

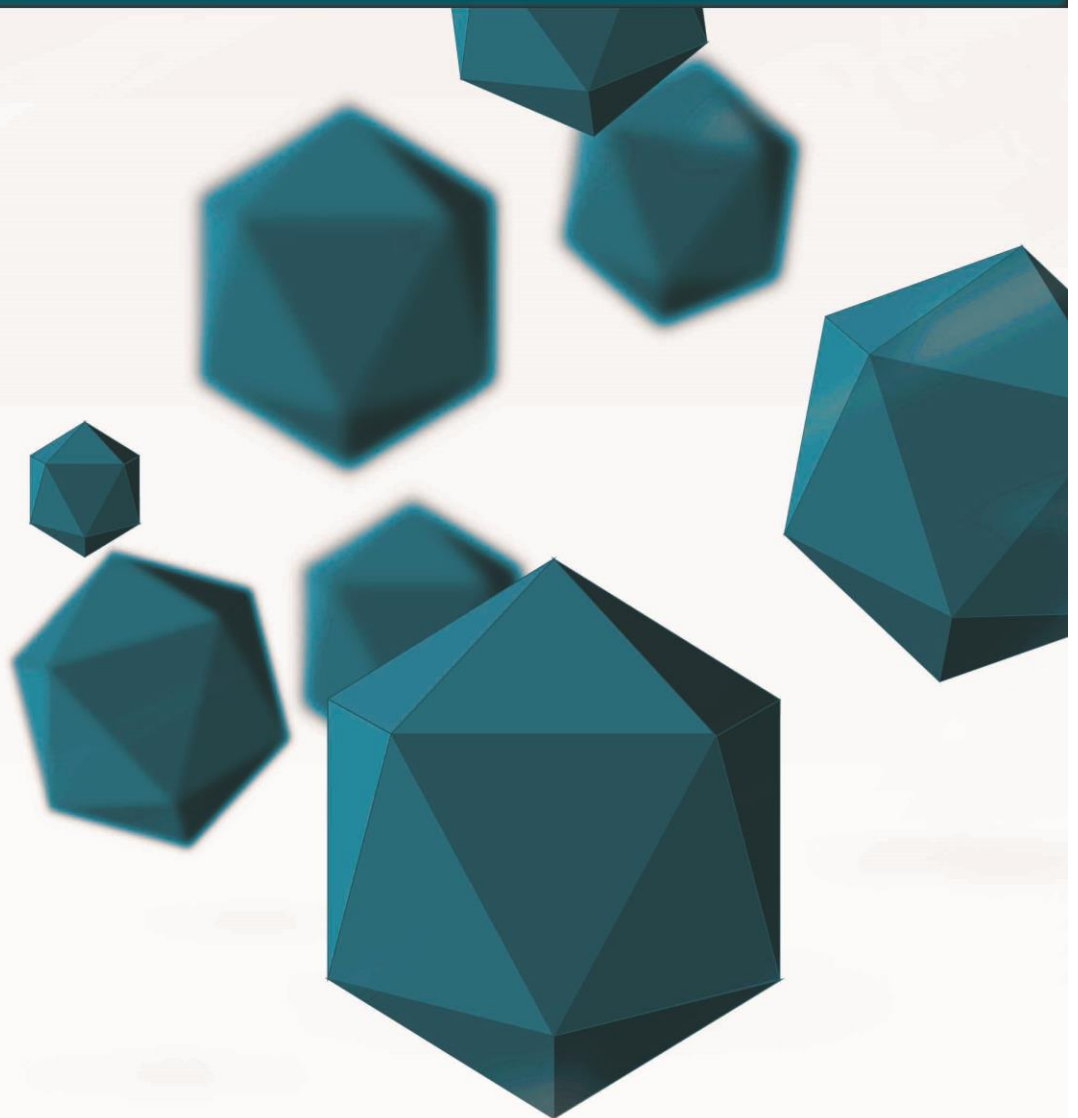
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*Editor in Chief*

Dr. Swapnesh Taterh

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# FOREWORD

I am pleased to put into the hands of readers Volume-5; Issue-12: 2018 (Dec, 2018) 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

Date: Jan, 2019

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39	<p><a href="#"><u>Use of Clay Sludge Water Treatment Plant Sludge to Produce Ceramic Brick</u></a>  <b>Author:</b> Eliza Anik de Oliveira, Jandecy Cabral Leite   DOI: <a href="https://doi.org/10.22161/ijaers.5.12.39">10.22161/ijaers.5.12.39</a>  <b>Page No:</b> 281-293</p>
40	<p><a href="#"><u>Weightless Neural Network with Transfer Learning to Detect Distress in Asphalt</u></a>  <b>Author:</b> Suayder Milhomem, Tiago da Silva Almeida, Warley Gramacho da Silva, Edeilson Milhomem da Silva, Rafael Lima de Carvalho   DOI: <a href="https://doi.org/10.22161/ijaers.5.12.40">10.22161/ijaers.5.12.40</a>  <b>Page No:</b> 294-299</p>
41	<p><a href="#"><u>Figuring out Extinct Values of Yeast Gene Microarray Expression (YGME) and Influencing Successive Time for Hierarchical Clustering Technique – An Improvement</u></a>  <b>Author:</b> Akey Sungheetha, Rajesh Sharma R   DOI: <a href="https://doi.org/10.22161/ijaers.5.12.41">10.22161/ijaers.5.12.41</a>  <b>Page No:</b> 300-308</p>
42	<p><a href="#"><u>The use of ISO 37122 as standard for assessing the maturity level of a smart city</u></a>  <b>Author:</b> Eber da Silva de Santana, Éldman de Oliveira Nunes, Leandro Brito Santos   DOI: <a href="https://doi.org/10.22161/ijaers.5.12.42">10.22161/ijaers.5.12.42</a>  <b>Page No:</b> 309-315</p>
43	<p><a href="#"><u>Non-Conventional Food Plants in Paraná Coast- Brazil: A Brief Overview of Production and Trade</u></a>  <b>Author:</b> Adilson Anacleto, André Felipe Stadler Costa, Luan Guilherme Santos Saladini, Jean Augusto de Oliveira Silva, Rodrigo Mendes do Rosário   DOI: <a href="https://doi.org/10.22161/ijaers.5.12.43">10.22161/ijaers.5.12.43</a>  <b>Page No:</b> 316-321</p>

# Site Design of Public Space under the Jenggolo Sidoarjo Flyover, East Java is reviewed from the Location Characteristics

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**Abstract**— This public open space under the Sidoarjo jenggolo flyover is known to be not optimal in its operations, both from zoning arrangements, number of visitors, and types of activities. Based on the results of the analysis, the most prominent activity in this area is the central street vendors that are made as a substitute for street vendors who used to sell along the shoulder of the road. The existence of this center PKL from its operational time and sales has decreased by 50 percent compared to before, this is because the operational time of the center vendors is only effective at night. In addition, what affects the lack of optimism is that there is an empty space under the overpass that is not utilized. The space is left empty so that it gives the impression of slums, darkness, and crime-prone, so that with this empty space can cause a negative image on that location.

