALI project.

    - Strengths
    - Difficulties
    - Learnings

3.  Implementation of the minimum viable product (MVP) and / or product solution (good or service found) in your company. Briefly highlight the following:

    - Strengths
    - Difficulties
    - Learnings

4. Based on the 3 questions above, which of these points was the most challenging and why?

5. Complete the statement below according to the following options: The contents and tools worked on during the ALI project were _____ to put innovation into practice in my business.

    - Extremely useful
    - Partially useful
    - Neutral neither useful nor useless
    - Partially useless
    - Extremely useless

6.      Would you like to add any other point that has not been explored and would you like to contribute? (optional)

# The impact of the implantation of *e-BAÚ* platform for commercial licensing in Nampula

Almeirim Deus Da Incarnação Jaime Nacarapa[1], Luís Borges Gouveia[2]

[1]Doctoral Student in Projects – Corporate Development and Business Management at FUNIBER-UNINI – Universidade Internacional Iberoamericana do Mexico.
Masters in Touristic Management and Consulting (Field of Business Organization, Managing Development and Human Resources) by FUNIBER – Fundação Universitária Iberoamericana da Espanha. Nampula One-Stop Shopemployee.
[2]Luis Borges Gouveia. Completed the Academic Title of Aggregate in 2010 by the Universidade de Aveiro and the Doctorate in Computer Sciences in 2002 by the Lancaster University (United Kingdom) and the Masters in Electrotechnical and Computers Engineering in 1995 by the Universidade do Porto. Full Professor at the Universidade Fernando Pessoa.

*Abstract*— *This study analyses the impact of the implementation ofe-BAÚ platform for commercial licensing at the One-Stop Shop located in Nampula, Mozambique, in the period of 2014-2018. The e-BAÚ was introduced in 2014 as a result of the Mozambican Public Administration Reform and the improvement of the National Informatics Policy. In order to achieve the objective of this study, the following question was defined: to what extent does the implementation of the Electronic One-Stop Shop contribute to the improvement in the provision of public services? Methodologically, the study is document based with a qualitative nature and it involved six interviewees and it used the thematic content analysis technique for data analysis. The obtained results indicate that the implementation of the e-BAÚ allowed the principles of speed, debureaucratization, flexibility in commercial licensing processes to be achieved, in addition to support revenue generating for the State Treasury. Despite these advances, it is understood that the e-BAÚ still requires the creation of a quality platform that has interoperability capacity with other sectors and institutions of the State or the private sector that are part of the commercial licensing process and that has the capacity to detect false and expired documents avoiding fraud and errors.*

*Keywords*— *Public Administration, Electronic One-Stop Shop, Debureaucratization, e-BAÚ, e-government, interoperability.*

*Resumo*— *Este estudo analisou o impacto da implementação da plataforma e-BAÚ do licenciamento comercial no Balcão de Atendimento Único localizado em Nampula, Moçambique, no período de 2014-2018. O e-BAÚ foi introduzido a partir do ano de 2014 na sequência da Reforma da Administração Pública Moçambicana e do aprimoramento da Política Nacional de Informática. Para o alcance do objectivo deste estudo, foi definida a seguinte questão: em que medida a implementação do Balcão de Atendimento Único Electrónico contribui para a melhoria na prestação dos serviços públicos?Metodologicamente, o estudo é documental e de natureza qualitativa e envolveu seis entrevistados e empregou a técnica de análise de conteúdo temática para a análise dos dados. Os resultadosobtidos sinalizam que a implementação do e-BAÚ permitiu alcançar os princípios de celeridade, desburocratização, flexibilidade nos processos de licenciamento comercial, além de gerar receita para os Cofres do Estado.Apesar desses avanços, entende-se que o e-BAÚ ainda requer a criação de uma plataforma de qualidade que tenha capacidade de interoperabilidade com outros sectores e instituições do Estado ou entidades privadas que fazem parte do processo de licenciamento comercial e que tenha capacidade de detectar documentos falsos e fora de prazo, evitando a ocorrência de fraude e erros.*

*Palavras-chave*— *Administração Pública, Balcão Único Eletrónico, Desburocratização, e-BAÚ, governo electrónico, interoperabilidade.*

## I. INTRODUCTION

The beginning of the 90s marks the emergence of the Information Era thanks to the tremendous impact caused bytechnological development and by the Information and Communications Technologies (ICTs). In the Information Era, the financial capital grants throne to intellectual capital. Knowledge becomes the new wealth, the most valuable and important organizational resource (Chiavenato, 2008). For this author, the Information Era brought the concept of virtual office and non-territorial. The ICTs allow the compression of time. Communications become mobile, flexible, fast, direct and in real time, allowing much time for attention to the client. Chiavenato still considers that the ICTs profoundly modify the work in and outside organizations in their relationship. The connection to Internet and the adoption of intranet, as well as the internal communication networks intensify the economy globalization through the globalization of information as well. In this new era, the more powerful the information and communications technology, the more informed and powerful the users become, be it a person, organization or a country. Information becomes the main source of energy of a organization: its main fuel and the most important resource or input. Consequently, information may guide all the efforts and indicate the courses to be followed.

These transformations make the world increasingly globalized and involve new demands to the economies, organizations, both private and public. Mozambique is not unconnected to this new reality. It is in this context that, since 2000, the country adopted the new technologies promotion and expansion policy that considers its potential for development. In this context, the Education Technological Plan (*PTE* from Portuguese) presents an integrated policy approach, with a solid strategic vision and an action framework that intends to articulate and mobilize the financing and implementation ecosystems around a strategy whose implementation will promote, not only the improvement of the education system, but also the economic and social development (*Ministério da Educação* [MINED], 2011). In other words, the Government of Mozambique approved, through the Resolution no. 28/2000, of December 12, the Informatics Policy, with the objective of including Mozambique in the world of the Information and Communications Technologies (ICTs) which have the Internet as their highest exponent. The Informatics Policy offers an array of principles and objectives that may allow *"the ICTs to be the driving force behind the various aspects of national development, contributing for absolute poverty eradication and general improvement of the lives of Mozambicans; for*

*the broadest citizen participation in the global society of information; for the increase of the effectiveness and efficiency in services provision; for governance improvement and democracy further development; for its participation in the global economy, increasingly based on information and knowledge".*

The Informatics Policy Implementation Strategy indicates as the main vectors in relation to the governance area: electronic network for all the Central and Province Government Bodies and Departments; presence on *Internet* of all Ministries and other State Agencies; centralized and uniform databases related to human resources, public accounting, assets and legislation.

In compliance with the Informatics Policy, it is created of the Electronic Government (*e-Gov*) in Mozambique, in 2011, through the Government of Mozambique Quinquennal Programme (2005-2009), with the objective of driving the creation of other specificand sectoral platforms in order to improve the provision of services to the citizen. The e-government constitutes an effort to improve the public sector, strengthening communication technologies and their social tools, and improving information and the social service. An effective change is based onhuman resources leadership and in the collective intelligence of allinvolved agents taking advantage of the potential promised by an interconnected and interdependent vision of the world (Lane & Roy, 2002). In turn, Gouveia asserts that the e-government is the utilization of information technology to support the Government and Public Administration operations, involving citizens, and promoting electronic-based services that relate the political power and Public Administration with the citizen andcompanies (Gouveia, 2004, p.21).

In terms of importance, Mateus (2008), asserts the following:

> The Electronic Government has assumed an increasing importance in current society, becoming a vital process for the modernization of the Public Administration and its high priority is the improvement of the quality of public services provided by the Public Administration through the utilization of ICTs (p. 125).

The e-Government constitutes an effort to improve the public sector, strengthening the communications technologiesand their social tools and improving

information and public service, what is confirmed by Lane & Roy (2002). As a response to the level of fulfilment of the implementation of the *e-Gov* in Mozambique, in 2014, it was implemented the *e-BAÚ* system, also known as Integrated Platform for Service Provision to the Citizen designed for economic activities online licensing, which is the object of study and analysis of this paper.

The Government of Mozambique conceived, approved and implemented the *e-BAÚ* project, through the Business Environment Improvement Strategy I (EMANI – 2008-2012) as a means of operationalization of the Electronic Government Strategy (*e-Gov)* in order to rationalize the utilization of information technologies in the Public Sector, whose aim is to improve the quality of services and accountability to their citizens.From their point of view, the system focuses on the relationship between the BAÚ andeconomic agents in Service Provision to the citizen in commercial activity licencing.

The implementation of *e-BAÚ* aimed to improve public services provision through simplification, flexibilization, and speed in the administrative processes related to the requests presented by the citizen, assure Government efficiency and provide access to information in order to facilitate the private sector activities and simplify the life of the citizen. This action made the activities flexible, enabling faster responses to the citizen than before its implementation.

Based on what was described, the following research question was raised: what are the impacts of the implementation of the *e-BAÚ* system in Nampula from 2014 to 2018? On the basis of this question, this study aimed to analyse the impacts of the implementation of the *e-BAÚ* system in Nampula Province, in Mozambique.

This study is academic and professionally motivated. Professionally,the author is part of the employees of the One-Stop Shop (BAÚ), what motivated him to understand and improve the functioning and the effects of the system under study, on the one hand. On the other hand, the research is part of his Doctorate thesis. Therefore, the results depict the level of efficiency and effectiveness of the system under analysis in order to contribute to its improvement, what may allow better service provision with safety and effectiveness, and generate revenue for the institution under investigation.

## II.  METHOD

This study is exploratory and qualitative. Its exploratory nature is based on the fact that the topic under study is less explored in Mozambique, especially in Nampula, the place of study. For Minayo (2014) a qualitative research is that research that devotes itself to the study of history, relationships, representations, beliefs, perceptions and opinions, products of the interpretations thathumans make about the way they live, build their artifacts and themselves, feel and think. In this context, the option for a qualitative research sought to understand, from the employees who operate the *e-BAÚ* system, its efficiency and limitations. Besides, it is considered a qualitative research due to the number of participants, the data collection technique (interview) and data analysis technique (content analysis) which are further described.

The data were collected through document analysis and semi-structured interviews. The document analysis consisted of the study of the legislation about the creation of the National Informatics Policy, e-Government, e-BAÚ and the institution report aiming at understanding the missions, objectives and purposes of the system under study. The interview was administered to six subjects, among them State employees, private sector economic agents from the Economic Association Confederation – Provincial Economic Council, scholars and researchers on Mozambican public administration reform. The choice for interview is justified by the fact that it is considered as one of the widely used tools in qualitative research (Minayo, 2014; Sionek, Assis & Freitas, 2020), and having become a broadly used technique in the context of human and social sciences, being considered as the most privileged in the study of perceptions about feelings, artifacts and activities.

Through empirical saturation technique, six subjects were interviewed individually, among them, one Chief Executive Officer, one officer from the Department of Economic Analysis, one officer-trainer, one lecturer and Reform Specialist, one Public Sector Reform officer and one Economic Advisor, all of them male working in public and private sector in Nampula city, in Mozambique.

Categorical content analysis was the technique employed for data analysis. Content analysis is a group of techniques for the analysis of communications, based on systematic and objective procedures, aimed at obtaining description of the content of messages, and indicators (quantitative or qualitative) that allow for inferences of knowledge related to the conditions of production/reception (inferred variables) of the messages (Bardin, 2011). The use of content analysis implies three essential stages: *pre-analysis, exploration of the material, and treatment of the results.* In this study, the interviews were transcribed in the pre-analysis. At the exploration stage, codification and analysis of the speech were done. At this very same stage, the categories were defined on the

basis of the objectives formulated and the data collected. In this context, three categories arose, namely: a) positive effects of the *e-BAÚ* system; b) limitations of the *e-BAÚ* system, and; c) proposals for the improvement of the system.

## III.      RESULTS AND DISCUSSION

This section is aimed at stating and discussing the results of the research on the basis of the predetermined categories.

*Table 1: Business license issuance process: Comparative analysis of the period before and after the implementation of e-BAÚ.*

| Performance Key-indicators | | Before e-BAU | With e-BAU |
|---|---|---|---|
| Industrial licensing | Procedures | Nine steps | Two steps |
| | Time | 36 Days | 10 days |
| | Cost | USD 870 | USD 348 |
| Commercial licensing | Procedures | Nine steps | Two steps |
| | Time | 8-15 Days | Seven days |
| | Cost | USD 98 | USD 40 |
| Simplified licensing | Procedures | Two steps | One step |
| | Time | One day | Immediate |
| | Cost | Floating rate | Single rate |
| Tourism licensing | Procedures | Nine steps | Four steps |
| | Time | 45 days | 17 days |
| | Cost | USD 719 | USD 288 |

**Source:** Research data.

Table 1 reveals that the implementation of e-BAÚ system reduced significantly the waiting time for business licensing issuance as well as its cost.

**Licensed processes and collected revenue**

On the basis of Table 2, the Nampula one-stop shop, in the period in question, licensed a total of 7.336 (seven thousand, three hundredthirty six) economic activity licensing processes, being 1.704 (one thousand, seven hundredfour) simplified licensing, 1.053 (one thousand, fifty three) service provisions, 1.091 (one thousand, ninety one) wholesale trade, 2.167 (two thousand, one hundredsixty seven) retail trade , 153 (one hundredfifty three) industry processes, and 1.168 (one thousand, one hundredsixty eight) foreign trade operators.

*Table 2: Revenue collected from 2014 to 2018*

| Activities | Amount of licensed processes | | | | | Total |
|---|---|---|---|---|---|---|
| | **2014** | **2015** | **2016** | **2017** | **2018** | |
| Simplified Licensing | 683 | 537 | 255 | 132 | 97 | 1.704 |
| Wholesale Trade Establishment Licensing | 100 | 187 | 185 | 354 | 265 | 1.091 |
| Retail trade Establishment Licensing | 290 | 403 | 553 | 505 | 416 | 2.167 |
| Service Provision Establishment Licensing | 111 | 226 | 165 | 334 | 217 | 1.053 |
| Industrial Establishment Licensing | 30 | 22 | 45 | 21 | 35 | 153 |

| Issuance of Import and Export Licences | 185 | 157 | 173 | 422 | 231 | 1.168 |
|---|---|---|---|---|---|---|
| **Total Annual** | **1.399** | **1.532** | **1.346** | **1.768** | **1.261** | |
| Investment Volume in USD | 2.036.046 | 2.397.295 | 3.112.814 | 2.791.866 | 475.825 | 10.813.853 |
| Jobs created | 3.872 | 4.011 | 8.917 | 4.297 | 2.678 | 23.775 |

**Source:** Research data.

As a result of these processings, in the period in question, **23,775** (twenty-three thousand, seven hundredseventy-five) potential jobs were created and USD **10,813,853,06** (ten million, eight hundredthirteen thousand, eight hundredfifty-three, six) collected in investment. Still in the same period, Nampula e-BAÚ collected and saved in the State Treasury, from licensing fees and other complementary services to licensing USD **291,702,58** (two hundred ninety-one, seven hundred two, fifty eighty).

**Functional analysis of the e-BAÚ platform**

Aimed to analyse the functionalities of the e-BAÚ system and its contribution to the improvement of service provision to the citizen and to economic activities licensing in Mozambique, some questions were asked to the employees (technicians) responsible for operating the system. The analysis was made in relation to the commercial licensing cycle, from the first client's contact and/or businessman to the stage of issuance and delivery of the license. The cycle under analysis obeys the following stages: (i) general information stage, where the user is informed about the conditions for commercial activity licensing, (ii) registration stage, where the system operator, in the presence of the user or their agent, inserts the businessperson data on the system, all documents needed for the acquisition of the license, (iii) commencement of proceedings stage, for checks on the lawfulness, (iv) authorizations stage, (v) decision stage, which consists on approval or rejection, and, finally, (vi) printing and delivery of the license.

One of the problems detected in relation to the functioning ofe-BAÚ system is the action of the public servants responsible foroperating the platform, namely, general information, registration, commencement of proceedings, authorization and decision, as illustrated by the following remark from an interviewee:

> *I can categorically affirm that most of the officers responsible for operating the e-BAÚ system act in bad faith, given the*

*inefficacy of the platform, taking advantages in their own benefit (I1).*

The gaps and weaknesses of the e-BAÚ system, create conditions for operators to take advantage in their own benefitat the expense of the State or the institution, as the following statement shows:

> *Just to mention some examples, one of the conditions for licensing a foreigner's economic activity is a passport with a business or work visa, and the majority of them do not have it. Foreigners look for a friend, a relative or a fellow countryman who as visa and take copy of their visa and attach it to his/her passport since the visa is valid, although it does not belong to him/her but to someone else, and since the checks on the lawfulness is done by eye, it is unable to detect fraud, thus he/she gets the license (I2).*

Other cases of bad faith are related to forgery of deposit bank slip. Since there is not reconciliation between bank balances and BAÚ, withonly one scanned coloured bank slip or one coloured copy, the system operator issues several licenses.

> *For a clear picture of what I say, imagine if you are a technician or responsible for registration of e-BAÚ system, in a dishonest way you intend to use a white A4 paper in place of a deposit bank slip corresponding to commercial activity licensing fee, the system accepts the white A4 paper as if it were a bank slip, it is unable to detect the error (I3).*

> *Another example of errors of the system is that it issues bill of sale for commercial activities licensing fees for any situation and these bills of sale do not demand for a deposit slip number, tax identification number, legal entity identification, visa number, ID, etc., the system is not*

*intelligent. It is manipulable and vulnerable (I4).*

## IV.    DISCUSSION

The results of this study show that, in general, the implementation of e-BAÚ brought improvements, both in revenue collection and simplification of the steps in licensing process. Similar to the findings of this research, in a study by Brito, Borges and Tavares (2015), it was observed an increasing improvement in the performance of State Tax Authorities, having been facilitated the monitoring of goods in transit and of establishments, since the ICTs provide better identification to our public servants in the processing of electronic data of industries, trade and services that operate in the State where the research was conducted and allowing data triangulation.

In the analysis of the functionalities of the *e-BAÚ* system, the lack of interoperability contributes to the manipulation of the system, causing some bad faith employees to insert false and/or expired documents. It originates revenue collection problems. Gouveia (2014) asserts that the interoperability of systems based on ICTs, the sharing and reutilization of information, and the integration of administrative processes, both inside and outside the public sector organizations is essential in order to assure high quality, innovation and transparent services centred on the customer/citizen. It is necessary to define the interoperability, considering the relationships among the public sector organizations (central and local Public Administration). For the author, interoperability can be seen as a means of unification that allows information and computer systems to be connected within organizations and even with external organizations and citizens. It is possible to consider three aspects: **Technical interoperability:** related to the technical aspects about computer systems connections; with the definition of open interfaces and with telecommunications; **semantic interoperability**: related toassurance of meaning, precisely, of  the shared information, which assures that different applications and services have common understanding of the same information; **organizational interoperability:** related to business processes modelling, with compatibility of different information architecture to organization goals and assist in the cooperation of business processes from different entities.

The author still considers that if the interoperability question is solved, it is easier for integration of processes to occur with greater efficiency gains and less operating costs. There is also the possibility of integrating the public sector with the private

organizations that comply with the proposed conditions for information sharing. Interoperability, thus, becomes an essential requisite, both from an economic perspective and technical, for the development of efficient and effective services (Gouveia, 2004, p.40).

As in this study, Campelo (2006) verified that the dissemination of e-Gov is deficient, with the existence of problems related to the infrastructure and training of public servants who influence the changes proposed by the Programme. For the author, the improvement of performance proposed by the Electronic Government Programme means that tools, techniques and good practices are identified and published to public managers; and also that a plan of implementation of the National Plan for Electronic Government Development is defined, including the approval and effective implementation of the standards of interoperability of the electronic government; discussions around the adoption of the software. Campelo (2006) understands that a programme has the opportunity to improve its performance in relation to citizen-related public services provision when orienting public bodiesto have considerable knowledge of the target people, their electronic services, their needs and opinions about the quality of the services.

## V.    CONCLUSION

This study aimed to analyse the impacts of the implementation of e-BAÚ system in the One-Stop Shop located in Nampula city, in Mozambique. The results show that the system brought improvements related to cost reduction and time needed for license acquisition. Therefore, it reduced the procedures and requisites for license solicitation of six elements, namely, architectural plan, location map, opinions, tax identification number, legal entity identification, applicant's identification document, to only two (2): the applicant's identification document and tax identification number, or three (3): applicant's identification document, tax identification number, and legal entity identification, depending on the type of license. It also reduced licensing fees, which changed from class-based to activity-based, that is, wholesale, retail and services.

Notwithstanding, it was noticed that e-BAÚ shows certain limitations and weaknesses such as not being able to detect forged and expired documents, and not being interconnected with the systems from other institutions, namely, banks, Migration Directorate, Finance Directorate, Civil Identification Directorate, National Institute for Roads and Traffic, National Institute for Refugee Support, Registration and Notary Affairs,

Technical Secretariat for Electoral Administration, embassies and Consulates of Mozambique overseas, in order to check on the lawfulness of the documents at the moment of license application. Gouveia (2014) warns that the target of e-government must not be the Information and Communications Technologies, but its use, which when combined with organizational changes and new competences,improves public services provision, public policies, and the exercise of democracy, representing the real sense of democracy (it is, therefore, represented by both the e-government and the ICTs, and the tool for a better, efficient and effective governance).

There is, therefore, a risk of lack of quality of the system caused, by a fault in the introduction and/or an effective implementation of the interoperability. Interoperability is perceived, here, as the ability for two or more systems to share data, information, and knowledge, enabling government agencies to provide effective and efficient services to the citizens, the private sector and other government agencies. Precisely, this lack if interoperability makes the quality and safety of the integrated platform for citizen service provision not to be one of the best.

On the basis of these findings it is suggested that such interconnections with other systems from the institution involved in Commercial Activity Licensing are made, namely Identification Document Issuance System, Tax Identification Number, Foreigner's Identity Card, Legal Entity Identifier, driving licences, voter registration card, and the licensing fees bank slips. Gouveia (2004, p.39) referring to a European Commission document, stresses that the interoperability approach is not a mere technical issue related to computer network connections, it is a really important aspect to the development of the e-government. This importance is justified by the fact that it allows integration of services and information between the Central Public Administration and various territories served by the local e-government, what allows the establishment of a network of exchange and share of information which stretches and multiplies the e-government benefits.

This study was conducted in a specific institution; it allows for generalization of results from the studied institution to other institutions that use the analysed e-BAÚ system. In this regard, it is recommended that future researches involving other institutions and / or clients that resort to e-BAÚ in order to license their projects are conducted in order to analyse the level of satisfaction in relation to its functionality.

# REFERENCES

[1] Brito, C. S., Borges, P., & Tavares, J. M. (2015). O uso das TIC na Administração pública – estudo de caso na secretaria da receita do Estado da Paraíba. *Revista Eletrônica da FAESNE*, 1(2), 53-65.

[2] Campelo, V. (2006). *Avaliação do Programa Governo Electrónico*. Tribunal de Contas da União. Nova Série. Brasília, Brasil.

[3] Decreto n.º 5/2012 (2012). Boletim da República, quarta-feira, 07 de Março de 2012, I Série – Número 10.

[4] Decreto n.º 24/2007 de 5 de Julho cria os Centros Regionais de Ciência e Tecnologias.

[5] Decreto n.º 50/2002 de 26 de Dezembro cria a Unidade Técnica da Implementação da Politica de Informática.

[6] Decreto n.º 2/2007 de 8 de Março cria Comissão Interministerial da Reforma do Sector Publico.

[7] Decreto n.º 32/2006 de 30 de Agosto cria Conselho Ciência e Tecnologia.

[8] Decreto no. 34/2013, de 2 Agosto, aprova do Regulamento do Licenciamento de Actividade Comercial.

[9] Decreto nº. 22/2014, de 16 de Maio aprova o Regulamento de Licenciamento Industrial.

[10] Decreto n.º 94/2013, de 31 de Dezembro, aprova o Regulamento do Exercício da Actividade de Empreiteiros, e de Consultores de Construção Civil.

[11] Decreto 97/2013, de 31 de Dezembro aprova o Regulamento de Empreendimentos Turísticos, Restauração e Bebidas e Salas de Dança.

[12] Decreto 39/2017 de 28 de Julho aprova o Regulamento para o licenciamento simplificado e a Certidão de Mera Comunicação Prévia.

[13] Gouveia, L.B. (2004). Local e-Government-A Governação Digital na Autarquia. Porto: Sociedade Portuguesa de Inovação**.**

[14] José, M.L. (2014). *Governo Electrónico em Moçambique: uma analise do grau de implementação: o caso do BAÚ e do e-SISTAFE*, 2006-2013. (Dissertação de Mestrado). Universidade Eduardo Mondlane, Maputo.

[15] Relatório de Actividades do e-Gov (2013). Instituto Nacional de Tecnologias de Informação e Comunicação. Maputo.

[16] Relatório Quinquenal (2014-2019) das actividades realizadas pelo BAÚ de Nampula-2019.

[17] Resolução nº 28/2000 (2000). Política de Informática. Conselho de Ministros. Maputo: Imprensa Nacional de Moçambique: 3º Suplemento do Boletim da República, I Série – Número 49.

# Mobile Applications for autisticchildren: An analysis of the Google Play Store platform

Fabrízia Miranda de Alvarenga Dias[1], Daniele Fernandes Rodrigues[2], Carlos Henrique Medeiros de Souza[3]

[1]Master in Cognition and Language, Department of PGCL, North Fluminense State University, BRAZIL-RJ
[2]PhD in Cognition and Language, Department of Business, Federal Fluminense University, BRAZIL-RJ
[3]PhD in Communication and Culture, Coordinator of the Post Graduate Program in Cognition and Language, Department of PGCL, North Fluminense State University, BRAZIL-RJ

*Abstract—This study aims to categorize mobile applications for autistic children available on the Google Play Store platform, analyzing how these applications are arranged on the platform and how to best facilitate the search function for parents and professionals working with autistic children. The process should ease search and access of specific applications for parents and professionals working with autistic children by arranging applications from diverse areas in a table format rather than requiring that apps be checked individually in the search engine on Google Play Store. Methods: the survey was conducted in three stages: identification of all applications for autistic children; mapping and categorization of the 10 most installed applications; analysis of the features and benefits of the two applications selected. The survey qualifies as qualitative, since it proposes a survey of mobile applications for children with ASD, arranged on the Google Play Store platform. Thus, we describe the main characteristics of the selected applications, their purpose, features and benefits for use with autistic children. Conclusion: at the end of the survey, it was concluded that the 249 applications found were poorly organized and that only 44 were specific to autistic children. Of these, 10 applications were selected and arranged in a table to facilitate search for parents and professionals working with autistic children. In addition, 2 mobile applications were selected and analyzed for their purpose, functionality and benefits.*

*Keywords—Mobile Applications, Autism, Children, Google Play Store.*

## I. INTRODUCTION

If your child was within the autistic spectrum, would you consider using a mobile application to help him/her? And how would you search for this application? The answer seems obvious and practical but it's not that simple.

Given this scenario, the objective of this research is to check all applications specific to autistic individuals available on the *Google Play Store* platform, in order to categorize them and identify the 10 most installed overall. Of these, the first two identified will be more carefully analyzed. By identifying and categorizing applications available on the *Google Play Store* platform in a single table, rather than having to search for applications individually, parents and professionals working with autistic children will be able to access these applications more efficiently and further select individual applications that best suit their specific needs.

This study is justified given the growing number of ASD cases in Brazil and around the world. In addition, when using the platform to identify applications that are appropriate for autistic children, parents and professionals are currently confronted by a disorganized platform with a high number of apps across different areas. Under these conditions, it is challenging to find specific or suitable applications by potential users who may not fully understand the functionality or appropriateness of certain applications.

Thus, the search conducted in December 2019, with the words *"Autism"* and *"Applications"*, in the *Google Play Store* platform search engine, identified 249 applications. An initial analysis was carried out for each application in order to identify the first characteristics which would make it possible to categorize them by topic. Among the more than two hundred applications found, the 10 most installed by users were selected, and then a more careful analysis

was carried out on two of these applications identifying their purpose, features and benefits.

## II.  AUTISM SPECTRUM DISORDER AND MOBILE APPLICATIONS

The World Health Organization (WHO) has pointed to alarming statistical data on Autism Spectrum Disorder (ASD). According to the organization, ASD affects one in every 160 children in the world and it is estimated that one percent of the world population is affected by the disorder (UN News, 2017).

In Brazil, although there isno available official statistical data, it is estimated that there are around twomillion cases, considering a population of approximately 200 million people (Brazilian Institute of Geography and Statistics - IBGE, 2016) and the prevalence of the disorder in the world population.

The Diagnostic and Statistical Manual of Mental Disorders (DSM-V, 2014) defines the following characteristics of ASD: i) inadequate social interaction; ii) deficits in verbal or non-verbal communication; iii) behaviors with restricted, repetitive and stereotyped patterns, with unusual sensory responses.

The "Autism Primer: Guidance for Parents", of the Ministry of Health (2000, p. 10), describes the signs that may appear, together or separately, in individuals with ASD: "they present mental isolation; this isolation resists, excludes, and ignores what comes from the external world; they have an obsessive insistence on repetition, with repetitive and stereotyped movements and noises; they adopt elaborate rituals and routines; they have highly directed and intense fixations and fascinations; they present limited facial expressions and gestures; they do not look directly at people; they have an abnormal use of language; they displaygood relationships with objects; they present excessive anxiety; they do not acquire speech or may lose previously acquired speech". In this sense, it is possible that specific mobile applications geared towards autistic individuals available onthe *Google Play Store* platform, are important tools in supporting those with ASD. Digital environments, and information and communication technologies can be important resources for improving social interaction for those with disorders that hinder functional relationships with the outside world (Caminha et al., 2016). According to Caminha (et al., 2016, p.125), "[...] it is fundamental to reflect on the potential of these resources, especially as mediators that benefit communication and expression of these people". Thus, mobile applications can be a resource that potentially promotes the autonomy of autistic individuals.

Therefore, since technology is clearly a resource that helps children and adolescents learn, autistic individuals also learn to write and to communicate this way, making this virtual universe more collaborative by means ofa variety of available applications, in addition to other emerging tools and resources in the field (Cunha, 2012).

Technological resources such as tablets can become indispensable and extremely relevant when working with autistic people, considering that games and applications help in the most diverse forms of expression and communication; and, also offers an attractive interface, with colors and animation, stimulating concentration (Orrú, 2016).

According to several authors (Aragão et al., 2019); (Mello and Sganzerla, 2013); (Farias and Cunha, 2015), mobile applications can help autistic children in the development of motor skills, autonomy, and improved interaction with others. The authors state that such applications can help children with this type of disorder to express themselves better, in addition to facilitating gains in cognitive skills and logical reasoning. Thus, it is relevant to analyze which specific characteristics of the available applications will result in developmental gains for these individuals.

Authors Alda and Leffa (2014, p. 86), affirm that mobile applications "are software, work as computer programs, offering some advantages of use. Applications tend to be more interactive and enjoyable to use, as they are able to cover and integrate several types of activities into one - for example, instead of using SMS, internet, audio player, and video player functionalities separately, one application is able to unify several functions into a single program". Therefore, mobile applications usually have a simple interface with an interesting layout, making it easier for ASD children to understand and interact with it. The features on these applications create activities that are more attractive to children with ASD compared to conventional methods of learning. In addition, it may be possible that the use of mobile applications facilitates or motivates these individuals to communicate with their surroundings, arousing interest in speech and learning. A user's interest in these activities may enable professionals working with these children to obtain a better assessment of their cognitive level and understanding of their thought process.

## III.  METHODS

This is an applied scientific study, as it generates knowledge for practical application, aimed at solving a specific problem: assisting parents, therapists and teachers

of children with ASD, in the selection of mobile applications available on the *Google Play Store* platform. The main contribution of the present research is the establishment of parameters for selecting mobile applications, i.e., a grouping that highlights the main purpose, benefits and functionalities of applications available for children with ASD on the *Google Play Store* platform.

Regarding the approach to the problem, the research is qualitative, since it deals with the interpretation of phenomena and assignment of meaning, as clarified by Kauark (et al., 2010, p. 26): "the interpretation of phenomena and assignment of meaning are basic in the process of qualitative research. It does not require the use of statistical methods and techniques". Therefore, the researchis considered qualitative, since it proposes a survey of mobile applications for children with ASD, arranged on the *Google Play Store* platform.

Regarding the objectives, the research is descriptive. From its level of interpretation, the survey can be considered descriptive because, according to Gil (2002, p. 42), "descriptive surveys have as their primary objective the description of the characteristics of a given population or phenomenon, or the establishment of relationships between variables. Accordingly, we attempted to describe the main characteristics of the selected applications, their purpose, functionalities, and benefits for use with autistic children.

Regarding technical procedures, this research can be classified as bibliographic, as it was based on several materials previously published, such as books, magazines, newspapers, journal articles, and materials available on the Internet (Kauark, Manhães e Medeiros, 2010).

As far as methodology of the current study, the research stages on the *Google Play Store* platform, its context, and description are detailed, as well as the purpose, features, and benefits of the two applications selected, according to the following steps:

1- Identification of all applications for autistic children; 2- Mapping and grouping of the 10 most installed applications; 3- Analysis of functionalities and benefits of the two selected applications.

## IV.    RESULTS AND DISCUSSION

The *Google Play* virtual store offers applications that use the Android system. Research done by the *International Data Corporation* - IDC (2015), an American research company in digital technology, revealed that the Android system leads the market as the system most used by smartphone users, showing a significant number of 82.2% of users, followed by iOS with 13.9% and Windows Phone with 2.6%. In 2018, IDC conducted a new survey showing that the Android system maintained its position as market leader with 85.1% of users, followed by the iOS with 14.9%. Thus, in view of the statistical data on the predominance of Android system usage, the use of the *Google Play Store* platform is justified for this research.

The *Google Play Store* search took place in December 2019, with the purpose of mapping and categorizing all applications aimed at children with ASD. The initial proposal was to conduct a survey based on the analysis of applications for autistic children available on the platform. The research was conducted in three stages, described below.

### Stage 1: Identification of all applications for autistic children

To refine the search, the keyword *"Autism"* was used under *"Applications",* a function available on *Google Play* virtual store site search engine**.** It is worth mentioning that the term *"Autism Spectrum Disorder"* was also used, but the result was the same as when using the single keyword *"Autism".*

After applying an initial filter aimed at searching applications that had been extensively installed, it was established that of the 249 applications available on the *Google Play Store* platform, only 193 had more than five thousand installations.

The increase in the number of ASD cases, explicit in the statistical data performed by renowned institutions identified in the body of this study, coupled withthe verification of the 249 mobile applications supporting ASD individuals available on the *Google Play Store*, can configure a possible correlation between the growth in the number of cases of the disorder and the use of applications specifically aimed at ASD thus showing a possible demand for these tools in supporting individuals with ASD.

A previous search conducted in November 2019 on the *Google Play Store* platform, aimedate stablishing a quantitative visualization of mobile applications for children with ASD, identified 235 available applications. This data shows that there has been an increase in the availability of these applications, since the same search, when conducted in December 2019, identified249 applications.

During the present research, it was observed that applications are randomly arranged on the platform, making it difficult for users to understand the functions

and features of selected individual tools in advance. Searching for the most appropriate application ina specific area in which an autistic child may need support is also more challenging given the random arrangement of applications.

Mobile applications developed specifically for autistic children, provide parents and professionals who work with these children the possibility to be users, and to further create opportunities that help these individuals become more independent in their choices. This makes the use of mobile applications for autistic children an interesting field of study.

Of the 249 applications available on *Google Play Store*, the 193 most installed were identified, and individually analyzed and classified according to inclusion and exclusion criteria, as described in the table below.

*Table 1 - Inclusion and Exclusion Criteria*

| Inclusion | Exclusion |
|---|---|
| -specific applications for autistic children;<br><br>-applications in Portuguese;<br><br>-applications for children up to 8 years old. | -duplicated applications;<br><br>-applications without relevant research correlations. |

**Source:** Elaborated by the researcher (2020)

Following the analysis of each of the 193 most installed applications, 44 mobile applications in Portuguese, specifically for autistic children up to eight years old, were identified.

**Stage 2: Mapping and categorization of the 10 most installed applications**

In this second phase, the 10 most installed applications were selected, including how they are identified and their main characteristics. The categorization took into account factors such as: application use, number of installations, cost and recognized awards**.** Thus, of the 44 applications identified in the previous step, 10 were selected according to the following criteria: 1) application area: Informative or Educational; 2) greater number of installations.

"Educational" applications are aimed at instruction, such as teaching reading and writing. "Informative" applications consist of several games with the objective of developing the cognitive functions of autistic children, thus meeting a greater variety of user interests.

Therefore, the 10 most installed applications were selected because they are available on the *Google Play Store* platform, under "Informative" and "Educational" applications and are then categorized and presented in "Table2" (Appendix I).

The application area (classification used in this search, to identify the field of each application), appears when clicking on the selectedapplication on the*Google Play Store* platform. There isno clear specification if this information is made available by the system itself or if it is one of the options provided bythe product developer. In a subsequent search, two of the 10 applications arranged in "Table 2" were analyzed in more detail regarding their purpose, functionalities and benefits, as described in stage 3, below.

**Stage 3: Analysis of the functionalities and benefits of the two selected applications**

In this phase, functionalities and benefits of the two selected applications were analyzed, based on the previous selection of the 10 applications shown in "Table 2". The two selected applications were studied in more detail, in order to identify their purpose, functionalities and benefits.

For an even more detailed approach with regard to the purpose, functionalities and benefits of mobile applications for children with ASD, the following criteria were established as guidelines for the selection and analysis of the applications:

i. Cost; ii. Applications previously awarded by recognized institutions.

Regarding the "cost" criterion, only 3 applications were found to be free of charge. Although the PictoTEA application presented more than 50,000 installations and is free of charge, it was not considered as a reference in this research. It has received no awards and does not specify the methodology, if any, it uses in the treatment of autistic children. In this sense, the applications *"ABC Autism"* and *"Jade Autism",* have a high number of facilities, are free, and can be used more independently by the child, because they are based on the TEACCH and ABA method that do not induce error.

In the second criterion, "awards" received in national events that are globally recognized, only two applications stood out: *"ABC Autism"* and *"Jade Autism".* Therefore, among the 10 applications with the highest number of installations selected, as per "Table 2", only the two applications mentioned met all the criteria of items "i" and "ii" described above.

The following is an analysis of the purpose, functionalities, and benefits of the two selected applications. It should be noted that the selected mobile applications cover fields such as: reading, writing, memory, logical reasoning, motor coordination, temporal and spatial aspects, emotions, among others.

## ABC Autism" Application

*"ABC Autism"* was created by Wellison Souza and Ezequiel Batista, students at the Information Systems College of the Federal Institute of Alagoas (IFAL). Before becoming available to the public, the application was tested by the Association of Autism Friends (AMA) of Alagoas. It can be downloaded free of charge in Portuguese and English on smartphones and tablets; it has an Android operating system and is available on *Google Play Store*.

It should be noted that the "*ABC Autism"* application was developed based on the principles of the Treatment and Education for Autism and Children with Communication Deficits (TEACCH) program, a system developed by Eric Schopplerat the University of North Carolina (USA) in 1964.

The application won first place in the "product creation" category in the Apps.edu contest, held during the Brazilian Congress of Information Technology in Education (CBIE, 2015), in Maceió-AL. The *"ABC Autism"* is a software created by technology professionals in cooperation with professionals who work with autistic individuals.

## ABC Autism: Purposes

*"ABC Autism"*is an application that aims to facilitate the development of reading and writing skills in autistic children based on behavioral psychology and psycholinguistic approaches**.**

The application was tested through a study conducted with 21 autistic children and results were analyzed to validate its effectiveness. Autistic children were organized into two groups. The first group was composed of autistic children with verbal language, which are usually at a more advanced cognitive level. The second group was composed of autistic children who did not present verbal language and who were in the initial levels of treatment.