The analysis that will be carried out is by reviewing the negative and positive potential of the open space, as well as reviewing in terms of behavior and user needs based on location characteristics. The design method used is qualitative descriptive method. As for the analysis technique used using walkthrough analysis and SWOT techniques.

The final result of this study is the concept of developing an open space design under the overpass with a character approach from the local location. So that efforts to optimize existing activities can be achieved.

**Keywords**— public open space, flyover, street vendors, behavioral architecture.

## I. INTRODUCTION

The research that will be carried out here is to make an exploration of the design of public spaces and city parks under an overpass that is adapted from the results of surveys and literature studies from several examples of existing flyovers.

Based on the results of the survey at the bottom area of the Jenggolo Sidoarjo flyover, there were already arrangements for both PKL and RTH, but they were not optimal. This phenomenon can be seen from the lack of visitors, the decreasing operational time of street vendors,

there is still a lot of land that is not utilized, zoning between activities is not clear, and there is no integration with existing activities around the site. In the background because of the lack of optimal functioning of existing activities, it is necessary to overcome this problem by developing the area according to the potential of the site and the behavior of the park's users. The purpose of developing the park area is as an effort to restructure and improve the quality of the design of the park and its surroundings.

## II. LITERATURE STUDY

### Behavioral Architecture

Behavioral architecture is an architecture that in its application always includes behavioral considerations in the design of behavioral linkages with architectural design (as a physical environment) namely that architectural design can be a facilitator of behavior or vice versa as a barrier to behavior (JB Watson, 1878-1958).

### Public Space

The definition of public space is a public place where people perform routine and functional activities that bind a community, both in normal routines of daily life, and in periodic celebrations (Carr, 1992).

In designing the public space must be in accordance with the context, because every design of public space is a good expression in culture, behavior, habits, needs, history, and psychology of the surrounding community.

### Street Vendor

The term PKL appeared during the Raffles era, which at that time referred to the 5 feet space, which was precisely located on the shoulder of the road along the pedestrian. And in the area, it is finally used by small traders to sell. From this phenomenon finally traders who sell on the roadside are not formally referred to as street vendors. Meanwhile, according to Mc. Gee and Yeung (1977: 25) in Susilo, Agus; 2011 characteristics of street vendors, namely:

1. There is an accumulation of people doing activities together at the same time, throughout the day



2. Located in certain areas which are centers of urban economic activities and urban non-economic centers, but often visited in large numbers.

3. Having the ease of occurring relationships between street vendors with buyers, even though it is done in a relatively narrow space

4. Does not require the availability of public service facilities and utilities.

#### **Flyover under area**

The space at the bottom of the overpass / bridge is the space created by the overpass / bridge. In accordance with government regulations, the space under flyovers / bridges is generally included in the RTNH (Non Green Open Space) category, especially in locations with hardened surfaces or not covered with plants. Even though the space under the overpass / bridge is included in the RTNH, however, specifically for this type of RTNH, the amount of provision is not regulated in government regulations.

The space below the overpass or bridge generally has a surface made of pavement, so it is included in the RTNH category. Although including RTNH, many cases of space under bridges / bridges are not used for activities. This is related to efforts to maintain security and order in urban areas. Space under flyovers / bridges is mainly used for certain ecological support areas. In accordance with the Guidelines for Provision and Utilization of Green Open Space, the space created under flyovers / bridges is ideally equipped with certain vegetation elements that can live with limited sunlight, using pots or tanks that can also be RTNH. The aim is to increase the beauty of the area under the overpass / bridge in question.

### **III. METHOD**

#### **Research Method**

The research used in this study uses qualitative descriptive methods (Groat and Wang, 2002). The aim is to make a systematic, factual and accurate description, description or painting of the facts, traits and relationships between the phenomena under study.

The research stages are as follows:

- Identify potential sites both physically and non-physically. This process includes site surveys, observations, interviews, and sorting of existing data.

- Formulate design criteria as a reference in the design development. In formulating the criteria here, walkthrought analysis analysis is used which is used to find out all the potential and activities that are visually visible, and then proceed with a SWOT analysis to find out the advantages, weaknesses, opportunities and threats.
- Formulate the concept of Arrangement design and Design of thematic park area. Planning strategies that have been obtained from the SWOT results can be used as criteria that will later be drawn from the design concept..

### **IV. RESULT AND DISCUSSION**

#### **Location Characteristics**

When viewed from the location, the open space area is created because it is under the overpass and is limited by a turning road under the overpass. Whereas for this type of area is an area that is indeed possible for a public activity, because the transportation on the turntable has a low intensity, in other words the area is not too dense and the average speed of the vehicle is around 20km/ hour so in terms of accessibility, this area has the potential to be used as a public space. In addition to being viewed from accessibility, there are several other potentials that can make this area optimal, including the existence of street vendors, parks and spaces that are under the overpass, as well as buildings or activities around the site. For detailed discussion will be discussed as follows:

- **Street Vendor**  
From the results of the analysis that has been carried out, there are known problems and potential that can later be used as design development. In the aspect of street vendors, there is a lack of optimism in its operations, this can be seen from the decrease in the number of visitors by 50% compared to the previous when it was still a wild street vendor, this happened because the location of street vendors was less visible, there was no supporting activity that could invite visitors to come, location adjacent to the empty space under the overpass, so the location seems dark and gloomy, there is no clear zoning between street vendors and other open spaces.