According to Farias (et al., 2014, p. 468), the results of the *"ABC Autism "application* with autistic children from AMA-Alagoas, were promising. The authors stated that "the results obtained are encouraging. All of the application's functionalities, as well as the process of creating original screen models and subsequent design of the elements used in the interface, were fundamental for

wide-spread acceptance by children who used the application". An application with the potential to establish an automatic process that is already internalized by children represents a significant differential for intervention and treatment. In the future, it mayprovide statistical information that can be more effectively used to monitor achild's development and possibly facilitate diagnosis of the degree of cognitive impairment of the child within the TEACCH dynamic. Subsequently, additional benefits from the use of *"ABC Autism"* could emerge.

Therefore, the application's functions that lead to improved literacy are represented in the complexity of each phase and its varying levels, which support the autistic child's cognitive development through individually tailored learning. In this study, it was concluded that the tool can support the treatment of autistic children, especially with regard to reading and writing skills. Furthermore, this tool provides teachers and therapists with a time saving resource in elaborating materials or tasks for the optimal learning of these individuals (Farias; Silva; Cunha, 2014).

The application has been tried with several specific activities directed at autistic children making it possible to replace adaptive tasks teachers needs to prepare, thus allowing professionalsto dedicate more timeto the individual child.

## ABC Autism: Features and Benefits

By using the application, children with ASD come into contact with a visually organized structure in order to work on concrete skills activities more effectively, using simple figures (Farias; Silva; Cunha, 2014).

The application has four levels of difficulty. The application allows children to make letters and syllables,and convert figures and geometric shapes from levels one to four. In addition, the application helps in learning word formation and in identifying vowels and letters in the alphabet.

The*"ABC Autism"* application also offers a clean and unencumbered interface to prevent distraction by autistic users. As the application itself states, "the elements used in the storage area, aside from being simple, contain only one representation to favor the transportation of stimuli" (Farias; Silva; Cunha, 2014).

In order to respond to challenges found in the application, elements are arranged with few options as far as variety of size, favoring a correct response. This application layout is organized so as to optimize the therapist's job; the child's

performance is enhanced while simultaneously avoiding their possible frustration with behavioral disorganization. In addition, the tool initially presents, large drawings and areas which are graduallyreduced, according to the child's progress in facing the challenges proposed in the application.

The application's functionalities are based on the TEACCH method (Treatment and Education for Autistic People and Children with Communication Deficits), therefore, all levels of activity follow this methodology. *"ABC Autism"* presents 40interactive phases, distributed in four different levels of difficulty. Its phases are composed of tasks in which of figures are relocated from an area called *Storage Area* (left half of the screen), to the *Execution Area* (right half of the screen).

The methodology presents specific elements, such as: increasing levels of difficulty; differentiation between size, shape and color of represented objects; randomized position of elements on the screen; use of letters; learning without error, so that the child can only advance levels by dragging the answer to the correct option. In addition, the application allows the user to visualize the concrete object by dragging figures of diverse shapes and sizes on the screen, an essential technique in intervention activities with autistic children (Farias; Silva; Cunha, 2014).

Thus, the child is stimulated in several ways, from the recognition of shapes and colors to motor skills coordination. Children come into contact with the objects in a conventional way according to the TEACCH program methodology; the application is only used in addition to intervention procedures already in use with autistic children (Farias; Silva; Cunha, 2014).

## Jade Autism" Application

The application *"Jade Autism"* was created by Ronaldo Cohin, a Computer Science student atthe University of Vila Velha, who has an autistic child. The project was developed with the purpose of helping his son and other children diagnosed with ASD in their cognitive development.

Cohin conceived *"Jade Autism"* after searching for quality applications for parents of autistic children and failing to find anythat specifically and satisfactorily were aimed at the challenges faced by his six-year old son, Lucas. *"Jade Autism"* is a game that can record behavioral data of autistic children to efficiently assist in their treatment. From the onset, Cohin collaborated with therapists and professionals specializing in Autism Spectrum Disorder

(ASD) from the Association of Parents and Friends of the Exceptionals of the Holy Spirit (APAE-ES).

The application won the Mobile Campus Award (2019), a program conducted by the NET Claro Embratel Institute in conjunction with the University of São Paulo (USP), which aims to identify and stimulate the development of university talent who work in content creation and innovation in mobile telephony services. In addition to a financial award, the creators of *"Jade Autism"* won a trip to Silicon Valley (United States), to participate in a full immersion workshop atGoogle, Facebook, Twitter, and Stanford University in order to further improve the application. Recently, the application received an award from Tele. Synthesis Yearbook of Innovation in Communications (2020), in the "Application Developers" category. The award seeks to encourage innovative projects with a total of twenty awards given out in seven different categories: Communication Service Providers, Regional Operators, Product Providers, Software and Service Providers, Apps and Content Developers, and the Tecnologia Nacional e Soluçõesem IoT.

*"Jade Autism"* has been implemented in the 42 APAEs of the State of Espírito Santo, Brazil and is in the process of being implemented in APAEs of other states throughout the country. Cohin reports on the *"Jade Autism"* website that the application sparked the interest of the English government: "we participated in an event in Florianopolis organized by the government of England, which after learning of the application contacted us directly. We were in Florianopolis for 10 days holding meetings and presenting the project after which time we were invited to implement the project in England where it will be used in the public health sector. We are working towards making the application standard use by autistic children in England". This year (2020), the application was selected to be implemented in the region of Abu Dhabi (United Arab Emirates), by a group of technology companies called HUB 71 founded in 1971, and whose main objective is to foster development and investment in the field of technological innovation.

## Jade Autism: Purposes

The *"Jade Autism"* application was designed to help the cognitive development of autistic children, and is based on association games of colors, numbers, letters, animals, and objects, which are part of a child's everyday life. Thus, the application aims to stimulate the child's cognitive development in order to improve his/ herpotential and work on the weaknesses inherent to the disorder. The application is also available in English.

**Jade Autism: Features and Benefits**

Considering that the *"Jade Autism"* application is based on association games of colors, numbers, letters, animals, and objects, which are part of the child's everyday life, one of its main features is that it generates reports that reveal the child's performance when playing. The data from the reports are clearly presented and can help therapists improve their approach to autistic children.

The application has no advertisements and does not allow external grouping, therefore no third-party contact can be made with the child from outside the application. The functionalities of *"Jade Autism"* are based on algorithms that analyze a child's behavior during play. Therefore, the application evaluates the autistic child's reaction to a certain action, for example, the time it takes to click and start the different phases. With this, the game generates follow-up reports of the child's abilities, according to the text published in the *Folha Vitória Newspaper*.

The *"Jade Autism"* model was based on the Applied Behavior Analysis (ABA) methodology, which helps to increase the ASD child's behavioral repertoire. Through a discrete series of individual attempts, the application follows a gradual order from simple to complex, enabling the user to develop relations of identity, linking stimuli and learning.

There are four available navigation options on the application's main screen:

- Play - which opens available game options on the screen;

- Results - which allows access to performance reports;

- About the App - which contains information about the application's specifications, and

- Contact - which provides the user with support information for proper use of the application.

The application has more than 732 exercises in game format. There are several thematic fields, divided into categories, which can promote learning and fun for autistic children. The application also offers the opportunity to work on pairing and separating objects. This game expands the child's knowledge and vocabulary on issues of daily life, since objects are grouped in a simple way allowing the child to connect, for example, animals to their food. This type of activity allows the user to classify and categorize food, a fundamental step for the child's sensory-motor development.

Therefore, to use the application, the user must first select one of the available options at the top of the screen, click on the icon, then look for the corresponding image in the available options, clicking again to perform the action. The application's layout is built to allow activities to be performed easily and intuitively. In this context, the *"Jade Autism"* application can be considered as a game with therapeutic validation which presents important features and benefits.

Aside from the specific benefits for a child's cognitive development, the application *"Jade Autism"* has the *"Results"*option, which helps the therapist determine intervention approaches. At the end of each game there is the option of sending reports detailing the child's performance in the respective activity.

This feature aids the therapist and those working with autistic children by allowing them to observe the number of errors and hits in each category the child has played, as well as the length of time of play, leading to a better understanding of the child's cognitive development.

**A brief comparison between the analyzed applications**

The following is a brief comparison between the *"ABC Autism"* and *"Jade Autism"* applications, reinforcing that these mobile applications have already been tested on autistic children, and can favor their cognitive development and learning.

Aragão (et al.,2019, p. 55), states that "the use of applications with autistic children can help in the development of motor skills, increasing independence, reducing barriers of interaction with other individuals," corroborating authors Mello & Sganzerla (2013) andFarias & Cunha (2015). Thus, such applications can help autistic children to better express themselves, providing gains and abilities weakened by the disorder.

In order to better visualize the purposes, functionalities and benefits of the selected mobile applications, "Table 3" presents a comparative analysis of the applications. The comparison serves to highlight the most important items to be considered when selecting the most appropriate application according to the area of weakness caused by ASD, therefore allowing the reader to more efficiently apply the tool to a child's specific needs.

*Table 3 - Comparative Summary of "ABC Autism" and "Jade Autism" Applications*

| Categories | ABC Autism | JADE Autism |
|---|---|---|
| **Purposes** | Facilitate learning of autistic children in their reading and writing process. | Stimulate the child's cognitive development, tracking its development. |

| Features | - has a storage and a response area (error-free learning); <br> - the storage area contains a single representation; <br> - few elements arranged in the response area, with variety of size; | - allows capturing data on children's behavior; <br> - based on association games of color, numbers, letters, animals and objects, which are part of the child's everyday life; | Benefits | - prevents the child from advancing if you drag the answer to the wrong option or invalid field; <br> - facilitates the therapist's work, as it avoids possible frustration and consequent mental disorganization of the child; <br> - provides contact with the concrete object by means of the figures dragged on the screen that are presented in the most diverse shapes and sizes. <br> - based on the TEACCH model; <br> - favors motor coordination and visual and motor perception; <br> - increase of challenges, benefiting the cognitive development of the child; <br> - allows the distinction of colors, shapes and sizes of the elements, and the relationship between them; <br> - Provides greater cognitive effort in defining criteria for discerning elements among | - helps in the treatment, because it allows the capture of data on the child's behavior during the game; <br> - facilitates the association of the elements of the game with the child's daily life, providing greater motivation and better recognition of these elements; <br> - stimulates cognitive development, memory, reasoning, ability and performance of the child; <br> - based on the ABA methodology; <br> - helps the therapist in the use of more effective techniques, based on the data that are clearly presented by the application; <br> - generates results by analyzing the autistic child's reaction to that action. For example: the time it takes for the child to click and start the phases; <br> - favors the therapist and those who work with autistic children, through the analysis of |
|---|---|---|---|---|---|
| | - begins with large areas, which decrease as the child succeeds in the task; <br> - distinguish and list elements in the execution of the activities; <br> - offers a greater number of stimuli as the child changes levels in the application; <br> - image pairing activities, with combination of sound x element, image x image, action x image, letter x letter, number x number; <br> - activitiesfocusedonliteracy; | - generates reports that reveal the child's performance when playing; <br> - has algorithms that analyze how the child behaves during play; <br> - arranges objects in a simple way, so that the child connects, for example, animals to their food; <br> - the application is a game with therapeutic validation; | | | |

| | | |
|---|---|---|
| | themselves and in their correct selection.<br><br>- works sequencing, pairing and logical reasoning;<br><br>- helps to improve abstraction and symbolism;<br><br>- promotes the learning of basic literacy skills, word composition and number sequencing. | reports, to observe the number of errors and hits in each category played by the child, the total time of play, allowing better understanding of the child's cognitive development.<br><br>- works on pairing, distinction of objects, broadens the knowledge and vocabulary of the child with regard to issues of daily life;<br><br>- allows the user to classify and categorize food, these steps being fundamental for the child's sensory-motor development. |

**Source:** Elaborated by the author (2020)

Thus, according to the layout of "Table 3", parents and professionals working with autistic children can better evaluate the appropriate application by understanding the objectives, functions and benefits of each application. This would further allow them to understand which would better support these children in their development and learning.

As presented, we studied each one of the skills flagged in the specifications of mobile applications contained in the *Google Play Store* site, as well as those that emphasize the development of skills of autistic individuals which are not clearly explained on the site, but are present in the application's functions.

It was also observed that not all applications available on the *Google Play Store* platform display complete specifications, such as the date of creation or even whether it is free of charge or not, and in many cases, the information contained on the site has insufficient details about the cognitive goals to be achieved by autistic children.

## V. CONCLUSION

At the end of this research, it was evident that the topic of ASD and mobile applications is broad, and that there is a range of possibilities for future studies in the field. Therefore, there is a clear need to further study, learn, and investigate the subject, which due to its interdisciplinary nature, provides insight into the areas of both education and health creating important links to the available technologies for ASD diagnosis and treatment.

ASD has affected a significant number of children worldwide and the inherent inabilities caused by the disorder create a need for research on how mobile applications and other technologies can contribute to improving the quality of life, learning and development of autistic children.

The methodology used met the main objective of this work, which was to conduct a search on the *Google Play Store* platform, regarding mobile applications for autistic children. Thus, a description of the functionalities of the most frequently installed applications was given, highlighting their purpose and benefits, presented through the preparation of comparative "Table 3", in order to help parents and professionals who work with these children to more efficiently select the most appropriate application for the areas the child needs to work on.

Thus, in accordance with the authors cited in the body of this work, the research proves that mobile applications can support the learning and development of autistic children by helping parents and professionals who work with these children in their daily lives, both in terms of assessment and intervention. In addition, the use of mobile applications can help to improve various skills (logical reasoning, fine and gross motor coordination, auditory perception and visual perception in the exploration of size, colors, shapes), further promoting challenging experiences that support the development and learning of these individuals.

Thus, in order to improve the quality of life of autistic children by helping them become more functional and independent, it is necessary to contemplate new evaluation and intervention alternatives using mobile technology, especially mobile applications.

## VI.  APPENDIX I

*Table 2 - Ranking of the ten most installed applications for autistic users on the Google Play Store platform*

| Apps | Apps Area | Instalat. | Free | Award |
|---|---|---|---|---|
| Child'smemory game - Food | Educative Puzzle | 1.000.000 | No *Paywall* * | No |
| ABC Autism | Educational | 100.000. | Yes | 1st place in Brazilian Congress of Information Technology in Education, 2015 |
| MITA Language and Cognition Therapy | Educative Puzzle | 100.000. | No | No |
| PictoTEA | Educacional | 50.000. | Yes | No |
| Autism Image Discussion | Educacional | 50.000. | No | No |
| Jade Autism | Educative | 10.000. | Yes | 1st place in the Facilities category of the Mobile 2018 Campus Award, an award held at USP in São Paulo |
| | | | | and will be taken to implementation in England. |
| AutApp Autism | Educative | 10.000. | Not specified | No |
| AutismCPM - Game for children with autism | Educative | 10.000. | Not specified | No |
| Auts | Educative | 10.000. | Not specified | No |
| Learning from Biel and his Friends | Educative | 10.000. | No | No |

**Source:** Elaborated by the researcher (2020)

## REFERENCES

[1] Alda, L. S.; Leffa, V. J. Entre a carência e a profusão: aprendizagem de línguas mediada por telefone celular. Conexão – Comunicação e Cultura (UCS), v. 13, p. 75-97, 2014.

[2] Aragão, M. C. M.; Bottentuit, J. B. J.; Zaqueu, L. C. C. O uso de aplicativos para auxiliar no desenvolvimento de crianças com transtorno do espectro autista. Olhares&Trilhas. Uberlândia, vol.21, n. 1. Jan/abril, 2019 - ISSN 1983-3857, p. 44-58.

[3] Antunes, C. Jogos para estimulação das múltiplasinteligências. 12ª ed. Petrópoles: Vozes, 1998.

[4] Barbosa, H.F.A.; Castro, A.A.V.C.E. Análise do recurso a novas tecnologias no ensino de autistas. Engenharia Informática. Instituto Politécnico do Porto. Instituto Superior de Engenharia do Porto., Portugal, 2009. Disponível em: https://bit.ly/2DbpBCm . Acesso em: 17 de jul. 2019.

[5] Caminha, V.L.P.S.; Huguenin, J.; Assis, L.M.; Alves, P.P. Autismo: vivências e caminhos. São Paulo: Blucher, 2016.

[6] Cybis, W.; Betiol, A. H.; Faust, R. Ergonomia e Usabilidade: conhecimentos, métodos e aplicações. São Paulo: Novatec, 2007.

[7] Cunha, Eugênio. Autismo e Inclusão: psicopedagogia e práticas educativas na escola e na família. Rio de Janeiro: WakEditora, 2012.

[8] Farias, E. B.; Cunha, M. X. C.; Souza, J. W. S. ABC Autismo? Um a Aplicação Mobile para Auxiliar no Processo Alfabetizador de Crianças com Autismo. In: IV Congresso Brasileiro de Informática na Educação, 2015, Maceió. Anais dos Workshops do IV Congresso Brasileiro de Informática na Educação (CBIE 2015), 2015.

[9] Gil, A. C. Como elaborar projetos de pesquisa. São Paulo: Atlas, 2002.

[10] Google Play Store. Aplicativo para o sistema operacional Android. Disponível em:https://play.google.com/store/search?q=autismo&c=apps&price=1. Acessoem 05/10/2019.

[11] Instituto Brasileiro de Geografia e Estatística – IBGE. Projeção da população do Brasil e das Unidades da Federação. 2016. Acesso em 20.08.2019. Disponível em: http://www.ibge.gov.br/apps/populacao/projecao/

[12] Instituto Federal de Alagoas (IFAL). https://www2.ifal.edu.br/noticias/aplicativo-abc-autismo-conquista-1o-lugar-em-congresso-brasileiro-de-informatica-na-educacao Acesso em 05.08.2019.

[13] International Data Corporation – IDC. Smartphone os market share. 2018. Disponível em: http://www.idc.com/prodserv/smartphone-os-mar- ket-share.jsp. Acesso em: 20.08.2019.

[14] Jade Autismo. Disponível em https://jadeautism.com/quem-somos/ Acesso em 05.08.2019.

[15] Kauark, F. S.; Manhães, F. C.; Medeiros, C. H. Metodologia da pesquisa: um guia prático. Itabuna: Via Litterarum, 2010.

[16] Lucian, B. O.; Stumpf, A. Análise de aplicativos destinados ao aprendizado de crianças com transtorno do espectro autista. Design e Tecnologia, v. 9, n. 19, p. 43-65, 30 dez. 2019.

[17] Manual Diagnóstico e Estatístico de Transtornos Mentais: DSM-5 / [American PsychiatricAssociation, tradução Maria Inês Corrêa Nascimento ... et al.]; revisão técnica: Aristides VolpatoCordioli... [et al.]. - . e . Porto Alegre: Artmed, 2014. xliv, 948 p.; 25 cm.

[18] Mello, C. M. C.; Sganzerla, Maria Adelina Raupp. Proposta de aplicativo Android para auxiliar no desenvolvimento matemático de pessoas com autismo. In: VI Congresso Internacional de Ensino da Matemática, 2013, Canoas. VI Congresso Internacional de Ensino da Matemática, 2013.

[19] Ministério da Saúde. Cartilha Autismo: orientação para os pais. Casa do Autista - Brasília, 2000.

[20] Organização Mundial de Saúde - OMS. Classificação de Transtornos Mentais e de Comportamento – CID-10 (versão em português da sigla ICD, do inglês International Statistical Classification of Diseases and Related Health Problems); Porto Alegre: ArtMed, 1993.

[21] Organização das Nações Unidas – ONU. News de Nova Yorque, 2017. Disponível em: https://news.un.org/pt/story/2017/04/1581881-oms-afirma-que-autismo-afeta-uma-em-cada-160-criancas-no-mundo. Acessoem: 29.07.2019

[22] Orrú, Sílvia Ester. Aprendizes com autismo: aprendizagem por eixo de interesses em espaços não excludentes. Petrópolis, RJ: Vozes, 2016.

[23] Pereira, N. M.; Vieira, N. J. O Transtorno do Espectro Autista e a Utilização de Aplicativos para Dispositivos Móveis como Ferramenta Educacional. Revista P@rtes. ISSN 1678-8419. Disponível em: https://www.partes.com.br/2020/01/29/o-transtorno-do-espectro-autista-e-a-utilizacao-de-aplicativos-para-dispositivos-moveis-como-ferramenta-educacional/ Acesso em 25/05/2020.