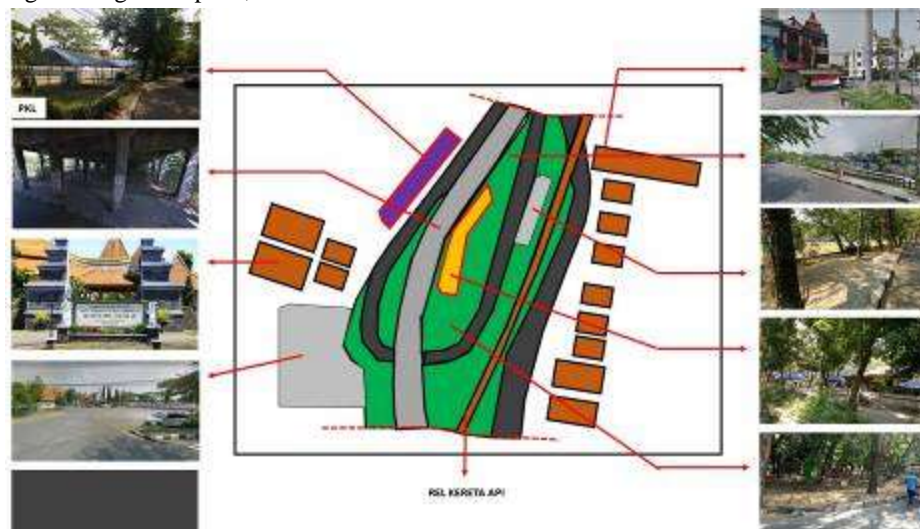
Picture 1. PKL activities before and after curbing  
 ( Private Source Data, 2018)

Whereas the existing potential, namely the existence of empty space under the overpass can be used as a central PKL development, the location adjacent to the museum and shophouse is a potential for the operation of the center PKL.

- RTH and RTNH

For RTH in this location there are two categories, the first is the green open space, and there is an unregulated green space, the ratio is

around 1: 3. With the large number of unregulated green space areas, it makes a negative impression on this area. Besides that, the existing open green space is passive, there is only pedestrian in the park but there are no supporting facilities to be able to invite more visitors. When viewed by plants that grow, this large green space is covered by large trees as shade.



Picture 2. Existing site design  
 ( Private Source Data, 2018)

The existence of these large trees does provide maximum imagery in the green space, but this condition gives a slight negative impression because the imagery gives a dark and gloomy effect on the location.

Whereas the existing RTNH conditions also give a negative impression on the location, this is because the area under the overpass is not utilized so that what appears is a dark, shabby and crime-prone impression. In addition to the

area below the flyover there are many large columns whose function is to support the bridge. The dark impression on the RTNH area besides being influenced by large trees, this location is dark because of the many columns that make it seem dark.

- Comunal Space

In site conditions, it is seen that there are public activities both in the park area and in the street

vendors area, but the presence of visitors especially in the street vendors is very lacking. Compared to before 2017, in this area, especially in the area of the highway, the number of visitors in many categories. It is known in the location that there is no special room that is used as a communal space, only pedestrians are available, and often there are many visitors who sit on the pedestrian, making it a bit disturbing when there are other visitors walking on the pedestrian.



Picture 3. Neighborhood Building Functions  
 ( Private Source Data, 2018)

Of the several buildings that are located around the open space area, this open space area must have an integration of activities in the surrounding buildings. In the existing condition, the existing open space seems to have only been used to move the street vendors who used to be on the shoulder of the road to move to an area in a green open space. So that the condition of this open space still looks shabby and prone to crime at night due to the lack of lighting conditions in the area.

#### - Educational Building Function

There are two schools that are located around this open space, where the existence of the school has an influence on this open space, not a positive influence but a negative influence, this can be seen by the use of open space as a parking space for students. From this phenomenon it can be seen that the use of open space is not right on target, where the open space is planned to be a space that can support the activities of teaching

#### • Neighborhood Building Functions

At this location there are several building functions around this site, among others, the Mpu Tantular Museum, Shops, High Schools, and Vocational High Schools. So that if it is categorized in a building function, there are functions of educational buildings and also functions of commercial buildings.

and learning activities and not as a residual space.

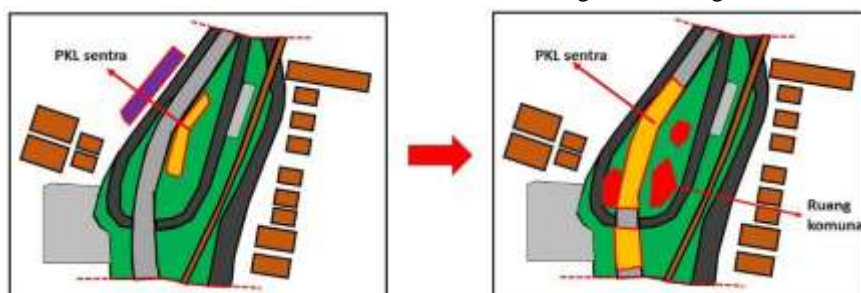
#### - Comercial Building Function

For commercial buildings in this area there is no effect on the physical open space, because each shop has its own parking lot corridor. However, another influence that can be seen is that the existence of this shop can trigger many visitors in this area..

### V. DEVELOPMENT OF SITE ZONING MODELS

#### Street Vendor

From the analysis and SWOT that has been done, the proposal is that first, to optimize the existence of street vendors there must be complementary activities in the form of communal and playground spaces. Secondly, RTNH that are under the overpass can be used as street vendors. Third, provide advertising space on several walls as a sponsor of the sustainability of the center PKL, so that the central street vendors can later be optimized in the design and arrangement.



Picture 4. Site zoning  
 ( Private Source Data, 2018)



**RTH and RTNH**

The results of the analysis and SWOT on RTH and RTNH obtained the proposal that is first, changing the green open space design from passive design to active. Second, designing communal spaces for the surrounding

community. Third, designing green open spaces and communal spaces that are educational, given the dominant area around many buildings with educational nuances. Fourth, to make this area more visible, the branches of large trees must be tidied up.

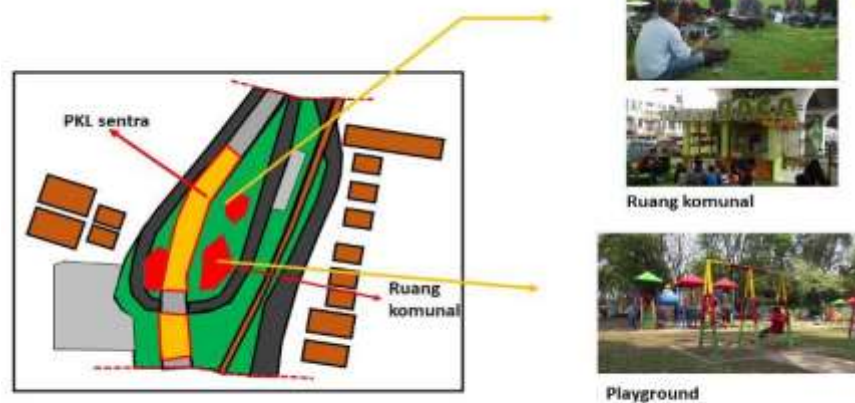


Picture 5. Vegetation around site  
( Private Source Data, 2018)

Fifth, in the RTNH room it is better to use it as a center PKL development, with the hope that the location will not become slum. Sixth, manipulate the supporting columns of the overpass to make it look neater.

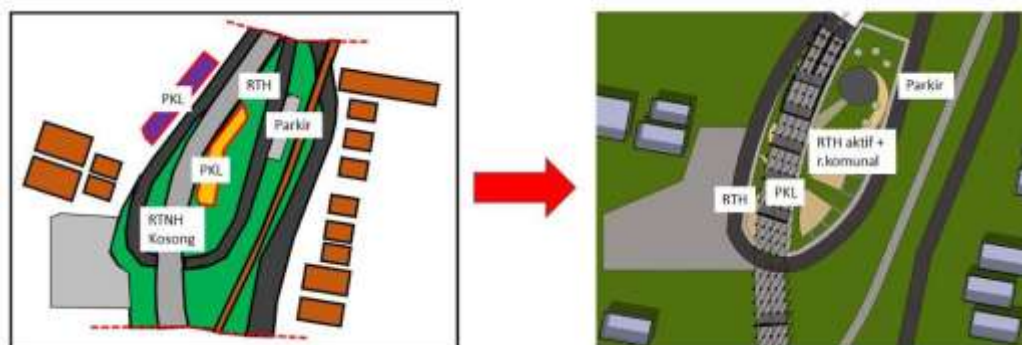
**Comunal Space**

The results of the analysis and SWOT on communal space obtained the proposal that is first, because there is public activity in the location, it is necessary to have a forum to accommodate the communal space.



Picture 6. Cmunal space Concept  
( Private Source Data, 2018)

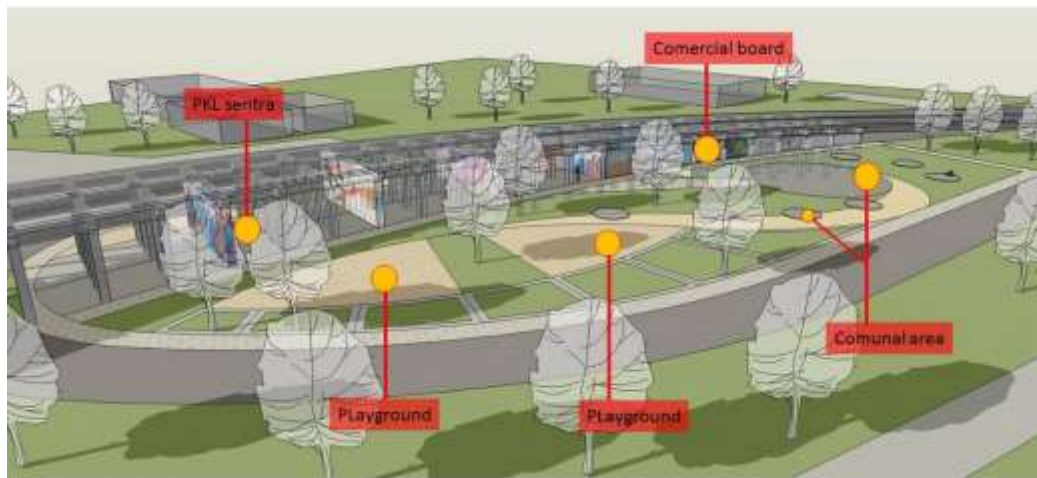
Second, because the location around many buildings has educational nuances, there is more communal space to accommodate teaching and learning activities.

**KESIMPULAN**

Picture 7. Site Zoning Changes  
( Private Source Data, 2018)

From the results of the analysis and SWOT, it was concluded that the site design as above, where green space is maximized as active activities and communal spaces such as discussion rooms, open stands, and

playgrounds. In addition to maximizing central PKL, the PKL area was moved to the RTNH area with a more communicative design.



Picture 8. Site Design  
( Private Source Data, 2018)

With the creation of a new zoning design and site layout as shown above, it is hoped that later it can be used as a reference in the development of detailed designs and can provide an overview of the design design variants of open spaces under the overpass.

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# Emphasis on Mathematical Modeling: The Problems of Contour Values in Calculating the Deflection of a Beam

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**Abstract**— *Mathematical Modeling has played a fundamental role in the process of teaching and learning mathematics at the various levels of education. The great challenge of today's education is to create means to minimize the distance between the relations of mathematical theory and practical models of everyday life. This work aimed to treat the study of Ordinary Differential Equations through a very usual model of civil construction. Often, students of Mathematics Degree develop skills to understand the abstractions of the vast theory associated with the areas of mathematics, but without being able to exemplify and / or correlate with everyday models.*

**Keywords:** *Mathematics Teaching and Learning. Contour problems. Deflection and Beams.*

## I. INTRODUCTION

In the present day a great amount of publications in the area of Mathematical Modeling has been a prominent factor in the Brazilian scientific production in Mathematical Education. The evolution of knowledge and new technologies have transformed the teaching and learning process of mathematics into modern and motivating educational practices, and therefore mathematical modeling has played an extremely important role in this transformation.[1] Thinking Mathematical Modeling as one of the possible paths of a new way of establishing, in school spaces, the insertion of the way of thinking the relations of mathematical knowledge and the most participatory and democratic society."

Contemporary education, more precisely, the way in which educators construct their knowledge for their apprentices, there is a gap between the traditionalist way of teaching and the evolution of the modern world. The scientific and technological transformations that have occurred in the last decades have ignited a warning signal for a large number of theoretical educators and resistant to change in the way of teaching mathematics.

For [2], knowing how to differentiate what is a problem from an exercise is one of the most common and most difficult practices for the teacher. A real problem must be a real challenge in which students, by means of sequences of actions, will seek to obtain the results. In this way, Mathematical Modeling has a crucial role of minimizing the distances between contents without immediate applications and the usual models of daily life.