[24] Redação Folha de Vitória-ES. https://folhavitoria.com.br/geral/noticia/09/2019/aplicativo-criado-por-capixaba-sera-implementado-na-inglaterra-jogo-ajuda-criancas-autistas Acesso em 16/09/2019.

# From (In) Involvement to (In) Territorialization of the Quilombola de Negros de Gilú Community, in Itacuruba – PE

Simone Francisca Ramos de Sousa[1], Nilton de Almeida Araújo[2], Lucia Marisy Souza Ribeiro de Oliveira[3]

[1]Graduada em Ciências Sociais  pela UFPI – Universidade Federal do Piaui.Mestranda em Extensão Rural - PPGExR/UNIVASF, Especialista em Estado e Direitos dos Povos e Comunidades Tradicionais - UFBA, Antropóloga do INCRA.
Avenida Gilberto Freire, 283, Apartamento 003, Bloco B, Condomínio San Rafael, Petrolina – Pernambuco, CEP -56.306 -355
[2]Professor Adjunto de História do Brasil - Ciências Sociais / UNIVASF e do Programa de Pós Graduação em Extensão Rural/UNIVASF, Coordenador do Núcleo de Estudos Étnicos e Afro-Brasileiros Abdias Nascimento - Ruth de Souza -NEAFRAR. Licenciado em História/ UEFS,2002. Mestre em Ensino, Filosofia e História das Ciências - UFBA/UEFS, 2006. Doutor em História Social - UFF, 2010.
Rua Santa helena, 53. Bairro Alto do Cruzeiro/ Juazeiro – Bahia CEP 48.905-259
[3]Pedagoga. Especialista em Metodologia do Ensino Superior. Mestra em Desenvolvimento Regional. Doutora em Desenvolvimento Socioambiental. Docente Associada IV da UNIVASF. Pesquisadora do CNPq em Extensão Inovadora. Pesquisadora nas temáticas Agricultura familiar e Populações Tradicionais. Coordena projetos de Extensão nas áreas de Desenvolvimento Territorial; Inclusão Digital e Agroecologia. Docente no mestrado acadêmico Saúde e Ciências Biológicas e no mestrado professional em Extensão Rural. Docente no 10 Doutorado em Agroecologia e Desenvolvimento Territorial.

Universidade Federal do Vale do São Francisco
Praça da República, 33. Bairro Dom Tomaz, CEP 48907-180 Juazeiro – Bahia

***Abstract****— The aim of this study was to describe the trajectory of the quilombolas called Negros de Gilú, in their struggle for permanence on the land from the construction of the Luiz Gonzaga hydroelectric plant in the 1980s of the 20th century by CHESF - Companhia Hidroelétrica do São Francisco, in the locality of Itacuruba , in the state of Pernambuco. It is an exploratory study, developed through documentary research, involving reports and administrative process established by INCRA - National Institute of Colonization and Agrarian Reform; anthropological report issued by UFPE - Federal University of Pernambuco; documents and reports from the Palmares Foundation, which advised this population on the paths to be taken in the search for their ideal, and minutes of deliberative meetings of the Gilú quilombola association, whose compiled data gave rise to this article.*

***Keywords****— **Quilombolas, blacks from Gilú, Itacuruba, sustainable development, Territory.***

## I. INTRODUCTION

The Federal Constitution of 1988, Art.68 in the Transitional Provisions Act (ADTC), makes the term quilombo a legally juridical category in the validation of the rights to the remnants of African populations, regarding the title of the lands occupied by them, regardless of having a document. they referenced. As Arruti (2006) informs, the legitimation of the ownership of these traditional territories is the responsibility of the State, to meet the main claim of the quilombola movement as an act of resistance against slavery and territorial sovereignty (LEITE, 2000).

Territory is being conceived here as a process of social construction that involves different public and civil society actors. With this understanding, Tizon (1995), defines territory as "a space of life, action, and thought for a community, associated with identity construction processes". Likewise, Pecqueur (2000), conceives the territory as "the meeting of social actors in a given geographical space, which seeks to identify and solve common problems." In an approach closer to the sociology of development, Abramovay (1998), presents the idea that "a territory represents a web of relationships with historical roots, political configurations and identities that play a little-known role in economic development itself".

In this sense, the territory is built as a space for social relations, with strong ties of solidarity and belonging between the actors (BRUNET, 1990). This sense of solidarity is defined by Scheren Warren (1998) as "the principle of individual and collective responsibility towards the social and the common good, whose practical implications are the search for cooperation and complementarity in collective action and, therefore, for work in partnership."

The slavery period left marks in the population of African matrices that became ingrained, such as social inequalities, prejudice and racism, so present in society, whose consequences are the lack of opportunities for entering public higher education; the unequal treatment in the selection for occupation of positions; the difficulty in accessing public policies on health, housing, food, transportation and, especially, access to land to work, live and achieve social and economic autonomy there. In the case of the Gilú community, who owns their land, it is to repair part of the damage caused by slavery, ensuring its members the dignity of producing their own food, maintaining their culture and habits and taking care of the environment, since the their way of planting and harvesting is based on the principles of agroecology and respect for nature. As titling is a collective act, it means that the titled land cannot be sold, and must remain "ad infinitum" with itsdescendants. This commitment greatly contributes to the strengthening of the quilombola identity and the feeling of ethnic belonging to the territory, preventing them from being tempted by the offers of those who want the land to speculate or to produce unsustainably, with the goal of unbridled profit, with the exploitation of wood, ores, or implementing the cultivation of commodities, which are highly consumers of agrochemicals.

The incentives of the Brazilian State to the agricultural sector have always been concentrated on large rural properties, aiming to improve the balance of trade, with resources aimed at agricultural production for the foreign market. In 2003, the then Ministry of Agrarian Development, through the creation of the Secretariat for Territorial Development, reoriented public policies for rural development, having as main focus the territorial approach, starting to operate with the strategy, whose concept of adopted territory is:

> [...] a physical space, geographically defined, generally continuous, comprising cities and fields characterized by multidimensional criteria, such as the environment, the economy, society, culture, politics and institutions, and a

population with social groups relatively distinct, that relate internally and externally through specific processes, where one or more elements that indicate identity and social, cultural and territorial cohesion can be distinguished (BRASIL, 2003).

According to Delgado et al. (2007), the territorial approach offers another perspective for development, in which the different local actors are invited to think and decide about their own future, their demands, their projects and the way of managing the initiatives to be implemented. However, the great challenge is to move from rhetorical innovation to a true process of institutional change, with the participation and involvement of community-based organizations (FAVARETO, 2009).

This article, in addition to the introduction, is divided into three parts. The first points to the history of occupation and resistance of Negros de Gilú. The second, addresses the main discussions about said development and the damage caused by it. The third part shows how the community reconstructed its identity, memory, culture and what mechanisms they use to activate their territorial rights, highlighting the impeccability to guarantee them, in addition to the final considerations.

## II. HISTORY OF OCCUPATION AND RESISTANCE OF GILÚ'S BLACK QUILOMBOLS

The Negroes of Gilú, come from free slaves, whose origin goes back to the couple Antonio Isidoro and Maria Rufina da Conceição, who abandoned the Palmares quilombo in Alagoas and came to the São Francisco backlands, at the end of the 19th century. The place they chose was Fazenda Retiro, in the municipality of Floresta - PE, in the hope of guaranteeing land to produce and improve the quality of life, which occurred, first planting in the river's ebb, which is the wet earth process after the flood, leaving the land fertile and very suitable for farming. Then, by buying a piece of land from one of the landowners, being able, from there, to maintain his family and increase the number of children, to serve as labor on the property.

The fact that an ex-slave became the owner of land displeased the colonels in the hinterland and Antonio Isidoro was soon murdered. It didn't take long for Maria Rufino who took control of the land, to have the same end, being murdered. Intimidated by the events, the couple's children decided to sell the property and each took their own course. However, four of the seven children decided

to live in the territorial limits of the town of Itacuruba-PE, giving rise to the so-called "Rua de Baixo", where the Negroes of Izidoro and Maria Rufino decided to organize themselves socially, to constitute their families respecting their identity and its culture. There, Rua de Baixo, came to be called "Comunidade Dona Gilú", in honor of a strong and determined woman, who stood out for the struggle in favor of the dispossessed. She had many children, whose descendants still reside on the site and identify themselves as "Negros de Izidoro and Maria Rufino", due to the story they weave day after day.

The quilombola community of Negros de Gilú, after the flooding of the old city of Itacuruba, was located in a neighborhood of the municipality of the new city of Itacuruba, state of Pernambuco, in the middle São Francisco, better known as the microregion of Itaparica and is 466 km from Recife, the state capital, bordering the cities of Belém de São Francisco, Floresta and Petrolândia, in Pernambuco; and Rodelas, in the state of Bahia.



*Fig.1: Map of Itacuruba –PE*
Source: Google Maps, 2020

The old Itacuruba was flooded by the waters of the São Francisco River, with the installation of the Luiz Gonzaga hydroelectric plant, which belongs to CHESF - Companhia Hidroelétrica do São Francisco, which caused the displacement of several families of Negros de Gilú to other regions. This relocation of families caused many social, economic and cultural conflicts, in view of the deterritorialization caused by the breaking of family and friendship bonds, built in years of coexistence, struggle and resistance. In addition, the ecosystem where many families were forced to live, in some cases very different from what they were used to planting, left the feeling of helplessness, for not knowing what to do and how to live to feed their children. Those who stayed in the newly created municipality took up residence in Alto da Caixa D'Agua, on the outskirts of the city, facing for the second time the adversities of those who need to defend their

space; the guarantee of work and income; the benefits of treated tap water; basic sanitation; electrical energy; paving in the streets; social facilities such as daycare, so that mothers can work; public school, to ensure citizenship for children and young people; public transport, which allows the necessary displacement; sports and leisure areas for young people to engage in educational activities; ecumenical temple for religious practices and cultural center that ensures the valorization of its practices.

According to Martins (1993), these ruptures have caused the inconvenience of living with strangers in the rural population, who, in his view, not only invade theirterritories but also bring different habits and customs, imposing values that are not yours. This trajectory, likewise, brings suffering to those who arrive and realize they are not welcome.

*Fig.2: Luiz Gonzaga Hydroelectric Plant*

Source: Google Maps, 2020

In this sense, for the Gilús da Caixa D`Água, the struggle for the territory has a symbolism and a wealth that cannot be measured, because there they can maintain their ethnic identity; traditions; the culture; kinship ties and the possibility of triggering other rights, which until then were neglected by the oppressivestate, in favor of a concept of economic development that does not involve traditional communities, making them increasingly invisible to society.

## III. DEVELOPMENT AND DETERRITORIALIZATION OF GILÚS

The environmental crisis in the world was driven by the destruction of natural resources, resulting in desertification; the increase in the greenhouse effect with the emission of gases; deforestation; the use of pesticides that contaminate soils and the population; the destruction of rivers, lakes, seas and oceans; the reduction of animal and plant species, generating social, ethnic, racial and gender inequalities, increasing poverty. Leff (2009), guarantees that the environmental crisis is the portrait of the appropriation of nature by capital in the expansion of profits, being the result of economic rationality.

In the mid-1980s, the mobilization of civil society around the Constituent of 1988, redefined the role of the State and the decentralization of public policy management, triggering the transformations that took place in the Brazilian economy, politics and society. Such changes observed in this period, must be noticed, taking into account what Dagino (2004), called "perverse confluence", due to the coexistence of two projects, fruits of the crises experienced in the country in the struggles for

democracy: the neoliberal project in progress and the democratizing project.Therefore, two strategies were adopted: to continue with the policy of promoting business agriculture, encouraging competitiveness; maximizing productivity; exporting agricultural products and the trade balance surplus, through the Ministry of Agriculture, Livestock and Supply (MAPA), and the other, to promote agrarian reform and develop family agriculture through the then existing Ministry of Agrarian Development (MDA), now extinct.

Bonnal and Kato (2010), state that thinking about development through a territorial approach implies the strengthening of local social groups and their organizations, the consolidation of collective actions, the articulation and harmony between the different dimensions of development. Likewise, Veiga (2008), tells us that development is not only the result of the action of the government, but of the strength of organized populations and the idea of sustainable development leads to the search for solutions that contemplate the environment and traditional peoples and communities, such as indigenous, quilombolas, riverside and forest peoples.

The United Nations Conference on Environment and Development, an event that took place in 1992 in Brazil, in the city of Rio de Janeiro, greatly contributed to defining the limits between economic rationality and the challenges of environmental degradation in the civilizing project of society (LEFF, 2006), bearing in mind that the developmental practices proposed by large companies and by the State itself have caused many land conflicts; violation of rights; violence in the countryside; emission of gases, which causes environmental and social damage.

The Negros de Gilú Community in 1988 was affected by the construction of the Itaparica dam, now Luiz Gonzaga, in honor of the "Rei do Baião", becoming deterritorialized, in the name of economic development. Deterritorialization, when it occurs at the desire of the population, is understood as something natural in the dynamics of society, however, when it occurs in an authoritarian way, through the exercise of political power, it can bring consequences that are difficult to assimilate. As stated by Haesbaert (2006), deterritorialization does not exist without reterritorialization, as geography defends, because man is a territorial being. Thus, the Negros de Gilú population without territory cannot manage it, but it can manifest its relationship with the land and its culture.

From the point of view of Almeida (2008), territoriality is a factor that functions as identification, defense and strength, in which the bonds of solidarity and mutual help are informers of a set of rules established on a physical basis considered common, essential and inalienable (ALMEIDA, 2008). In this way, the Gilús are in a permanent state of struggle, in search of their constitutional rights, to reconstitute their territory. Leff (2006), explains that the territory is a peculiar place of the wishes, demands, and complaints of the population, being a space to reconstruct their ways of life and reconfigure their identities through cultural and environmental valorization, designing new strategies for the re-appropriation of nature.

## IV. THE RECONSTRUCTION OF IDENTITY AND THE FIGHT FOR THE RIGHT TO EARTH

With the installation of the Luiz Gonzaga hydroelectric plant, the territory of Negros de Gilú disappeared, and they began to live in invisibility. For CHESF, the reparation of damages to the population, took place with their resettlement in other spaces. Emotional issues, belonging to the place, cultural identity, were not addressed universality of all dimensions, that is, solutions that lead to growth that is environmentally beneficial, and not socially destructive. In this perspective, only solutions that promote economic growth with positive socio-environmental impacts can be called sustainable development (VEIGA: 2008).

In 1983, the General Assembly of United Nations (UN) organizations, concerned with the change in nature caused by forms of development, created the World Commission on Environment and Development, an independent body linked to governments and the United Nations system, but not subject to its control

(BRUNTLAND, 1991). However, the concern about man with the planet was not yet latent and it was necessary that this control of actions was more forceful. In this sense, the World Commission on Environment and Development, proposed the idea of sustainable development, with a view to meeting the needs of the present, without affecting the ability of future generations to meet theirs (Bruntland Report, 1987).

Based on this framework, the debates on sustainable development were gaining visibility in all fields, in the academic, governmental sphere, by private companies and by civil society organizations, seeking to reconcile economic development and socio-environmental development, with respect to the environment in count. In order not to be separated from their relatives, many gilus abandoned the land that CHESF assigned to them, and began to live as households, next to their own. In this case, these families were harshly penalized, compromising the assets they had, without the descendants in the future being able to enjoy it.

In triggering the right to land, the community that still did not have information on article 68 of the ADCT, was instructed by the Fundação Cultural Palmares (FCP) to rescue the common use of the land, that is, to tell their own story, as remaining quilombo, for certification. It was the first step towards the group's social reorganization, creating the Association considered a symbol of ethnic emergency.

The ethnic emergence of the Gilús was reaffirmed with the return of those who returned from other locations where they were relocated. In the fight for their territorial rights, they were building fundamental fundamental partnerships for the solution of their problems, such as, the National Coordination of Articulation of Quilombolas Black Rural Communities-CONAQ; Pernambuco State Articulation; Itacuruba Rural Workers Union; Movement of People Affected by Dams - MAB, whose goal was the reconstruction of their territory. These social networks were decisive for understanding the process of claiming the territory, which at the time was under the responsibility of Fundação Cultural Palmares.

The next step was the preparation of the anthropological report that tells the entire story of the occupation and deterritorialization of the Gilús. This action encouraged them to continue the struggle to get out of invisibility, participating in training moments to understand the constitutional and legal provisions of the re-territorialization process, which guaranteed certification at Fundação Cultural Palmares, as remnants of the quilombola community, issued on March 2 of 2005. Each

successful action contributed to the elevation of the group 's self - esteem, through their recognition as quilombolas.

In the collective memory of the group, the memories are vivid and strengthened by the feeling of belonging to the territory, for which they seek title.

Decree 4,887 / 2003 (BRAZIL, 2003), which "regulates the procedure for the identification, recognition, delimitation, demarcation and titling of lands occupied by remnants of quilombo communities referred to in art. 68 of the Temporary Constitutional Provisions Act ", is a legal provision under the responsibility of the National Institute for Colonization of Agrarian Reform (INCRA), which aims to guarantee the physical, social, economic and cultural reproduction of quilombola communities. It's throughof this legal provision, that the Quilombola de Negros de Gilú Community mobilizes politically and legally for the State to regularize its territory. In this context, the community filed a lawsuit with the extinct Regional Superintendence of the Middle São Francisco - SR 29, today the Advanced Sertão Unit (UAE), to request the regularization of their lands, since the requirement Anthropological Report - RA, carried out by the Department of Anthropology and Museology at UFPE - Federal University of Pernambuco, has already been completed and handed over to INCRA - National Institute of Colonization and Agrarian Reform.

Anthropologists, through the Brazilian Association of Anthropology, have an important role on the notions that are the basis of judgment of quilombo remnants, when using ethnographic research materials and anthropological reflections on ethnicity, ethnic groups and the construction of different cultures to debate the themes of this field of application of constitutional rights (O'DWYER, 2007), although it is in the public domain, that the regularization of quilombola territory is a political act, of governmental interest.

Even though the struggle for rights is slow and arduous, the quilombolas of Negros de Gilú have transformed discouragement, tiredness and anger into hope, resistance and action. Thus, new legalities are being created in opposition to the dominant model of development imposed by the owners of power. In a determination of the MPF - Federal Public Ministry, a discriminatory action was carried out in the municipality of Itacuruba in 2009, to locate areas where families could be settled, as well as their registration, having identified 214 families, at the time residing in municipalities in the states of Pernambuco , Bahia, Alagoas and Ceará. These actions are considered important to achieve the main objective, which is the regularization of the territory, the

process of which is at INCRA in Brasília, awaiting the purchase of the Fazenda Boa Sorte, chosen by them, for the final outcome.

## V. FINAL CONSIDERATIONS

Even with the interventions of environmentalists, NGOs, unions, social movements, Brazil still experiences a development model that excludes vulnerable populations in the countryside and in the city. Quilombola communities are a constant target of developmental practices, which ignore socio-environmental sustainability, destroying territories, devastating forests, contaminating soils and public waters, separating families and destroying the culture and identity of traditional populations.

The social consultation environment as a space for planning, executing and monitoring sustainable territorial development in Brazil, has been built and faces many challenges. It is necessary to move forward in the discussion, having as a central idea the development focused on a new ethics and common goods, with environmental justice, social and economic inclusion. Some challenges arise: access to natural and energy resources, such as access to water, an essential element of life, and clean energy; the agrarian question and the urban-rural relations.

Public policies must, through the territorial approach, enhance and value the diversity and multifunctionality of rural spaces and strengthen the institutionality and participation of social organizations in their design and operation, with the incorporation of new actors. The diversification of productive systems and the preservation of natural resources should take into account the traditional knowledge associated with biodiversity.

In the case of Negros de Gilú, after thirty-two years, the community has not recovered from the damage caused by the installation of the Luiz Gonzaga hydroelectric plant. Without legalized land to produce, they cannot claim other rights, such as financing, loans, Safra insurance, sale of products to the school system and others. They are also deprived of education, health, basic sanitation, public transportation, paving the streets and a day care center for their children. . However, the leaders have played their part in encouraging and maintaining hope, defending the motto that in a democracy, justice takes time but does not fail.