Over time, Modeling has been developed under various contours in the classroom and these different forms of conception reflect the experiences lived by its followers. Thus, the experience and level of teaching in which the teacher works, whether in Higher Education or in Basic Education, offer different characteristics, perceptions and directions to work with Modeling. It is important to make it clear that we understand that there is not one conception of Modeling that is truer than another, or one that is more correct than the other, but what is here is the need for clarity about the conceptions of "Man", "Education ", "Teaching and Learning "and the object of study, which implies in epistemological questions that guide our educational practice within the different levels and modalities of teaching [3].

In view of the above and the concerns about the best way of conducting the concepts of Equations Ordinary Differences, through Mathematical Modeling, for students of the degree course in Mathematics, came the idea of using a civil construction application.

Many natural phenomena, from physics to biology, can be described by means of differential equations. For example, suppose two working men are driving a large piece of board over their shoulders, each at one end of the board. It is easy to see that the middle of the board will curve downwards. This effect, we say that the board has suffered a deflection.

Solving a differential equation means finding an adequate family of curves. In engineering, there are a lot of problems in which we resort to these equations to find a solution. One of these problems is to determine the static deflection of an elastic beam caused by its weight or by

an external load. These beams, under load, undergo a deformation, flexing. The loads that produce this deformation can be of two types: they can be concentrated in one more points of the beam, or they can be evenly distributed by the beam. This article aims to find solutions of the equations of the curves in which the beams deform under a load uniformly distributed by the beam

## II. THE DIFFERENTIAL EQUATION OF THE DEFLECTION CURVE

[4] [5] [6] [7] Ordinary Differential Equation of order  $n$  is every equation,  $F(x, y, \frac{dY}{dx}, \frac{d^2Y}{dx^2}, \dots, \frac{d^nY}{dx^n}) = 0$ , which has an unknown function  $Y$  and its derivatives. The transverse deflection of a beam  $Y(x)$ , at the point  $x$ , satisfies a fourth order no homogeneous linear differential equation of the type:  $\frac{d^4Y}{dx^4} = \frac{W(x)}{EI}$ . Where,  $W(x)$  it is a vertical load per unit length, which acts transversely to the beam. The constant  $EI$  is called beam stiffness -  $E$  it is the modulus of elasticity of Yang of the material that is made to the beam and  $I$  is the moment of inertia of a cross section of the beam. The contour conditions (Table I) associated with the equation depend on the manner in which the beam is supported.

Table I: Types of beams under contour conditions

Types	Conditions
Crimped Beam	$Y = Y' = 0$
Rotary Beam	$Y = Y'' = 0$
Fixed End Beam	$Y''' = Y'' = 0$

Source: Elaboration of the author, 2018.

**Theorem:** The solution of the fourth order non-homogeneous linear differential equation

$$\frac{d^4Y}{dx^4} = \frac{W(x)}{EI} \quad \text{is given by}$$

$$Y(x) = C_1 + C_2x + C_3x^2 + C_4x^3 + \frac{W_0}{24EI}x^4.$$

Where,  $W(x) = W_0$  it is a constant charge evenly distributed along its length.

*Proof:* Let  $\frac{d^4Y}{dx^4} = \frac{W_0}{EI}$  (1) be the equation we wish to determine the general solution.

Hence, integrating successively in (1), we have:

$$Y'''(x) = \frac{d^3Y}{dx^3} = 6C_4 + \frac{W_0}{EI}x \quad (2),$$

$$Y''(x) = \frac{d^2Y}{dx^2} = 2C_3 + 6C_4x + \frac{W_0}{2EI}x^2 \quad (3),$$

$$Y'(x) = \frac{dY}{dx} = C_2 + 2C_3x + 3C_4x^2 + \frac{W_0}{6EI}x^3 \quad (4).$$

Therefore,

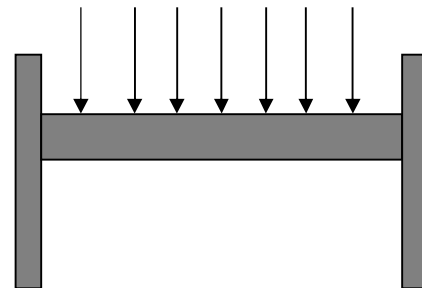
$$Y = C_1 + C_2x + C_3x^2 + C_4x^3 + \frac{W_0}{24EI}x^4 \quad (5).$$

The arbitrary constants  $C_1, C_2, C_3$  y  $C_4$  are determined from the initial boundary conditions. That is, for each type of beam used, the constants have different values.

## III. PROBLEMS OF CONTOUR VALUES AND MAXIMUM DEFLECTION OF A BEAM

A Contour Value Problem is characterized by a differential equation and extra conditions supplied at more than one point. Suppose a beam of length  $L$  is homogeneous and has a uniform cross-section along its length. Also, suppose a load is evenly distributed over the beam over its entire length. Under the presented conditions, we will show the solution of the contour problem for the calculation of the deflection of a beam, in the following cases:

**Case 1:** Beam Set at both ends:  $x = 0$  and  $x = L$ .



$$\text{Contour Conditions: } \begin{cases} Y(0) = Y(L) = 0 \\ Y'(0) = Y'(L) = 0 \end{cases}$$

Hence, since  $Y(0) = 0$  and  $Y'(0) = 0$ , by (5) and (4), respectively, we have  $C_1 = 0$  and  $C_2 = 0$ .



Under the conditions  $Y(L) = 0$  and  $Y'(L) = 0$ , respectively, they give us:

$$C_3 L^2 + C_4 L^3 + \frac{W_0}{24EI} L^4 = 0 \quad \text{and}$$

$$2C_3 L + 3C_4 L^2 + \frac{W_0}{6EI} L^3 = 0.$$

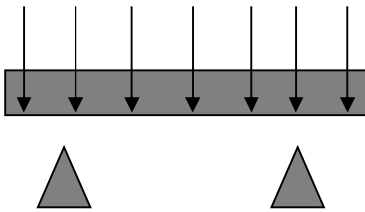
Solving the system, we will have:

$$C_3 = \frac{W_0 L^2}{24EI} \quad \text{and} \quad C_4 = -\frac{W_0 L}{12EI}$$

Therefore, the deflection, at the point  $x$ , is:

$$Y(x) = \frac{W_0 L^2}{24EI} x^2 - \frac{W_0 L}{12EI} x^3 + \frac{W_0}{24EI} x^4$$

**Case 2:** Beam at both ends:  $x = 0$  and  $x = L$ .



$$\text{Contour Conditions: } \begin{cases} Y(0) = Y(L) = 0 \\ Y''(0) = Y''(L) = 0 \end{cases}$$

Hence, since  $Y(0) = 0$  and  $Y''(0) = 0$ , by (5) and (3), respectively, we have  $C_1 = 0$  and  $C_3 = 0$ .

Under the conditions  $Y(L) = 0$  and  $Y''(L) = 0$ , respectively, they give us:

$$C_2 L + C_4 L^3 + \frac{W_0}{24EI} L^4 = 0 \quad \text{and}$$

$$6C_4 L + \frac{W_0}{2EI} L^2 = 0.$$

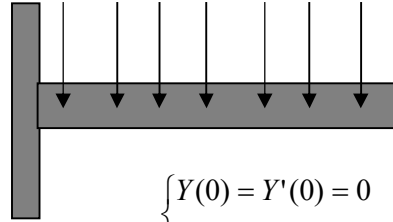
Solving the system, we will have:

$$C_2 = \frac{W_0 L^3}{24EI} \quad \text{and} \quad C_4 = -\frac{W_0 L}{12EI}$$

Therefore, the deflection, at the point  $x$ , is:

$$Y(x) = \frac{W_0 L^3}{24EI} x - \frac{W_0 L}{12EI} x^3 + \frac{W_0}{24EI} x^4$$

**Case 3:** Beam Set in  $x = 0$  and free end in  $x = L$ .



$$\text{Contour Conditions: } \begin{cases} Y(0) = Y'(0) = 0 \\ Y''(L) = Y'''(L) = 0 \end{cases}$$

Hence, since  $Y(0) = 0$  and  $Y'(0) = 0$ , by (5) and (4), respectively, we have  $C_1 = 0$  and  $C_2 = 0$ .

Under the conditions  $Y''(L) = 0$  and  $Y'''(L) = 0$ , respectively, they give us:

$$2C_3 + 6C_4 L + \frac{W_0}{2EI} L^2 = 0 \quad \text{and}$$

$$6C_4 + \frac{W_0 L}{EI} = 0.$$

Solving the system, we will have:

$$C_3 = \frac{W_0 L^2}{4EI} \quad \text{and} \quad C_4 = -\frac{W_0 L}{6EI}$$

Therefore, the deflection, at the point  $x$ , is:

$$Y(x) = \frac{W_0 L^2}{4EI} x^2 - \frac{W_0 L}{6EI} x^3 + \frac{W_0}{24EI} x^4$$

When a load  $W_0$  is uniformly distributed over a beam of length  $L$ , maximum deflection occurs in the middle of the beam. This deflection represents the maximum limit at which the beam can flex before breaking. As in our work, we take length beams, their maximum deflection occurs at point  $x = \frac{L}{2}$ . The table II, shows the maximum deflection reached by beam analyzed in the previous section.

Table II: Maximum Deflection of a Beam

Types of Beam	Maximum Deflection
Case 1	$Y_{\max} = \frac{W_0 L^4}{384 EI}$
Case 2	$Y_{\max} = \frac{5W_0 L^4}{384 EI}$
Case 3	$Y_{\max} = \frac{17W_0 L^4}{384 EI}$

Source: Elaboration of the author, 2018.

#### IV. PROPOSAL OF THE USE OF MATHEMATICAL MODELING IN CLASSROOM

The major concern of most mathematics teachers in higher education is to try to make the teaching and learning process of mathematics efficient. The use of Mathematical Modeling - Deflection Calculation of a beam - in the Ordinary Differential Equations is a good example for a motivational educational practice, because it leads the student to realize that mathematical theory has well defined, practical, everyday results. It is necessary to observe that this passage from the theoretical abstract model to the concrete practical model must happen following the demands and rigor in the treatment of mathematical concepts.

The development of the modeling activity involves procedures such as the search for information, the identification and selection of variables, the elaboration of hypotheses, the simplification, the obtaining of a mathematical model, the resolution of the problem by means of adequate procedures and the analysis of the identifying its acceptability (or not) [8].

The purpose of this article was to present a classroom practice that would lead the student to engage in mathematical relationships with the modern world. According to [9] we can say that students are able to produce three types of discussion in the Modeling environment: **mathematics** - refer to mathematical ideas, concepts, and algorithms; **technical** - refer to the representation of the situation - problem in mathematical terms; **reflective** - refer to the relationship between the criteria used in the construction of a mathematical model and its results.

Thus, our pedagogical proposal, for undergraduate mathematics students, for a good understanding of the Equations Ordinary Differences is the use of Mathematical Modeling, following rigorously pre-established steps and tasks.

**Step I:** Define Ordinary Differential Equation.

**Step II:** Show the differential equation of the transverse deflection of a beam.

**Step III:** Show the types of beams under contour conditions.

**Step IV:** Find the solution of the differential equation of the transverse deflection of a beam,

**Step V:** Calculate the deflection of a beam, in the cases: Beam, Fixed Beam and Fixed End Beam.

**Step VI:** Classroom Activity: Determine the Maximum Deflection of a Beam, in each case: Beamed Beam and Fixed End Beam. Present the one that suffers the greatest deflection.

It should be noted that the construction of knowledge must follow very well defined steps and tasks that

facilitate the teaching and learning process, respectively, of the teachers and students involved. This pedagogical proposal follows goals, without loss of generality, for the construction of a real, comprehensible and modern mathematical model.

#### V. CONCLUSION

This article was developed from a proposal to use Mathematical Modeling in Ordinary Differential Equations, using the calculation of Deflection of a Beam. Another fundamental point, highlighted in this article, refers to the use of Mathematical Modeling in higher education, often of high lack of consideration by traditional teachers and resistant to change.

This is a special time for college students to realize the many ways mathematics can be used on a day-to-day basis. The current profile of undergraduate courses in Mathematics in Brazil allows to create mechanisms in pedagogical practice to reduce the gap between what is presented as a theory and what is used as a practice. It can be affirmed that there are several ways to present Mathematical Modeling, at whatever level of education, it is enough only that the stages and tasks of the defined pedagogical proposal be completed. In view of the above, it is expected that this work may stimulate further research in mathematical modeling in order to minimize the lags between mathematical theory and its practice.