## REFERENCES

[1] ABRAMOVAY, Ricardo. **Desenvolvimento sustentável: qual a estratégia para o Brasil?** Novos Estudos, n. 87.

São Paulo, CEBRAP, 2010.

[2] ALMEIDA, Alfredo Wagner Berno de. **Os Quilombos e as Novas Etnias**. In: O'DWYER, Eliane Cantarino (org.). Quilombos: identidade étnica e territorialidade. Rio de Janeiro: Editora FGV, 2002.

[3] ALMEIDA, Alfredo Wagner Berno de. **Terras de preto, terras de santo, terras de índio- uso comum e conflito. In: Terras de Quilombo, Terras Indígenas, "Babaçuais Livres", "Castanhais do Povo", Faxinais e Fundos de Pasto: terras tradicionalmente ocupadas.** 2.ª ed, Manaus: PGSCA-UFAM, 2008.

[4] ARRUTI, José Maurício. **Mocambo: antropologia e história no processo de formação quilombola.** Bauru: Edusc, 2006. 370pp.

[5] BRASIL, Senado Federal. **Constituição da República Federativa do Brasil**. Brasília: Senado, 1988.

[6] BRASIL. Presidência da República. **Decreto nº 4.887/2003**, de 20 de novembro de 2003. Diário Oficial da União, Brasília, DF, 21 nov. 2003.

[7] BRUNET, R**.. Lê territoire dans ês turbulences**. Paris: Reclus, 224 p. 1990.

[8] COMISSAO MUNDIAL SOBRE MEIO AMBIENTE E DESENVOLVIMENTO. **Nosso futuroComum**. Rio de Janeiro. FGV, 1991.

[9] DELGADO, N.G.; BONNAL, P.; PEREIRA LEITE, S. **Desenvolvimento territorial: articulação de políticas públicas e atores sociais**. Rio de Janeiro. IICA /CPDA/UFRRJ, 71p. 2007.

[10] HAESBAERT, R. **O mito da desterritorialização: do "fim dos territórios" à multiterritorialidade**. 2. ed. Rio de Janeiro: Bertrand Brasil, 2006.

[11] FAVARETO, A. **Retrato das políticas de desenvolvimento territorial no Brasil**. Documento de Trabajo Nº 26. Programa Dinámicas Territoriales Rurales. Rimisp, Santiago, Chile. 2009. 86 p.

[12] LEITE, Emanual. Incubadora social: a mão visível do fenômeno do empreendedorismo criando riqueza. In: **Anais do 4º ENEMPRE**. Santa Catarina: UFSC/ENE, 2002.

[13] LEFF, Enrique. **Racionalidade Ambiental.** Rio de Janeiro: Civilização Brasileira, 2006.

[14] LEFF, Enrique. **Complexidade, Racionalidade Ambiental e Diálogo de Saberes.** Educação e Realidade, 34(3), Set/Dez. 2009.

[15] LEFF, Enrique. **Ecologia, capital e cultura*:* a territorialização da racionalidade ambiental**. Petropólis: Vozes, 2009.

[16] MARTINS, José de Souza. **A Chegada do Estranho**. São Paulo: Editora Hucitec, 1993.

[17] O'DWYER, Eliane Cantarino (org.). **Quilombos: identidade étnica eterritorialidade**. Rio de Janeiro: Editora FGV, 2002.

[18] PECQUEUR, Bernard. *Le Développement Local*, Ed. Syros, 2ème édition, Paris, 2000.

[19] RAFFESTIN, Claude. **Por uma geografia do poder**. Tradução de Maria Cecília França. São Paulo: Ática, 1993.

[20] SCHEREN-WARREN, I. Ações coletivas na sociedade contemporânea e o paradigma das redes. In: **Sociedade e Estado**. Volume XIII, número I: EDUNB, pp.55-70. 1998.

[21] TIZON, P. Le territoire au quotidien. In: DI MEO, G. **Les territoires du quotidien**. Paris: L'harmattan, 1995.

[22] VEIGA, J. E. da. **Desenvolvimento sustentável: o desafio do século XXI**. Rio de Janeira: Garamond, 2008.

# Memory, Culture and  authenticleadeship: why does this matter to a company?

Mário Nenevé[1], Miguel Nenevé[2]

[1]UNIVILLE – meneneve@uol.com.br
[2]FCRO – Faculdade Catolica de Rondonianenevemi@gmail.com

*Abstract— Memory, culture and  leaderhip in a company does matter, although many executives may think the opposite. In this study we investigate the importance of memory and leadership of a family  company in the city of São Bento do Sul, Southern Brazil, with the purpose of identifying its characteristics. We intent to study,through a questionnaire answered by employees, if they feel at home in the company and, therefore, if the leadership is authentic. Besides we want to identify  the company´s atmosphere:  can it be considered authentizotic? Which are the facts that characterize it as such.Brief and Weiss (2002), Gelfand, Erez and Aycan (2007), Hodgkinson and Healey (2008) and Judge and Kammeyer Muller (2012) are part of our theoretical support.*

*Keywords— Company´s memory - Authentic leadership,Buddemeyer, Family business.*

## I.    INTRODUCTION

"There's no need tostudy  the past; what matters in a company is the future" this is something we usually hear when people are talking about a company´s progress and success. This is a version of some people´s belief, people who have workedas  executives in some companies. They think it is no need to go back to origin of the company and to get to know how it started and how it has developed to reach the position it occupies now. Some people even think that study the compnay´s history and memory is just as irrelevant as some sad nostalgia. They may think that tohonour the memory of the company is a waste  of  time and that everybody needs to focus  only on the steps ahead. However, in this paper we want to argue that the history and development of the company do matter. Authentic leaders of companies know the importance of the employee´s confidence on their work and on their leader and in this case, they know that if they miss the history, the are missing part of the company.**Lisa** O'Keefe, Senior Advisor of Talent and Engineering Culture says that  "the more leaders can share what a company values in its culture, the easier it's going tobe for the culture to become a reality and not just these random words uttered without meeting or random quotes on a wall.[1]"

It is important for the employess to feel they belong to the company when they know where they are stepping on, that is

how the company was founded on what principles and objectives. Thinking on this and thinking of the importance of valuing local companies which has been in the region for a long time and can serve as  examples for new companies that we decided to research on the history and leadership of Buddemeyer, a company located in São Bento do Sul. Albert Memmi, a thinker in the area of postcolonial studies reflects on the importance of the colonized people, and here we can associate with the employees and the need ofbelonginess.

When employees are excluded from any values but work they become less interested in the government and in the progress of  the company. They are conditioned that their inadequacy is what makes them unable to feel part of the company, and "assume a role in history" as Memmi says in his work The Colonizer and the colonized (94). If the employees have no right to know more than their own job in the company, they can  never experience feelings belongingness and, therefore, will do little for the company.

Researching  the history, the leadership and the development of a company such as Buddemeyer, in our own place, has a great relevance for students and young entrepreneurs who need some encouragement and stimulus to plant new ideas and news business. As Frantz Fanon says, to go back to the past , to value the memory is to believe in a better future and  "an "invitation for action and a basis for hope" (231-. 232)." This, we believe ,it is possible to apply to discussion on the area of business as is the aim of our discussion too. Authentic leadership is another important issue

---

[1]CULTURE IQ blog." The Role of Leadership in Changing Organizational Culture". Avalible at https://cultureiq.com/blog/role-leadership-changing-organizational-culture/. Access on September 18th 2020.

related to the company (Buddemeyer) which is the object of our discussion here.

## II. AUTHENTIC LEADERHIP

In any situation in which people are involved, in a given context, when there is an intentionof achieving a common goal, it is necessary for someone to assume the commanding position. This person, whether they ascend naturally to that position or they are appointed by the group, or by someone else, is the leader within the common goal. Organizations, in general, are those that, in principle, have goals and objectives of their own, in their "raison d'être", hence they depend on their leaders for their success or failure.

The large number of research studies carried out in organizations (MUMFORD et al., 2009) attests to the importance of the leadership theme, as it permeates as a fundamental link in the complex organizational system. This area of study is placed among the ten most researched in the beginning of the twenty-first century (BRIEF; WEISS, 2002; GELFAND; EREZ; AYCAN, 2007; HODGKINSON; HEALEY, 2008; JUDGE; KAMMEYER MULLER, 2012).

An essential element for leaders to be respected is the question of their moral authority. This applies not only in the organizational context, but in terms of what happens worldwide when it comes to the effective representation of its leaders. In recent studies, several approaches to leadership profiles have deserved researchers' attention. However, one in particular, which emerged no more than 20 years ago, is the so-called "Authentic Leadership", which has moral values as one of its bases.

## III. AUTHENTIC LEADERSHIP AND THE AUTHENTIZOTICATMOSPHERE

Studies on authentic leadership have evolved from the beginning of this century, to the point that today this theory is already consolidated. This leadership characteristic flows to those leaders, said to be authentic, who have a solid "sui generis" behavior of their "selves", who are confident in themselves, based on a greater knowledge of their abilities and endowed with moral values.

These attributes lead them to be able to behave with relational transparency with those who they lead; they act out of awareness of their "selves" within the group's larger objectives, for an ideal, without the attachment to obtaining their own advantages. In an organizational context of integration between leaders and subordinates, a leadership that strives for transparency is necessary.

For their performance, organizations need continuous feedback between leaders and followers. Along this lime,

studies emphasize that authentic leaders are able to contribute to a positive atmosphere among their followers, so that workers make their insertion in the company an extension of their life purposes. For a healthy atmosphere, in which the team members feel committed and happily integrate into the work environment, the term "Authentizotic Organizations" emerged among theoretical researchers (Kets de Vries, 2001), or even "Authentizotic culture", or "Authentizotic climate".

Thus, the question that I present here is how authentic leaders can contribute to an authentic environment, under a case study in a company located in the north of Santa Catarina, BuddemeyerS.A. Under an empirical assumption that the leadership in this organization was authentic, this study aimed to confirm it and to understand if this factor contributed to their environment having a healthy atmosphere, one in which the employees feel engaged and committed with the organization.That is, it aims to understand whether the organization was theoretically typified asauthentizotic.

Theoretically, these two variables are intertwined, in other words, authentic leaderships converge so that there is a so-called authentizotic climate, one in which workers feel engaged with the organization, motivated, committed, in anenvironment in which the organization provides a purpose for your life, that is, naauthentizoticone. Studies emphasize that happiness at work, satisfaction and organizational commitment are positively related to the authenticity of the leader.

In this case study, the company mentioned above is a family organization that is now in its third generation, with a management done by family members, while still maintaining a percetible professional performance. An important aspect is that in order for the the family business to remain in succession, it is necessary that it has a reliable leader who can establish norms that separate the issues between family, property and management.

This company, which is the result of a family leadership that stands out today, managed to display a professional family management. And in this context, it is important to ponder on the work environment in the organization and its leaders. Although there are restrictions regarding families in the command of organizations done, this is the case "sui generis" that has experienced a successful experience through the command of family members.

The scholar Terry (1993) had already used the term authentic leadership, understanding that this conception carried a strong sense of value, essential for a rapidly changing world. In 1997, articles such as "Authenticity, intentionality, spirituality and sensibility" (BHINDI; DUIGNAN, 1997) and "The power of vulnerability in contemporary leadership" (BUNKER, 1997) contemplated this vision of leadership

based on personal values and shared among those who are led, in a sense of moral and ethical conduct that inspired reliability.

In the organizational area, Bill George, as the former head of the American company Medtronic, postulated the need for leaders to conduct themselves with purpose, moral values, with the courage to build their companies by meeting the needs of not only all parties related, but of society itself, in a long-term view (GEORGE, 2003).

In academic terms, in 2003, Luthans and Avolio published a book chapter on authentic leadership and began to publish scientific articles on the topic, culminating in an event, held in 2004, led by them in which they brought together professionals and scholars on the topic,especially to discuss this approach at a leadership conference at the Gallup Institute for Leadership at the University of Nebraska-Lincoln.

As a result of the discussions at this congress, an issue was published in the Leadership Quarterly Journal, entirely focused on the theme and whose title was: "Authentic leadership development: Getting to the root of positive forms of leadership" (AVOLIO; GARDNER; WALUMBWA, 2005). From the perspective of the authentic leadership construct, this special issue served as a paradigm for much of the research carried out later (KLENKE, 2007). This leadership approach emphasizes building a leader's legitimacy through transparent and honest relationships with those led.

Usually, the authentic leader is able to build a positive interaction, providing enough openness for the followers to believe in relational transparency. Mutual trust is a permanent construction, generating support for the team members, and capable of providing growth opportunities. In this sense, there is a conception that authentic leadership is a growing area of academic research on leadership, which, having originated at the beginning of this century, has grown from a new concept to the start of a totally mature concept.

Authentic leaders, when conducting themselves in anenvironment of transparent relationship, are able to act in a way that makes workers feel like members of a committed team. Thus, they are motivated to perceive themselves as active subjects, who belong in the organizational body. Kets de Vries (2001), based on his studies of companies,cites someorganizations with this kind of environment authentizotic.

This focus on the work environment originated from the project "The 100 Best Companies to Work for in America" (LEVERING; MOSKOWITZ, 1983). These companies seek to respond to the need to satisfy three purposes: professional fulfillment, family/personal fulfillment and organizational performance. In return, employees adopt a posture characterized by effort and organizational commitment,

loyalty and behaviors of organizational citizenship (REGO, 2004).

In a corporate sense, the organization's connectivity with its body of workers makes it possible for the goals are shared. This transparency, this authenticit functions as a balance between the personal aspect of the organization's components and the professional environment, creates the so-called authentizotic organization. Common goals create an environment for individuals to develop, constructing their autonomy as they become aware of their importance for the group synergy.

In this context, a good place to work is one where employees trust the people who lead and/or employ them, are proud of what they do, and like the people with whom they work.The environments in which these people feel inserted are called self-realizing, that is, one which promotes a high quality of life, assisting people with personal life goals that integrate with personal growth in the organization.

The leaders of these organizations (authentizotic) are capable of creating positive stimuli in the environment; they have high standards of behavior, are supported by ethics, and motivate their followers to pursue these values; with their examples and attitudes towards the community, they foster social responsibility (REGO, 2004)

## IV.    BUDDEMEYER – AN AUTHENTIZOTICORGANIZATION

Our study was conducted at the company Buddemeyer S.A., a nationally recognized industrial company in the textile sector in São Bento do Sul - SC. This organization was founded in 1924, by the German immigrant Friedrich Bernard Buddemeyer - who, in his luggage to Brazil, brought his experience in textile engineering, his bride, and the hope of a new life. Buddemeyer started as a loom factory in Itajaí - SC. In 1951 the company was transferred to São Bento do Sul, and started to manufacture textile products. It currently employs 1,200 people. In terms of command, Buddemeyer is led by the third generation of the family that gives its name to the textile company.

From the 1970s onwards, the organization gained new markets and consolidated its presence in Mercosur, in the European Community, and in North America. The questionnaires were applied to all employees of the company who exercised a leadership role, from team leaders to supervisors and managers.It should be noted that each respondent had someone as a superior who commanded them.

For our research, we applied 48 questionnaires within this sample population, covering all employees who held some leadership position. The questionnaire contained statements,

using the Likert scale (RENSIS LIKERT, 1932) with five positions in the range between 1 and 5, with the following statements: 5 - always; 4 - almost always; 3 - from time to time; 2 - rarely; and 1 - never.The statements were related to the behavior or to the facts in which authentic leadership was envisaged and regarding to the environment, that of an authentizotic organization.The Authentic Leadership Questionnaire was composed of sixteen factors that assess the main characteristics attributed to authentic leadership: self-awareness, relational transparency, internalized moral perspective and balanced processing, as follows.

Do the leaders say exactly what they think ?; Do they encourage others to say what they think ; Do they admits their mistakes?;Do they tell the hard truths?; Do they show emotions that correspond to what they feel ? ; Are their actions consistent with their beliefs? ;Do they take decisions based on their core values?; Do they ask me to take positions according to my core values? ; Do they make difficult decisions based on high ethical standards? ; Do they ask me for points of view that question their deepest positions? ; Do they analyse relevant information before making a decision? ; Do they listen carefully to different points of view before drawing conclusions? Do they seek to obtain information (feedback) from people in order to improve interactions with them? ; Do they have a clear sense of how others view their abilities?   Do they know when it is time to reevaluate their positions on important issues? Do they understand how their actions impact others? (This is questionnaire is an adaptation from Walumbwa (2008)

Along with the Authentic Leadership questionnaire, 21 questions related to authentizotic organizations were incorporated through a measure according to the structure proposed by Rego and Souto (2004). For example, Do people feel that they are assigned important responsibilities? In order to progress in their career, it is necessary to sacrifice family life?  Is there  a great team spirit? Can employee put creativity and imagination at the service of work and of the organization. Does the organization help people to reconcile work with family life.? Do the the superiors keep their promises ? Do people feel eat ease showing that they disagree with the opinions of their superiors? When good results are obtained thanks to the efforts of employees, are the "laurels" (eg rewards and praise) distributed only to a small number of managers ? Is the organization  concerned with reconciling work and family responsibilities? Do people feel that they can learn continuously.?(These questions were an adaptation from n from Rego andSouto (2004).

## V.    SOME CONCLUSIONS

Considering the statistical analysis, we can say that the company has an authentic leadership at a level of 3.78 on a scale of 1 to 5. The closer to 5, the closer it is to authentic leadership. 3.78 means at a level higher than 50% of the average, which would be 2.5, halfway between 1 and 5. The company may offer an authentizotic environment because the average was 3.68, when the highest score would be 5. However, it can be inferred that 3.68 is 47% above 2.5, which is the middle point between 1 and 5.

Although the company is family-owned and run by family members, the perception is that its leaderships are authentic and there is a healthy atmosphere within the organization. Normally, family businesses, as they conduct themselves in a non-professional manner, may have an environment that priveleges some and disconsiders others, which, in a way, would not lead to a healthy atmosphere. It is clear that in this company, in its third generation, employees, who are leaders, perceive their superiors as authentic and that they are, therefore, reliable, give them feedback, and act transparently. Additionally , this form of leadership leads to the company having an atmosphere in which employees are committed to seeing the company as an extension of their life purposes.

Moreover, we consider that it is very important to research on a company´s history, to honour the effort of the founder of the company and stimulate young entrepeneurs to learn about the importance of authentic leadership and of ethics if one needs to progress as a company .

## REFERENCES

[1] Avolio, B. J.; GARDNER, W. L.; WALUMBWA, F. O (2005). Authentic leadership development: Emergent trends and future directions. Authentic leadership theory and practice: Origins, effects, and development, p. 387-406,.

[2] Bass, B. M. (1985) Leadership and Performance. New York: Free Press .

[3] Bhindi, N.; Duignan, P (1997). Leadership for a new century: Authenticity, intentionality, spirituality and sensibility. Educational Management e Administration, v. 5, n. 1,

[4] Brief, A. P.; WEISS, H. M.(, 2002 ) Organizational behavior: Affect in the workplace. Annual Review of Psychology, v. 53, p. 279-307.

[5] Bunker, K. A. (1997) The Power of vulnerability in contemporary leadership.Consulting Psychology Journal: Practice and Research.

[6] Ferr, H; (2016) Bioestatística na Prática. Campinas: Unicamp

[7] Gelfand, M. J.; Erez, M.; Aycan, Z (2007)."Cross-Cultural Organizational Behavior". All UNF Research,.

[8] Fanon, Frantz (1990) *The Wretched of the Earth*. London: Penghin.

[9] George, B. (2003)Authentic leadership: Rediscovering the secrets to creating lasting value. New Jersey: John Wiley e Sons.

[10] Hodgkinson, G. P.; Healey, M. P (2008).Cognition in Organizations.Annual Review of Psychology.

[11] Kets de Vries, M. F. R.(2001)Criação de Organizações Autentizóticas: Bem-estar individual em sociedades vibrantes. RelaçõesHumanas, v. 54, n. 1, p. 101-111.

[12] Klenke, K (2007)Authentic leadership: A self, leader, and spiritual identity perspective. International journal of leadership studies, v. 3, n. 1, p. 68-97.

[13] Levering, R.; Moskowitz, M. (1983).The 100 best companies to work for in America.Fortune.

[14] Likert,, R.(1932) A technique for the measurement of attitudes. Archives of Psychology, v. 22, n. 140, p. 1-55.

[15] Luthans, F.; Avolio, B. J. (2003) Authentic Leadership: A Positive Development

[16] Memmi, Albert (1970). The Colonizer and the Colonized. London: Penguin Approach. In: Cameron, K. S.; Dutton, J. E.; Quinn, R. E. (Eds). Positive OrganizationalScholarship. San Francisco: Berrett-Koehler.

[17] Rego, A (2004). Organizações autentizóticas: Desenvolvimento e validação de um instrumento de medida. Estudos de Gestão.

[18] Rego, A.; Souto, S (2004).Development and validation of an instrument for measuring Authentizotic organizations. East Sussex: psychology press.

[19] StatSoft, Inc. (2007). STATISTICA (data analysis software system), version 8.0. www.statsoft.com.

[20] Terry, R. (1993) Authentic leadership. San Francisco: Jossey-Bass.

[21] Walumbwa, F. O et al (2008). Authentic leadership: Development and validation of a theory-based measure. Journal of management.

[22] Blog: CULTURE IQ blog." The Role of Leadership in Changing Organizational Culture". Avalible at https://cultureiq.com/blog/role-leadership-changing-organizational-culture/.Accessed on September 18th 2020.

# News production and the dangerous fake news noise

## Fernanda Couto Araujo

Specialization Lato Sensu, Rio de Janeiro – RJ, Brazil

*Abstract— Technological advances have propitiated the present Era, the possibility for all people to produce mass news. With globalization and technological evolution, there is also noise in communication: fake news. This work aims to address the challenge of producing information in the face of false news. The applied methodology was the bibliographic research, study of published works and investigation comparing the sources of false news with the publications of the correct sources.*

*Keywords— news, fake news, Communication.*

## I. INTRODUCTION

With the advent of the internet in the 60s and soon after the emergence of social networks, there was the possibility for people to communicate with the whole world instantly. The production of videos, photos and news, which previously belonged to the Journalist, is now possible for everyone, even before the professional fulfills his duty to inform society with investigated matters. From this point, the problem to be analyzed in this article arises: the fake news.

Great challenges face the art of producing information at a time when everyone is a content producer due to globalization and technological advancement. Anonymity and ease of access to news production brings with it the production of a lot of information that is not always true, often manipulative and without due investigation and sometimes the result of post replies without even checking the source or comparing it to others.

Fake news is gaining more strength than the very veracity of the facts. It is more concerned with producing fast content than if it is actually sustained by content consumers who read and replicate them as if they were true, sometimes because of the urge to be one of the first to publish.

In this article the danger of the fake news effect in the production of news, information will be addressed. The role of the communicator, the content producing agent, the consumer and their responsibility for information will be addressed, highlighting the importance of investigating and taking a broader view of the fake news danger. During the study, examples of fake news will be exposed, in contrast to credible information and the dangers arising from its use.

## II. NEWS PRODUCTION AND THE DANGEROUS FAKE NEWS NOISE

Communication is a fundamental part of living beings. Everyone has their way, even if biological, of communicating. The human body, for example, communicates with each other for proper functioning. The human race stands out for having a more developed intelligence of communication in relation to other living beings. As a social being, communication becomes fundamental to humanity.

But what is news in communication? According to Mário Wolf, in the book "Theories of communication", it is the facts that, due to their degree of importance, arouse interest in information consumers. Today, with globalization and technological advancement, information often turns into news without actually being true due to consumer anxiety driven by the pleasure of novelty.

The historian Jean Lacouture points in his book "The immediate history", to the danger of the excess of existing sources on the internet: "he places his study as a stairway along the wall, the wall of the event. He needs to climb quickly on it, to probe a just throw, discover quickly, express yourself in a kind of rapture, hurry and ardor "(LACOUTURE, 1998, p.225). It is important for the replicator, consumer or even communication professional to check the various sources that talk about

the same subject, to investigate, research your reliability before replicating or taking the matter as doable, real.

The art of informing, reporting, must strive for the search for faithful information, trying to be impartial in an attempt to reproduce the truth of each fact, reaching the maximum neutrality as stated by the mirror theory classifying journalism as a reflection of the truth or faithful reproduction of same (PENA, Felipe. Theories of Journalism, 2005). The importance of the investigation became very latent with the popularization of false news, fake news. As stated by Gradim (2005, p.5):

*[...] making your professional activity select, verify, and transmit information with impartiality and veracity, remains identical in relation to the core duties of journalism. Even if the means available have definitely changed, and the way in which the content is presented - the traditional journalistic genres - is itself changing.*

Although fake news has been around since the man first came out and communicated, the term was used most often in 2016 during elections in the United States, in which Donald Trump was elected president, as published on the world education website. According to the website, some specialized companies have identified a number of dubious content, most exploring sensationalism involving important people like Trump's opponent Hillary Clinton.

Today, Brazil is one of the countries with the largest number of production and circulation of fake news in the world according to Pablon Ortellado, professor at the University of São Paulo, in an interview with Veja Magazine (Pablo 2018) apud Review: Cruz Junior, Gilson: Pós Verdade the new war on facts in times of fake news. According to the Dfndr lab website, based on the total smartphone users in the country released by the Brazilian Institute of Geography and Statistics (IBGE), around 8.8 million people had been attacked with fake news and 95.7% were through whatsApp. The term post-truth, mentioned above, shows the value that society has given to new information and news without regard to the importance of their veracity.

## III.  EXAMPLES OF FAKE NEWS VERSUS FACTS

During the 2018 elections, the false news that candidate Fernando Haddad had created and would disseminate in schools a gay kit inducing children to be gay, according to the defamators, was disseminated and widely disseminated.

### Education

### Dilma Government: 'Gay kit' will be reformulated and released by the end of the year

By Nathalia Goulart access_time 16 Oct 2018, 18h49 - Posted on 27 May 2011, 14h53



Haddad says 'gay kit' will be distributed to schools that have already registered a case of homophobia (Marcello Casal Jr / ABr / VEJA / VEJA)

**Education Minister Fernando Haddad said on Friday in São Paulo that the controversial anti-homophobia kit will be overhauled and sent to public school teachers by the end of this year.**

In his Twitter, Haddad posted the link newspaper O Globo, refuting false information, published by the candidate at the time, Jair Bolsonaro, current President of Brazil.

For the umpteenth time Bolsonaro is denied: It's #FAKE that Haddad created a 'gay kit' and that Câmara held a children's LGBT seminar https://oglobo.globo.com/fato-ou-fake/e-fake-que-haddad-criou-kit-gay-que-camara-held-seminar

lgbtinfant23197396?  utm_source = Twitter & utm_medium = Social & utm_campaign = share

41.1 thousand 07:08 - Oct 30, 2018

Information and privacy on Twitter Ads

G1 among other means of communication also disseminated the true information combating the false information:

**It's #FAKE that Haddad created a 'gay kit' for six year olds**

'Gay kit' is the nickname of the 'School without homophobia' project, aimed at educators and not children; book 'Aparelho Sexual e Cia' was not part of the project and was not used in schools.

By G1

16/10/2018 14h51 Updated 4 months ago

As published on the G1 website, the so-called "gay kit" was part of the Escola sem Homofobia project, which, in turn, was part of the federal government's Brasil sem Homofobia program in 2004. It was aimed at educating educators, and there was no provision for distribution of the material to students.

The publication below, from the Revista Veja website of January 30, 2019 shows the result of a false statement in a tragedy:

Brazil

**Firefighters: Fake news hinder searches in Brumadinho**

In an interview, the Fire Department spokesman said that 'fake news' delayed the work of recovering the bodies.

By **Newsroom**

30 Jan 2019, 17:48 - Published 30 Jan 2019, 17:21

Rescuers work on the fifth day of searching for victims after the dam burst in Brumadinho (MG) - 01/29/2019 (Rodney Costa / picture alliance / Getty Images)

In the above report, the fire brigade spokesman, Pedro Aihara, said that when they are called upon by information from survivors in the region, firefighters have to go back and check whether or not at the suggested location there was someone who resisted the tragedy. , and when the news is false, it disrupts the service.

Another example was the disclosure of the WTOE 5 News website about Pope Francis supporting the Donald Trump campaign, which was quickly replicated through facebook, generating controversy:

**Pope Francis shocks the world, endorses Donald Trump for the president, releases the nomination**

**TOPICS: Pope Francis Endorses Donald Trump**



Photo by Jeffrey Bruno / CC BY-SA 2.0 / cropped & photo by Gage Skidmore / CC BY-SA 3.0 / cropped

VATICAN CITY - Worldwide news reports from around the world report the news that Pope Francis made the unprecedented decision to endorse a US presidential candidate. His statement in support of Donald Trump was released from the Vatican tonight:

*"I have been hesitant to offer any support to any of the candidates in the US presidential election, but now I feel that not expressing my concern would be an abandonment of my duty as the Holy See. A strong and free America is vitally important to maintaining a world strong and free and, in that sense, what happens in the American elections affects us all. The rule of law is the backbone of the American government as it is in any nation that fights for freedom and I now fear that the rule of law in America has suffered a dangerous blow. The FBI, in refusing to recommend the prosecution after admitting that the law has been broken on several occasions by Secretary Clinton, has exposed itself as corrupted by political forces that have become too powerful. Although I do not agree with Mr. Trump on some issues, I feel that voting against the powerful political forces that have corrupted the entire US federal government is the only option for a nation that wants a government that is truly for the people and the people . For that primary reason, I ask, not as the Holy Father, but as a concerned citizen of the world that Americans vote for Donald Trump for the President of the United States. "*

This alleged endorsement of Pope Francis to Trump originated on the website WTOE 5 News and was denied to the online newspaper National Catholic Reporter by Pope Francis himself at a long press conference aboard the Pope's flight to Rome on October 2:

Francis urges US Catholics to vote for his conscience in the November elections

October 2, 2016



Pope Francis answers a reporter's question about the U.S. presidential election on board his flight from Baku, Azerbaijan, to Rome on October 2. On the left is Father Mauricio Rueda Beltz, planner of the papal journey; on the right is Greg Burke, the new Vatican spokesman. (CNS photo / Paul Haring)

**Of Joshua J. McElwee - Vatican**

**ABOARD THE PAPER PLAN OF AZERBAIJAN** - Pope Francis advised US Catholics to vote in the November presidential election to study candidates' proposals well, pray about it and then "choose in conscience".

*"I never say a word about election campaigns,"* replied the pope. *"People are sovereign. I will just say: Study the proposals well, pray and choose consciously."*

Here is another case reported by the website, the press observatory of false information that went viral, producing many negative repercussions on former deputy Jean Wyllys:

**We tracked the hashtag that spread fake news about Jean Wyllys**

**By Bruno Fonseca on February 13, 2019 in edition 1024**

Originally published by Agência Pública.

(Photo: Reproduction) By Bruno Fonseca.

Bruno Fonseca, a step-by-step research on where the first publication that generated all the fake on the figure of Jean Wyllys came from and publishes in an orderly manner what happened. According to the article, it all starts with the first record on the networks that brings the names of Wyllys and Adélio together one hour after the publication of the Folha de São Paulo interview that revealed that Jean would leave the country. The controversy begins at 3:48 pm, when a user of social networks named Ruth Coriar, shares a note from the Renova Mídia website, which replied Folha's interview, adding that "this story" of Wyllys' resignation was poorly told:



(Photo: Reproduction)

The publications followed this without much commitment until Milene Reis, at 16 hours and 49 minutes, with more than 12 thousand followers, among them the councilman Carlos Bolsonaro and the advisor of the president Filipe Martins, writes that the escape of Wyllys occurred after a video proving Adélio's visit to the Congress.



(Photo: Reproduction)

The story that Adélio was registered in the Chamber of Deputies on the day of the attack, was denied by the Chamber itself. In September 2018, the house reported that the registration system for Adélio's entry was an error by the receptionist at the concierge where the visitor identification system (Sivis) is accessed.

More and more people were sharing similar content:



(Photo: Reproduction)

Then, under the influence of Maria Rita Lopes' publication, the rashtag investigates Jean Wyllys, which then solidifies with endorsements from celebrities who support the hashtag.



(Photo: Reproduction)

(Photo: Reproduction)

The morning after the publication of the Folha report, criticism of Wyllys resurfaced in the form of the hashtag #InvestigarJeanWillis. Lobão was one of the first to use a hashtag against Jean Wyllys.



(Photo: Reproduction)

Lobão was shared by deputy Alexandre Frota (PSL), who had already been convicted of defaming Wyllys by publishing a false speech by the former deputy in which he would treat pedophilia as something normal.



(Photo: Reproduction)

Note that the fake news effect spreads like a snowball and descends like an uncontrolled avalanche causing damage, often irreparable, such as the case of housewife Fabiana Maria de Jesus, who died after being beaten by several residents of Guarujá in 2014, coast of São Paulo, for their revolt that confused them due to information published on a social network with a sketch of the possible kidnapper of children for black magic rituals. She was lynched to death (G1, May 5, 2014 publication for Mariani Rossi).

## IV.      FINAL CONSIDERATIONS

The purpose of this article was to demonstrate how fake news, now known as fake news, interferes in the process of communication, dissemination and transmission of information, using for this analysis content published on websites, social networks and newspapers, in contrast to the news correct, factual, true.

It was possible to obtain a brief notion of technological advances, their influence on the communication process and the rapid advance of news production and consumption in an instant, fast way and without any concern for the truth, only worth the novelty. The fake news force is perceived with the support of the post-truth, this maneuver used to create doubts about the veracity of some information that is currently used.

With the results presented, it was found that fake news is false news created and disseminated for various reasons, including issues of a social, political, defamatory nature, among others. In this study, it was observed the use of fake news as the main objective of taking the credibility of facts many times to denigrate someone or any idea for several reasons in detriment of the truth.

It was exposed that fake news is a subject, somewhat recent, but widely used in the Information Age and that its results are harmful to the truth, dangerous to human life, often with irreparable consequences. It was also exposed, through the confrontation between fake information and official and correct information, the need to always investigate and investigate before producing, replicating, reporting or producing information. Good communication depends on this.

Understanding the meaning of fake news, its harmful results and the importance of a concern with the truth in the construction of content at the expense of novelty has never been more important in an era called Information, but which consumes and publishes, on a large scale, many false or doubtful news.

## REFERENCES

[1]  WOLF, Mário. Communication Theories. Lisbon: Editorial Presença, 1955.

[2]  LACOUTURE, Jean. "The Immediate Story" In: LE GOFF, Jacques (org.) The New Story. São Paulo: Martins Fontes, 1988.

[3]  PENNA, Felipe. Theories of Journalism. São Paulo: Ed. Contexto, 2005)

[4]  D'ANCONA, Mathew. Post-truth: the new war on facts in times of fake news. Barueri: Faro Editorial, 2018.

[5]  GRADIM, Anabela. Third Generation Digital Journalism. Portugal: Federal University of Bahia, 2005.

[6]  https://mundoeducacao.bol.uol.com.br/curiosas/fake-news.htm

[7]  https://www.academia.edu/38121339/P%C3%93S-VERDADE_A_NOVA_GUERRA_CONTRA_OS_FATOS_EM_TEMPOS_DE_FAKE_NEWS

[8]  https://www.psafe.com/dfndr-lab/wp-content/uploads/2018/05/dfndr-lab-Relat%C3%B3rio-da-Seguran%C3%A7a-Digital-no-Brasil-Primeiro- quarter-of-2018-1.pdf

[9]  https://veja.abril.com.br/educacao/kit-gay-sera-reformulado-e-lancado-ate-fim-do-ano-diz-haddad/

[10]  https://oglobo.globo.com/fato-ou-fake/e-fake-que-haddad-criou-kit-gay-que-camara-realizou-seminario-lgbt-infantil-23197396?utm_source=Twitter&utm_medium=Social&utm_campaign= to share

[11]  https://g1.globo.com/fato-ou-fake/noticia/2018/10/16/e-fake-que-haddad-criou-kit-gay-para-criancas-de-seis-anos.ghtml

[12]  https://veja.abril.com.br/brasil/bombeiros-noticias-falsas-atrapalham-buscas-em-brumadinho/

[13]  https://web.archive.org/web/20161115024211/http://wtoe5news.com/us-election/pope-francis-shocks-world-endorses-donald-trump-for-president-releases-statement/

[14]  https://www.ncronline.org/news/vatican/francis-tells-us-catholics-vote-their-conscience-november-election

[15]  http://g1.globo.com/sp/santos-regiao/noticia/2014/05/mulher-espancada-apos-boatos-em-rede-social-morre-em-guaruja-sp.html

# Evaluation of Quality of Life at Work in a Third-Party Company

Weder Ferreira dos Santos[1*], Laura Carneiro Silva[2], Magno De Oliveira[1], Layanni Ferreira Sodré[1], Joênes Mucci Pelúzio[2], André Felipe da Silva[1], Zildiney Dantas da Silva[2], Giselle Ferreira Sodré[1], Osvaldo José Ferreira Junior[2], Thaís Alves da Silveira Lourenço Borges[2]

[1]Department of Bioprocess Engineering and Biotechnology, Tocantins Federal University, Chácara 69-72 Rua Badejos, Lote 7 s/n - Jardim Sevilha, Gurupi - TO, 77404-970, Gurupi, Tocantins, Brazil
[2]Agronomy Department, Federal University of Tocantins, Chácara 69-72 Rua Badejos, Lote 7 s/n - Jardim Sevilha, Gurupi, 77404-970, Tocantins, Brazil
*Corresponding Author

*Abstract— The Quality of Work Life (QWL) is strictly related to satisfaction of employees and the function he/she plays in a company. In this way, QWL should is handled within an institution/company in order to provide a better work environment and conditions to staff. Despite this, many Brazilian institutions still do not exploit QWL to improve productivity. Besides that, they tend to underestimate such a tool due to its association with workers' satisfaction. The present study had the aim of evaluating the QWL within an outsourcing company, taking into account the employees' points of view. There were applied 13 questionnaires, randomly distributed among collaborators, in July 2017. For this, the questionnaires contained 24 questions, where 17 of them were distributed into five different satisfaction dimensions. The level of satisfaction was classified as high, average, and low, for each one of the dimensions. The results, obtained from the questionnaire, were exhibited through figures. The verification of satisfaction pointed to some of the company's weaknesses, considering that the level of satisfaction of some dimensions was qualified as average.*

*Keywords— QWL, administration, dimensions.*

## I. INTRODUCTION

The quality of life at work (QWL) became a topic of extreme relevance after the industrial revolution, with the implementation of Taylorism and Fordist models when the well-being of workers within companies became of interest not only to those but for the productivity of the industry itself [1].

Despite this, there is no concept defined for QWL, but only a notion of its correlations [2]. Li & Yeo (2016) [3], for example, they claim that QWL is related to the pleasure and well-being of employees in the workplace. While Boas (2017) [4] e Gómez-Salcedo et al. (2017) [5] recognize QWL as a multidimensional notion, as they encompass aspects such as cooperative relationships with supervision, benefits, personal fulfillment, safety at work, among others.

Therefore, the evaluation of QWL is essential to determine which factors, within the organization, to maintain high QWL, and to establish the magnitude of employee satisfaction. Consequently, a company that has access to this type of information is able to drive its resources and priorities in an Optimized way, focusing on the dimensions of QWL and providing a more comfortable work environment for its employees [6]. Thus, the measure of employee satisfaction, in relation to the dimensions of QWL analyzed, would indicate the order of importance of their investment, thus allowing employees to increase their productivity.

QWL has been studied in different areas, such as: oil and gas industry [7], hospitals [8], academic field [4], telemarketing companies [9], among others [10-14]. So that the analyses are carried out based on the employee's view of the company or public agency of which he is part.

Although concern QWL is present in diversified sectors, studies related to QWL in outsourced companies are still scarce [15]. Outsourced companies aim at the benefits that can be purchased at the lowest possible cost, often without realizing what this can bring to their employees. Therefore, it is common to find employees who work under minimum working conditions, the constant fear of layoffs and, consequently, low productivity [15, 16 ]. Thus, demonstrating a lack of interest in the QWL of employees of service companies.