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# Monitoring System for Agrometeorological Application with Voice-Controlled Interface

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**Abstract**—The objective of this work is to present aspects about the already completed development stages of a monitoring system for agrometeorological application that uses Human-Computer Interface controlled by written and spoken languages. Technologies related to the development of this type of HCI have been increasingly used and are gradually more connected to the most diverse devices and machines including fieldwork uses. This interdisciplinary work is supported by research in the areas of Meteorology, Linguistics, Natural Language Processing (NLP) and Computing using physical prototypes focused on monitoring: automated solar search, unmanned aerial vehicle (UAV), unmanned groundvehicle (UGV), mix of meteorological sensors and the system itself. The steps already completed and interrelated - automated solar tracker, the set of meteorological sensors and the system - show that this type of monitoring has a significant degree of accuracy, low cost and autonomy - it does not depend on the conventional grid and makes small decisions.

**Keywords**—Unmanned Vehicles, Digital Agriculture, Severe Weather, Linguistic, Agriculture Applications

## I. INTRODUCTION

In general, monitoring systems have become more common as technologies improves. Among them, there are those for agrometeorological application, which are quite useful when it comes to improving productivity and automation [1]. In this context, the objective of this work is to present some of the aspects related to the development stages already completed of a monitoring

system for agrometeorological application using Human-Computer Interface (HCI) controlled by written and spoken languages.

Technologies related to the development of this type of HCI have been increasingly used and are gradually more connected to the most diverse devices and machines including fieldwork uses [2, 3]. Therefore, the development of this monitoring system, has given opportunities to research works already developed in Brazil and has expanded the applicability of the automatic recognition of written and spoken texts for a greater variety of uses in the Portuguese-Brazilian language [4]. The applicabilities, including a photovoltaic automated solar tracker, a set of meteorological sensors and the system, are numerous: home automation, virtual robots for decision making, some functions in automobiles, elevators and games [5].

About technological innovations in agrometeorology, new tools are important for countries like Brazil. One of the main problems in the agriculture, mainly for the agricultural exportation items, is the meteorological extreme events. There are countless losses, both material and economical, in the history of Brazilian agriculture [6]. Extreme events may worsen in the country due to the effects of climate change [7]. Although hail is a well known extreme event, its study is innovative in Brazil. This is due to the fact that it is a highly local phenomenon of short duration. Therefore, it is extremely complicated to use an equipment to measure hail, mainly for the study of the formation of rocks in the clouds.

The development of this type of technology allows the obtainment of other advantages such as maintenance of interdisciplinarity, integration of other Units and educational institutions, greater proximity to Institution-Companies through junior companies or startups; and the motivation of users and companies on the use/industrialization of products generated among others.

## II. METHODOLOGIES

This interdisciplinary work is widely supported in research in the major areas of Meteorology, Natural Language Processing (NLP), Linguistics and Computing. The application of the research has been done directly in physical prototypes that, operating together, allow the agrometeorological monitoring.

The complete monitoring system will have at least five operational blocks: automated solar tracker, unmanned aerial vehicle (UAV), unmanned ground vehicle (UGV) coupled with a UAV recharger by electromagnetic induction, a set of meteorological sensors and a system with chat robot.

The steps already completed and inter-linked through the system are the automated solar tracker, the set of meteorological sensors and the mobile system itself. Each of these elements, which belonged to a separate project, were being integrated to each other as the needs for agrometeorological application became more complex.

## III. FINALIZED AND OPERATIONAL STAGES

The automated solar tracker (hereinafter *Solar* prototype) as shown in Figure 1 was the first physical prototype used for HCI implementation and testing for agrometeorological monitoring. Its basic software for monitoring physical quantities (ex. voltage, electric current and power, solar radiation, relative humidity, ambient temperature, wind speed and others) are finalized and controlled by voice and written text through a robot called *Solar robot* [8,9].



Fig. 1: Operational Automated Solar Tracker.

This automated solar tracker originally belonged to an interdisciplinary and interinstitutional project called S.O.L.A.R (in portuguese *Sistema de Orientação Latitude-longitudinal Automático Regenerativo*) - Automatic Regenerative Latitude-longitudinal Orientation System1 (hereafter Solar only). The basic function of the Solar project is the capture of solar energy through photovoltaic panels that follow the movement of the sun throughout the day with a microcontrolled mechanical solar tracker. The energy is stored in batteries and the process is monitored and controlled for better energy management. This prototype is responsible for the autonomy of the agrometeorological monitoring system, since it is done regardless of any conventional power grid.



Fig. 2: Basic interface of the solar robot.

The Solar robot (Figure 2) is a chat robot, which responds to commands by voice and voice synthesis. It has been



programmed in C# language, uses the *Coruja* as a recognizer [10] and uses *Loquendo* [11] to 'talk'. The word search system is done through hash tables [12, 13]. The robot responds very efficiently to commands in Brazilian Portuguese, returns in an essentially Brazilian language registry and presents a reduced rate of speech recognition failures. The block representation of the system integration used in the robot can be seen in Figure 3.

It is important to point out that the Solar robot is based on another existing robot called Tical - Interactive Conversational Technology on Language Matters [14-17], which is used for research in the area of Linguistics, specifically data of the Linguistic Atlas of Brazil - ALiB [18, 19] and the Historical Lexicon of Paraná - LhisPAR [20]. However, despite having similar resources and search techniques for synonyms and programming languages used, their respective applications are quite diverse: Tical is used for linguistic research; Solar is used for the management of photovoltaic energy.

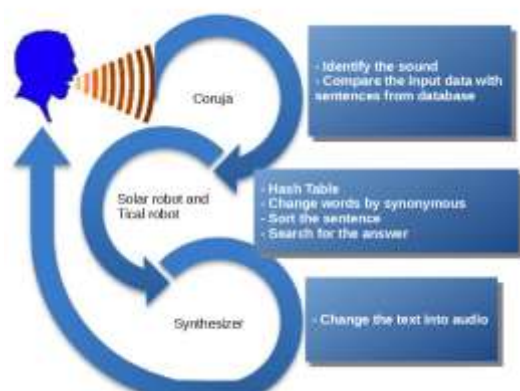


Fig. 3: Solar robot functionality.