In view of the above, the present study aimed to evaluate QWL in a third-party company in the Tocantins taking into account the point of view of employees. Additionally, the level of employee satisfaction was analyzed in relation to aspects of QWL, evidencing the factors of this one that required greater supervision and correction within the organization.

## II. MATERIAL AND METHODS

We applied 17 questionnaires, containing 24 questions each, to evaluate QWL in a third-party company in the State of Tocantins. Where the questions covered the following points: 1. Sex; 2. Age group; 3. Civil state; 4. Schooling; 5. Income; 6. Working time in the company; 7. If the service provided is outsourced; 8. Supply of benefits (transport/food); 9. Increased financial benefits along with the company's growth; 10. Company concern with QWL; 11. Satisfaction with workload; 12. Company treatment for employees; 13. Existence of benefits beyond food and transport; 14. Exemplifying the benefits; 15. Desired benefit; 16. Meeting personal expectations; 17. Presence of occupational risk; 18. Providing support to the employee's health in the event of harm caused to the detriment of work; 19. Supply of safety equipment; 20. Incentive in the participation of training courses; 21. Autonomy to dictate the rhythm/form of work; 22. Consistency of the work process; 23. Relationship with supervision; 24. Trust and security in the company.

The selection of employees was randomly given. However, their profile was as follows: men (58%) and women (42%); with a predominant age group between 35 and 59 years (67%), but other age groups were considered - between 25 and 34 years (8%) and between 18 and 24 years (17%). It is important to highlight that all employees provided outsourced services.

Regarding the level of education, the elementary, complete high school, incomplete and complete higher education was considered, the proportions obtained for this parameter were 25%, 17%, and, for marital status, 58% were married, 33% single, 8% were divorced. Half of the

interviewees had salary income between 1 and 3 minimum wages, 42% of them received up to 1 minimum wage, and 8% had an income of 3 to 6 minimum wages. Half of these people worked in the company evaluated for a time between 7 and 10 years, 25% to less than 1 year, 17% between 4 and 6 years, and 8% between 1 and 3 years.

The questionnaires contained 17 other questions, which were framed in 5 different dimensions to measure the following aspects of the company: satisfaction with the relationship with supervision (questions 10, 12, and 23); satisfaction regarding the level of security/confidence in the company (items 18, 19 and 24); satisfaction with respect to the benefits provided by the company (questions 8, 13, 14 and 15); intrinsic satisfaction to work (questions 11, 17, 20 and 22); and satisfaction with the participation of the employee in the company (questions 9, 16 and 21) [17].

To determine the level of satisfaction, scores were awarded to each of the answers, so that those that were more positive for the company would receive the highest score [17]. The score gradually decreased to the response option that represented the negative sides of the endearing for the factors evaluated. The options "do not know" and "did not open" received a score of 0 (zero), because they did not affect employee satisfaction with the company in a negative or positive way.

The satisfaction of employees in relation to the company was also classified at levels (high, medium, and low) for each of the dimensions. The deliberation of the levels was given as follows: the highest possible score was analyzed for the dimension considered and, from this, the percentages of 70% and 50% were determined. When the score reached for that level corresponded to 70% or more of the maximum score, the level of satisfaction was considered high. In the range between 50% and 70% of the maximum value allowed for the dimension to be analyzed, the level of satisfaction was given as average. And for scores below 50%, the level was considered low.

Through this questionnaire, the data were collected for the present research, the information is taken by the form of manual tabulation, were, all questions are closed, processed statistically, and represented by percentages expressing consistency, where their treatment was done through the Microsoft Excel 2010 program, demonstrated through figures.

## III. RESULTS AND DISCUSSION

The initial questions presented in the questionnaire (1-7) were intended to substantiate the profile of the

interviewed employee, for this reason, no statistical analyses were performed on these items. The first statistically considered question was number 8. Of the

interviewed collaborators, 92% stated that they received some beneficial (Fig. 1), mainly food aid, according to what was mentioned in question number 14.
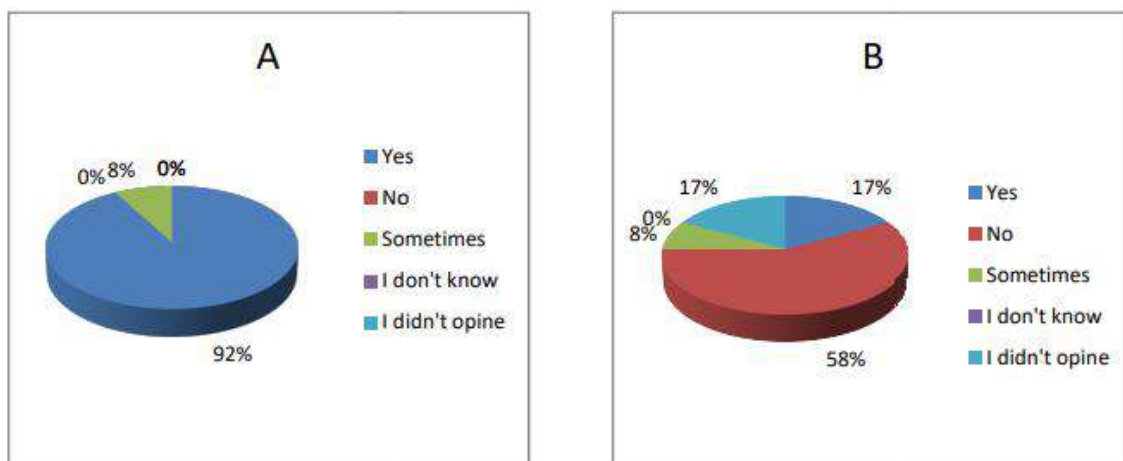


*Fig. 1 - Representative of answers to question 8 (A) and 9 (B).*

The profile of the operatives who affirmed the existence of benefits is, briefly, male, framed in an age group of 35-59 years of age, are properly married, have complete high school, are respectively 7-10 years in the company and their salary range is around 1-3 minimum wages. Despite most correspondents who answered "yes" to the question, all females are part of these (92%), indicating that there is no preferential treatment related to the gender of the employee. Of the 8% who answered "sometimes", males prevailed, along with single marital status, the income of 1 – 3 minimum wages, and with little time in the company (1-3 years). Demonstrating that supply may be tied to the taxpayer's company time.

Question 9 (Fig. 1), as can be seen, 58% of respondents said there was no increase in benefits, 17% said yes, another 17% did not open and 8% answered that sometimes the company provides more benefits. Considering that most of the answers were not, the profile of employees who stated that the benefits do not grow together with the company.

It was noticed that for this profile the highest fraction of these is male, presenting an age group of 18-24 and 35-59 years, are married, have complete high school, and are less than a year in the company. It is clear that newly hired women tend to state that they did not observe an effective increase in the benefits provided by the company, but

when comparing this with the profile of the previous question, it is observed that the same salary range was presented, but that they were in the company for more than 7 years. Therefore, it is correct to affirm that the non-growth of benefits is not strictly linked to young employees in the company, but it is a fact that should be considered generally within it.

Of the data obtained for the tenth question, we can affirm that 50% of workers consider the company flawed in this area, while 8% consider otherwise. Still, 17% said they sometimes realize that the company cares about QWL and 25% did not open (Fig. 2). The fraction that considers the company concerned about the quality of life of the operational, unlike the selfless, have been in the company for longer, collaborating to the interpretation that the quality of life of workers is not a major factor within the Company.

The profile of employees who stated "no", has representatives of both males and females, within an age group of 35-59 years, are married, have an only high school, and receive less than a single salary, are in the company for about 1-3 years. The high proportion related to the "did not opine" response leads us to think that most employees do not know what QWL itself is and the factors that can affect this parameter.
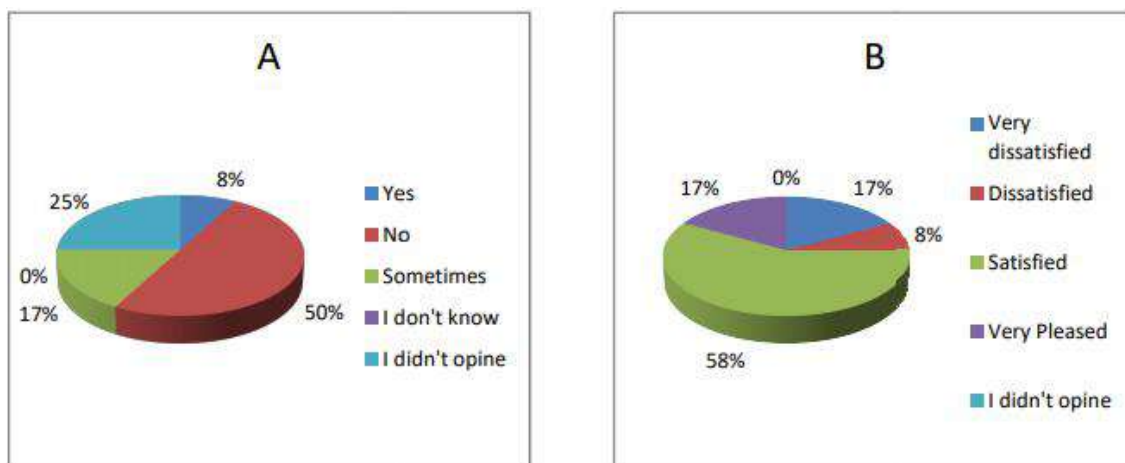
*Fig. 2 - Representative of answers to question 10 (A) and 11 (B).*

In sequence, it is observed for item 11 that most employees (58%) were satisfied, where 17% answered that they were very satisfied, (17%) said they were very dissatisfied and (8%) were dissatisfied with the amount of work given to them (Fig. 2). A profile of the collaborators for the responses of this item was outlined.

The profile of the operative who responded "very satisfied" is mostly represented by women, in the age group of 35-59 years, married, have complete high school, receive only one salary, and are approximately 10 years in the company. With this, and considering that the activity carried out by the majority of the company's taxpayers is related to manual labor, usually focused on cleaning environments, it is believed that the function of workers in conjunction with the age group a little leads to greater exhaustion of them when compared to employees who perform other functions in the company, such as repairs and safety.

For the next question (12), the vast majority (75%) replied that he is duly satisfied with the treatment given by the company. However, 9% were very dissatisfied,

followed by 8% dissatisfied, 8% did not open and no employee claimed to be very satisfied with the type of treatment. The profile of the employees as detailed in relation to the declared responses (Fig. 3).

The 75% who were satisfied with the company are mostly male, aged 35-59 years old, married, have a high school, and receive 1-3 salaries and work in the company for about 10 years. One reason that indicates the reason for such employee satisfaction is little contact with the representatives of the company's management so that they relate only to one coordinator, which reduces the pressure on employees.

On the other hand, of the very dissatisfied taxpayers, all were female, married, between 35 and 59 years old, with high school, receiving less than one salary, and working in the company between 7 and 10 years. Correlating this profile with the profile of the satisfied, it is noted that there may be preferential treatment within the company, favoring its relationship with male individuals.
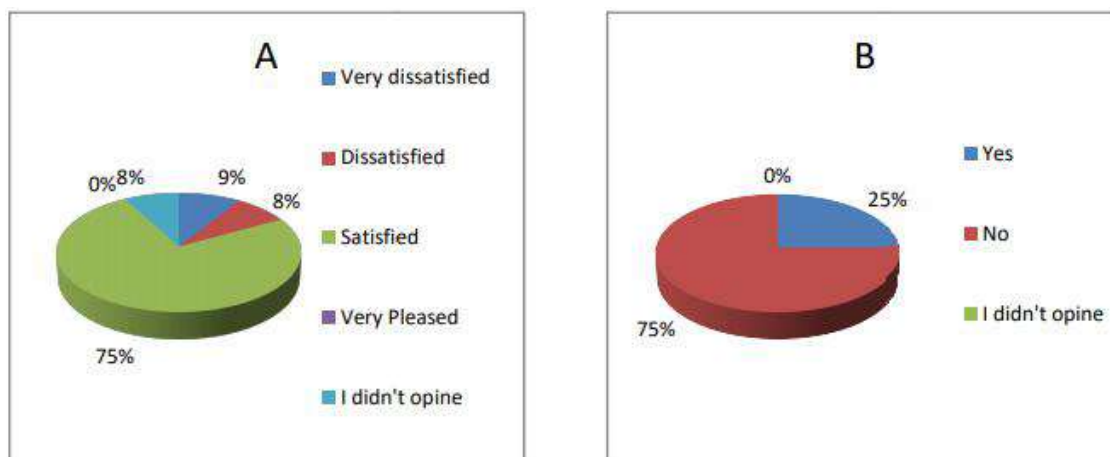
*Fig. 3 - Representative of answers to question 12 (A) and 13 (B).*

For question 13 (Fig. 3), the highest fraction of employees replied that no (75%), against 25% of those who answered yes. From the profile of those who claimed that the company does not provide such a type of benefit, there are employees of both males and females, both with higher representativeness in the age group of 35-59 years, married, with complete high school, receiving up to 3 minimum wages and in the company for 7-10 years. Of those who answered yes, they stated that the benefit received was worth the food, according to the answers of question 14, which corroborates the statistics of question 8.

Question 15 was related to question 13. Both taxpayers who answered "yes" in question 13 and those who answered "no", said they would like the company to provide health insurance and greater stability at work. The answer to the fifteenth question was interesting since the need for more stability at work may be tied to the fact that the company is outsourced, that is, the possibility of exchange occurs on the staff is too much High.

Regarding question 16, about 42% of respondents said that sometimes these expectations are met, 25% stated that their expectations people are not met, while 33% stated otherwise (Fig. 4). The profile of the collaborators shows that the group that answered "sometimes" is composed mostly of male individuals, receiving from 1 to 3 salaries, while the other parameters (marital status, schooling, age group) remained balanced, however, in agreement with the general profile of the interviewed collaborations, the highest number was for the age group of 35-50 years, married and with complete high school.

For the group of 33%, the profile was balanced for sex but proved to be higher for married employees and with complete high school, the rest of the parameters were balanced among all possibilities. For the group that claimed "no", the profile is of a majority female, 35-59 years old, 4-10 years old in the company, and the other factors were also equivalent. Therefore, it was noticed that men were more accomplished than women, corroborating the possibility of special treatment by the company.
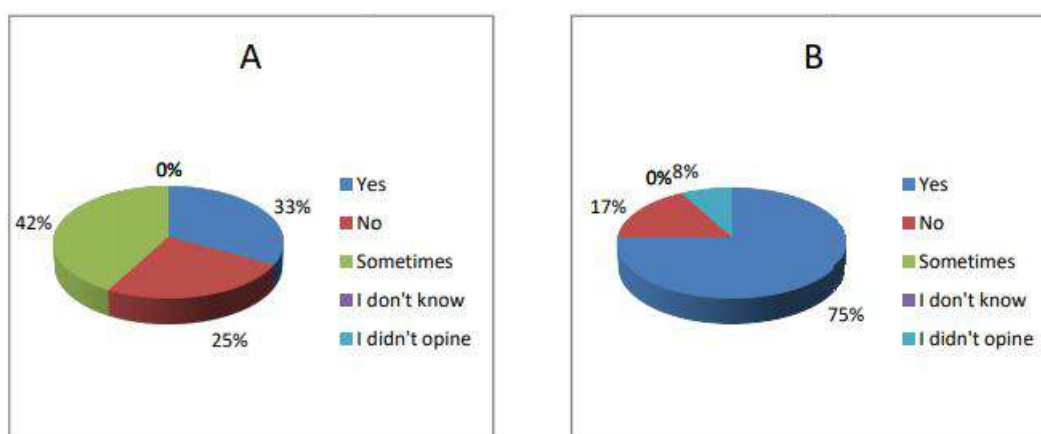


*Fig. 4 - Representative of the answers to question 16 (A) and 17 (B).*

Analyzing the profile of question 17 (Fig. 4), we have that majority who answered yes (75%) it is male, which performs functions within the company that is at higher risk, and, consequently, have a greater tendency to suffer health disorders due to chemical, biological, physical and ergonomic risks. The latter may be related to the service time, from 7 to 10 years, which was the profile that stood out in this questioning, confirming then that there are risks linked to the function performed. Those who gave other answers to this question are mostly male, and due to the function performed by these employees, the probability of health risks is reduced for this public.

In view of risk situations (question 18), the majority (33%) stated that the company offers support if the employee has its health compromised due to the work performed. The profile of the interviewees is divided between males and females and with longer working time, which generates some security regarding the response due to greater knowledge about the company's policies. 16% stated that the company does not take action if any damage to health occurred was both male and female, excluding the possibility of preferential treatment (Fig. 5).
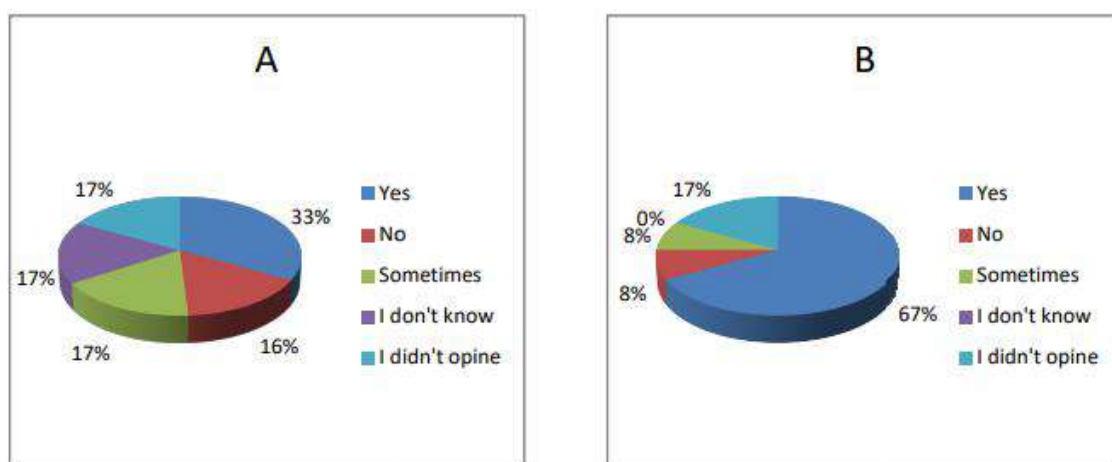


*Fig. 5 - Representative of answers to question 18 (A) and 19 (B).*

As for question 19, 67% of employees answered that the company offers safety equipment (Fig. 5), indicating that there is concern about possible accidents that can happen. The profile of this group indicates that the majority are female, pointing again to the function performed by these collaborators in relation to the activity performed by male collaborators. This group also has the following characteristics: 35-59 years old, married, with complete high school, receiving less than 1 minimum wage, and in the company between 7 and 10 years. 8% replied that equipment is not offered and another 8% stated that sometimes this type of resource is provided by the company. The remaining 17% of taxpayers decided not to give an opinion, probably due to the lack of knowledge about this appeal.

In item 20 (Fig. 6), the company leaves to be desired, since most employees (87%) claim that there is no incentive. We can observe in this result that the company is not willing to improve the level of training of its employees, promoting the search for knowledge, in order to improve the services provided by them, so that the company also grow and better serve your customers. This item also fits the question of employees' personal expectations, because if they are really happy to work in the company, this company should invest in improving their knowledge.
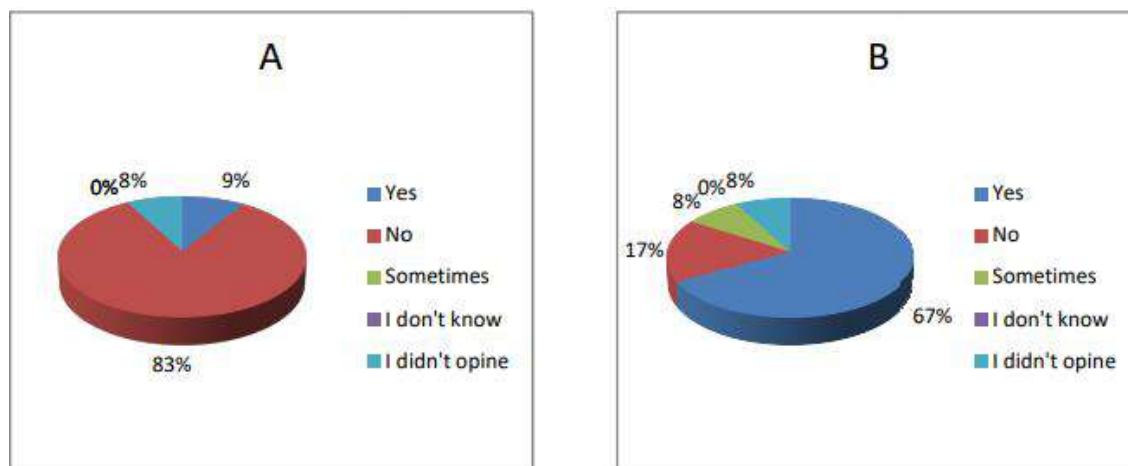
*Fig. 6 - Representative of answers to question 20 (A) and 21 (B).*

As for the way of work (question 21 and 22), employees claimed to have freedom and autonomy to determine how their work will be carried out, so they also claim that the organization of their work is effective and coherent, meeting the objectives Expected. The profile of employees for question 21 (fig. 6) shows that 67% of employees who answered "yes" are male, aged 35-59 years, married, with complete high school, receiving 1 to 3 minimum wages, and with 7-10 years of the company.

Those who answered "no" are the female majority, also between 35-59 years of age, having only elementary school, receiving up to 3 salaries, and working in the company in the range of 7 to 10 years. This states that men have greater autonomy than women, falling again on the issue of the treatment of collaborations within the company.

For question 22 (Fig. 7), 58% of employees stated that the work is given consistently, these are of a male majority, receiving up to 3 minimum wages, between 35-59 years, married, high school, and in the company from 7 to 10 years. It is important to highlight that no one has stated that the workload is incoherent; indicating that the company divides employees' work in order to avoid possible health risks and probably rotate between them.

17% of taxpayers claimed that sometimes work is coherent, they were represented by both sexes, with all other balanced aspects, except for the age group that was divided between employees aged 18-24 and 35-59 years of age.
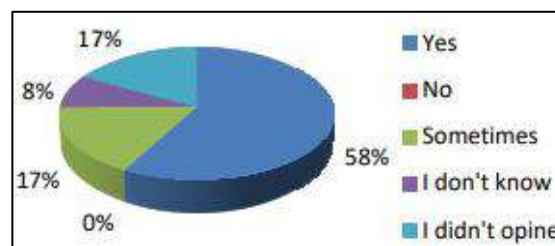


*Fig. 7 - Representative of answers to question 22.*

Question 23 addresses the professional relationship employees have with their supervisors (Fig. 8). About 50% of respondents said they are satisfied with their supervisor, and 42% are fully satisfied, which leads to understanding that they have good professional relationships. We can bring back what has been exalted in previous issues that employees are not in direct contact with superiors, only with a supervisor, which can smooth supervision relationships with them.

*Fig. 8 - Representative of answers to question 23 (A) and 24 (B).*

The profile of satisfied employees shows that they are both female and male, and the rest of the characteristics are similar to those of all generally interviewed collaborators: 35-59 years old, married, complete high school, from 7 to 10 years in the company, and receive up to 3 salaries. Of the very satisfied, all parameters presented equivalents, except for marital status, which concentrated on married and single.
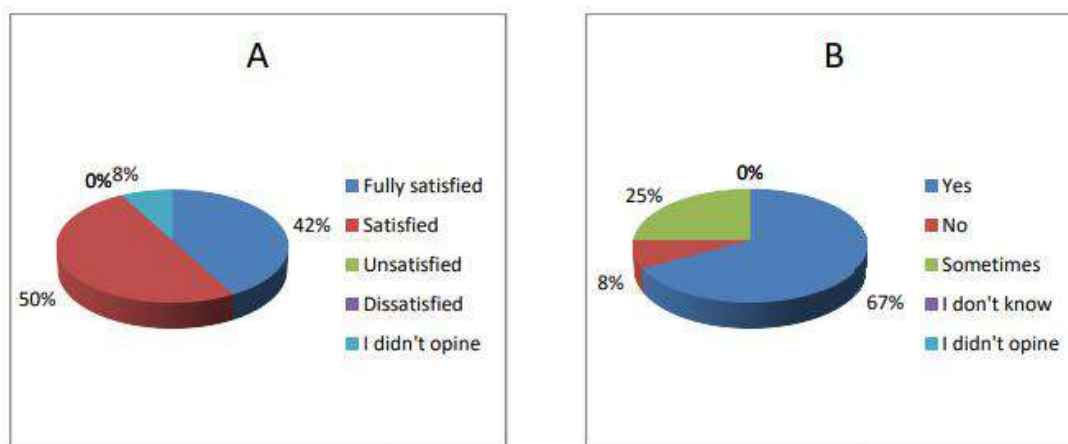
The profile of satisfied employees shows that they are both female and male, and the rest of the characteristics are similar to those of all generally interviewed collaborators: 35-59 years old, married, complete high school, from 7 to 10 years in the company, and receive up to 3 salaries. Of the very satisfied, all parameters presented equivalents, except for marital status, which concentrated on married and single.

*Table I - Level of employee satisfaction in relation to the five dimensions considered.*

| Dimension | Level of Satisfaction | Score |
|---|---|---|
| Benefits | High | 25-36 |
| Intrinsic to Work | Middle | 19-26 |
| Relationship with Supervision | Middle | 22-30 |
| Safety at Work | High | 25-36 |
| Participation in the Company | Middle | 18-24 |

Regarding the satisfaction of employees regarding the benefits provided by the company, it was possible, to observe that they were highly satisfied (Table I). To define the satisfaction of this dimension of QWL, the results

obtained for questions 8 and 13 were considered, so that the average score obtained for this item remained within 70% of the maximum score allowed for the dimension of benefits. Therefore, the company should present greater concern and investment in the dimensions that showed lower level, however, should not let the level of employee satisfaction be reduced because it helps in maintaining workers' productivity.

For what is related to the intrinsic to the work, questions 11, 17, 20, and 22 of the questionnaire were taken into account. The average score obtained for the intrinsic dimension to the work showed a value between 50% and 70% of the maximum allowed score, revealing that the level of satisfaction of the employees, regarding this dimension of QWL, is average (Table I). Therefore, the company studied should make more efforts to improve the working situation of its co-workers. In this way, they would perform their function with greater pleasure and satisfaction, which can lead to an increase in the productivity of the company itself.

For the dimension associated with the relationship of employees with supervision, items 10, 12, and 23 were considered. From this, it was possible to establish the average satisfaction of employees with supervision, since the average score obtained for this dimension belonged to the range of 50-70% of the maximum allowed score (Table I). As well as for the dimension of intrinsic to work, the relationship with supervision needs to undergo changes that ensure a more comfortable work environment, which, consequently, would eventually raise QWL within the company studied.

The dimension that deals with safety at work, on the other hand, showed that employees were highly satisfied with the measures adopted by the company because the average score was established above 70% of the total

allowed (Table I). This dimension comprised questions 18, 19, and 24. Therefore, the company must continue with the security measures being employed, and not let the satisfaction of this dimension, which is extremely important, decays.

Finally, the level of employee satisfaction in their participation in the company in question was evaluated, the result indicated that the level of satisfaction for this dimension was average (Table I). Therefore, measures are necessary to improve the QWL of employees within the company, such as a method to increase the participation of employees would make them shareholders of this company or also increase wages according to growth more autonomy to define the pace/form of execution of the work, and even seek to meet some personal expectations of employees within the company. Items 9, 16, and 21 of the questionnaire cover these points or measures that have been implemented in the company.

## IV. CONCLUSION

From what was exposed, the level of employee satisfaction was verified in relation to 5 aspects of the company.

Some of these dimensions pointed out where the company's weaknesses are in relation to employees because their level of satisfaction was average.
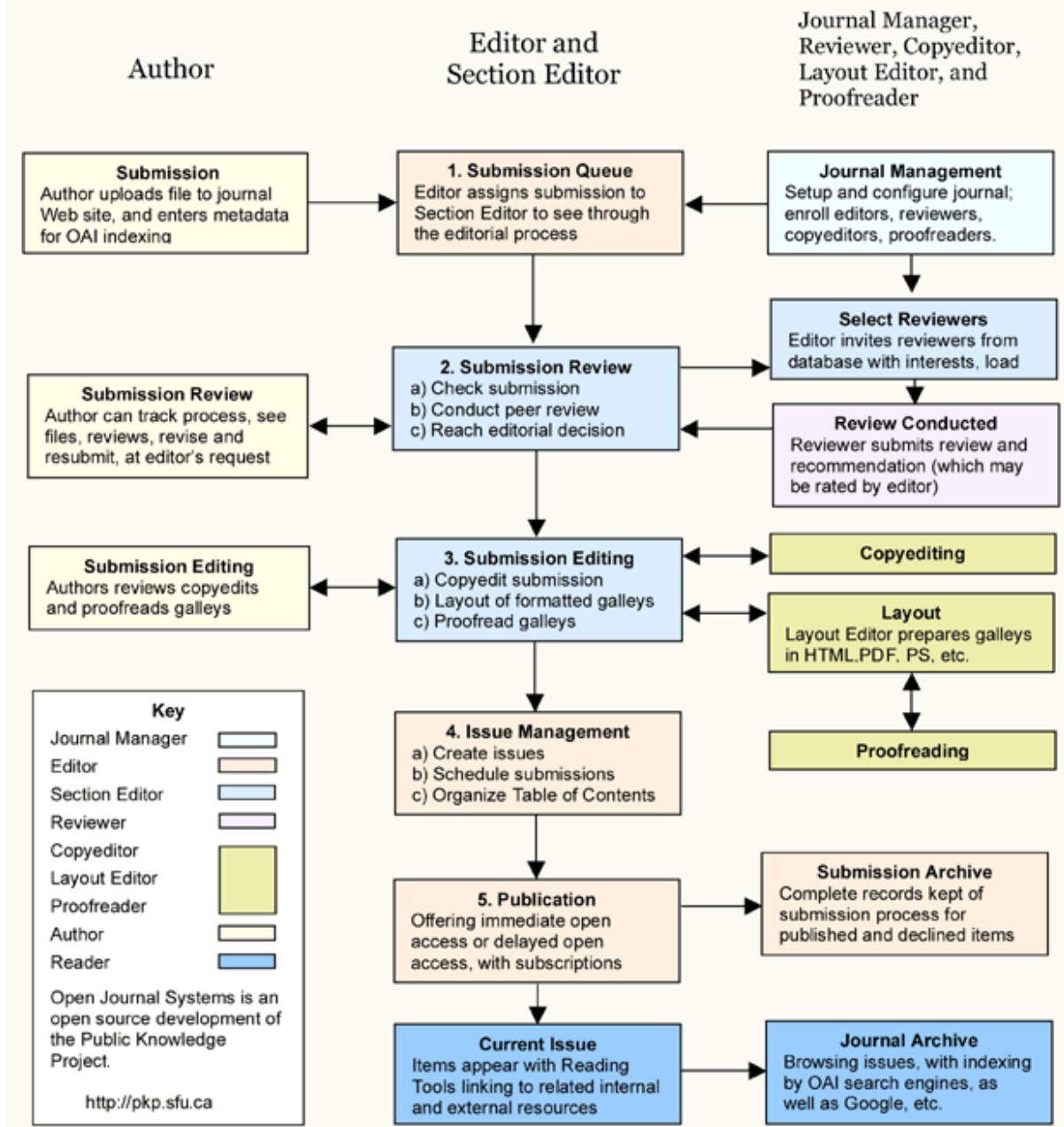
The company should improve the relationship between supervision and employees.

There is dissatisfaction with the benefits of the female.

## REFERENCES

[1] SOUSA, E.; NETO, J.V.G.; OLIVEIRA, I.V.; BARBOSA, R.F. (2014). Analysis of the quality of life at work and satisfaction of employees of a service provider company. Innovation and Technologies, Magazine, 3(4), 1035-1045.

[2] MONTEIRO, J.R.; SANTOS, J.W.X.M. (2017). Quality of life at work: a study with employees and interns in fada's administrative sector. Revista Formadores - Vivências e Estudos: Caderno de Gestão e Negócios, 10(3), 22-44.

[3] LI, J.; YEO, R.K. (2016). Quality of work-life and career development: perceptions of part-time MBA students. Employee Relations, 33(3), 201-220.

[4] BOAS, A.A.V.; MORIN, E.M. (2017). Quality of Life at Work: A Systemic Model of Analysis. Revista Administração em Diálogo, 19(2), 62-90.

[5] GÓMEZ-SALCEDO, M.S.; GALVIS-APONTE, L.A.; ROYUELA, V. (2017). Quality of Work Life in Colômbia: Um indicador difuso multidimensional. Pesquisa de Indicadores Sociais, 130(3), 911-936.

[6] SANTOS, F.A.G. 2011. Qualidade de vida no trabalho: análise da situação dos funcionários de uma agência bancária. https://www.lume.ufrgs.br/bitstream/handle/10183/77389/000879892.pdf?sequence=1

[7] MENDONÇA, M.A.; TIME, H.R.M.; COSTA, H.G.; MONTEIRO, G.T.R. (2014). Quality of life at work in the oil sector: a comparison between onshore and offshore employees. Brazilian Journal of Quality of Life, 6(2), 115-129.

[8] BARBOSA, F.L.S.; BIZARRIA, F.P.A.; NETO, A.R.; MOREIRA, R.N. (2016). Multidimensional view of job satisfaction: a study in a public hospital in Piauiense. REGE - Revista de Gestão, (23), 99-110. https://doi.org/10.1016/j.rege.2015.01.001

[9] TAKAHASHI, L.T.; SISTO, F.F.; CECILIO-FERNANDES, D. (2014). Assessment of vulnerability to stress in the work of Telemarketing operators. Revista Psicologia Organizações e Trabalho, 14(3), 336-346.

[10] BLAUSIUS, D.G. (2015). Turnover: a case study in the clothing industry in Santa Catarina. Criciúma: UNIESC.

[11] CRUZ, F.M.F. (2015). Quality of Life at Work: a study of the perception of employees of the National Land Transport Agency (ANTT). Brasilia: FATECS.

[12] ESTEVES, M.L.; SILVA, S.S.; ALIGLERI, L.M. (2007). Strategic management of social responsibility: the case of wholesale and foreign trade companies in the Southern Region of the country. FAE Magazine, 10(1), 19-26.

[13] HARIHARANPUTHIRAN, S.; VIVEKANANDHAN, R. (2015). Um estudo sobre qualidade de vida profissional no setor de BPO com referência especial a Chennai. Jornal de Avanços em Gestão de Negócios, 1(3), 174-179.

[14] PADMINII, K.; VENKATRAMARAJU, D.; BRINDHA, G. (2016). Um estudo sobre a qualidade das mulheres empregadas na transcrição médica. Jornal de Gestão da Saúde, 18(1), 13-20.

[15] PEREIRA, M.R.; JUNIOR, L.S.S.; NETO, E.R.C.; SILVA, B.G.F.; PEREIRA, M.M.P. (2016). Public Universities and the outsourcing of services: analysis of critical QOL factors for a public management bottomup. Gestión de laInvestigacíon y Compromiso Social de la Universidad. Arequipa.

[16] GUIMARÃES, C.M.; CARVALHO, J.C. (2012). Outsourcing in continued care – a risk management approach. Science & Collective Health, 17(5), 1179-1190.

[17] GADELHA, A. (2017). Clima, motivation, and quality of life at work: the case of the Regional Superintendence of Labor and Employment in Paraíba. B.S. thesis.

# OJS Editorial and Publishing Process

**Author**

**Editor and Section Editor**

**Journal Manager, Reviewer, Copyeditor, Layout Editor, and Proofreader**

**Submission**
Author uploads file to journal Web site, and enters metadata for OAI indexing

**1. Submission Queue**
Editor assigns submission to Section Editor to see through the editorial process

**Journal Management**
Setup and configure journal; enroll editors, reviewers, copyeditors, proofreaders.

**Select Reviewers**
Editor invites reviewers from database with interests, load

**Submission Review**
Author can track process, see files, reviews, revise and resubmit, at editor's request

**2. Submission Review**
a) Check submission
b) Conduct peer review
c) Reach editorial decision

**Review Conducted**
Reviewer submits review and recommendation (which may be rated by editor)

**Submission Editing**
Authors reviews copyedits and proofreads galleys

**3. Submission Editing**
a) Copyedit submission
b) Layout of formatted galleys
c) Proofread galleys

**Copyediting**

**Layout**
Layout Editor prepares galleys in HTML.PDF. PS. etc.

**Proofreading**

### Key

| | |
|---|---|
| Journal Manager | |
| Editor | |
| Section Editor | |
| Reviewer | |
| Copyeditor | |
| Layout Editor | |
| Proofreader | |
| Author | |
| Reader | |

Open Journal Systems is an open source development of the Public Knowledge Project.

http://pkp.sfu.ca

**4. Issue Management**
a) Create issues
b) Schedule submissions
c) Organize Table of Contents

**5. Publication**
Offering immediate open access or delayed open access, with subscriptions

**Submission Archive**
Complete records kept of submission process for published and declined items

**Current Issue**
Items appear with Reading Tools linking to related internal and external resources

**Journal Archive**
Browsing issues, with indexing by OAI search engines, as well as Google, etc.

*~IJAERS Workflow~*

## Important links:

**Paper Submission Link:**

https://ijaers.com/submit-paper/

**Editorial Team:**

https://ijaers.com/editorial-board/

**Peer Review Process:**

https://ijaers.com/peer-review-process/

**Publication Ethics:**

https://ijaers.com/publication-ethics-and-publication-malpractice-statement/

**Author Guidelines:**

https://ijaers.com/instruction-to-author/

**Reviewer Guidelines:**

https://ijaers.com/review-guidelines/

---

## Journal Indexed and Abstracted in:

- Qualis-CAPES (A2)-Brazil
- Normatiza (Under Review-Ref.020191511)
- NAAS Score: 3.18
- Bielefeld Academic Search Engine(BASE)
- Aalborg University Library (Denmark)
- WorldCat: The World's Largest Library Catalog
- Semantic Scholar
- J-Gate
- Open J-Gate
- CORE-The world's largest collection of open access research papers
- JURN
- Microsoft Academic Search
- Google Scholar
- Kopernio - powered by Web of Science
- Pol-Index
- PBN(Polish Scholarly Bibliography) Nauka Polaska
- Scilit, MDPI AG (Basel, Switzerland)
- Tyndale University College & Seminary
- Indiana Library WorldCat
- CrossRef DOI-10.22161/ijaers

- Neliti - Indonesia's Research Repository
- Journal TOC
- WIKI-CFP
- Scinapse- Academic Search Engine
- Mendeley-Reference Management Software & Researcher Network
- Dimensions.ai: Re-imagining discovery and access to research
- Index Copernicus Value(ICV): 81.49
- Citeseerx
- Massachusetts Institute of Technology (USA)
- Simpson University (USA)
- University of Louisville (USA)
- Biola University (USA)
- IE Library (Spain)
- Mount Saint Vincent University Library ( Halifax, Nova Scotia Canada)
- University Of Arizona (USA)
- INDIANA UNIVERSITY-PURDUE UNIVERSITY INDIANAPOLIS (USA)
- Roderic Bowen Library and Archives (United Kingdom)

- University Library of Skövde (Sweden)
- Indiana University East (campuslibrary (USA))
- Tilburg University (The Netherlands)
- Williams College (USA)
- University of Connecticut (USA)
- Brandeis University (USA)
- Tufts University (USA)
- Boston University (USA)
- McGill University (Canada)
- Northeastern University (USA)
- BibSonomy-The blue social bookmark and publication sharing system
- Slide Share
- Academia
- Archive
- Scribd
- ISRJIF
- Cite Factor
- SJIF-InnoSpace
- ISSUU
- Research Bib
- infobaseindex
- I2OR
- DRJI journal-repository

---

**AI Publication**

International Journal of Advanced Engineering Research and Science (IJAERS)

104/108, Sector-10, Pratap Nagar, Jaipur, India