From the usability and accessibility point of view of [21], once started, the Solar robot optimizes the queries because it is not necessary to use conventional data entry devices like keyboard and mouse to have access to the data. In other words, it eliminates the acts of typing or clicking buttons while managing photovoltaic resources. It is worth remembering that although all access can be done with voice commands, of course there is, a visual interface of the system (Figure 4) from which the user/operator can observe data and information concomitantly and, if necessary or preferable, the robot also responds by written text.

Table 1 presents a basic list of the commands that are answered by the robot. In this table, there are the subdivided quantities that are monitored, eventual linguistic variants, the unit of measure of reference and the expression used by the robot to answer by voice synthesis. The user/operator when asked by voice "panel voltage" - item 1 in Table 1 - has voice response "panel voltage 'x' volts". If the battery is 12.8 volts, the response

of the robot will be "panel voltage twelve-volt comma eight". The same question can be asked using the keyboard in the field for the written text.



Fig. 4: Monitoring system interface by the Solar-Sima project

Tab. 1: Basic information of Solar robot.

	Variable	Linguistic variants	Answers	
			Unit	Syntax
1	<b>Panel Voltage</b>	Panel Volts, Voltage Panel	V	Panel Voltage 'X' Volts
2	<b>System Voltage</b>	System Volts	V	System voltage 'X' Volts
3	<b>Power System</b>	Watts of System	W	System power in 'X' Watts
4	<b>Power Panel</b>	Panel watts, Power board	W	Generating 'X' Watts
5	<b>Solar radiation</b>	Sun, Light intensity	W/m <sup>2</sup>	'X' Watts per square meter
6	<b>Wind speed</b>	Wind velocity, Wind	m/s	'X' meters per second
7	<b>Temperature</b>	Degrees, weather	°C	'X' Celsius degrees
8	<b>Air Humidity</b>	Humidity	%	Air Humidity in 'X' percents
9	<b>Precipitation</b>	rain	mm	'X' millimeters
10	<b>Air Pressure</b>	Pressure	bar	'X' bars

The management of photovoltaic energy made possible by the HCI developed here, however, generated the need to monitor other physical quantities besides those specifically electric, such as voltage, current and/or power. The meteorological conditions influence directly on the generation of photovoltaic energy [22] and other

decisions can be taken, both by the user / operator and by the programmable routines themselves in the system. For this reason, the main screen of the second version of the HCI (Figure 4) already predicted the magnitudes related to atmospheric measurements such as wind speed, relative air humidity, solar radiation, among others.

The prototype Solar then incorporated another prototype called SIMA (*Sistema de Informações e Monitoramento Atmosférico*, in portuguese - literal translation: Monitoring and Atmospheric Information System; henceforth only Sima) and evolved to what is now called the Solar-Sima Prototype (Figure 5). This new set is able to generate metadata, that, means data of which it benefits itself, since it is possible to predict the generation of photovoltaic energy [22] from annual meteorological data, for example.



Fig. 5: Integrated Solar and Sima prototypes and in operation.

Sima added to Solar the ability to monitor physical quantities relative to meteorology such as solar radiation, relative humidity, ambient temperature, atmospheric pressure and wind speed. Since then, some findings regarding local weather conditions - Fatec Garça campus - could be verified. Among them there is a daily overview of available solar radiation shown in Figure 6 and essential to the management of photovoltaic energy.

In Figure 6, the surrounded fields highlight moments in which clouds partially obscured sunlight throughout the day and the field highlighted by the square shows the gradual fall of typical twilight solar radiation. Another possible monitoring is to observe the latitudinal and longitudinal tracings of the sun throughout the day through a graph (Figure 7). This measurement, although it is more associated to astronomical aspects than necessarily meteorological, it will allow the equipment to collect accurate data on useful angulation of the rays of the sun respecting the photovoltaic effect. After the data collection, these data can be crossed in certain periods and present, among other information, optimal conditions

for solar energy management through consultation with the Solar robot.

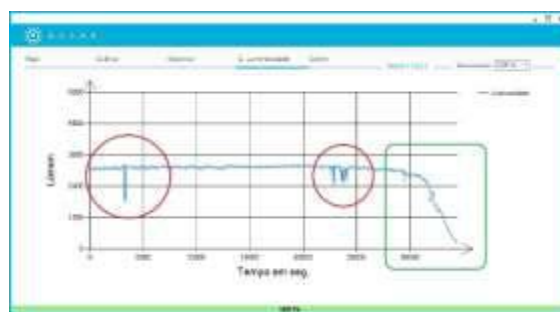


Fig. 6: Solar-Sima interface indicating the solar radiation in a specific day.

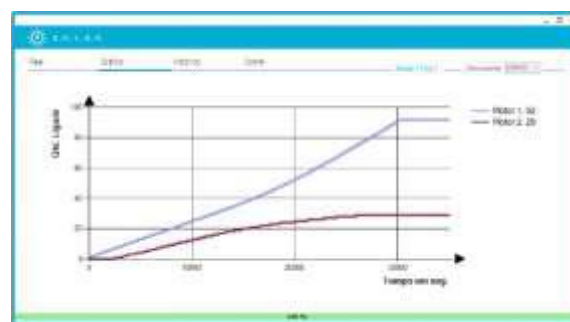


Fig. 7: Interface indicating latitude and longitude position of the sun in a specific day.

The HCI developed for the Solar-Sima monitoring system will help with the collection of data for a series of applications, whether for industrial use or applied to productive sectors. Among them was the integration of Solar-Sima to the Fapesp Project recently approved by Fatec Garça, in which IHC will help to better understand the formation of hail and to study its impact in a coffee production in the region of Garça. The UAV will be responsible for releasing appropriate sensors for this type of cloud and the sensor data will be sent to a data center with software that will treat them for further study. Figure 8 shows an overview of the Garça FAPESP Project, for which the programming proposed here is essential.

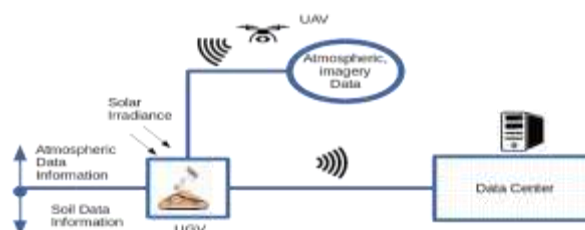


Fig. 8: General overview of the main project based on this work.



#### IV. CONCLUSION

This work presented preliminary results of a technological innovation project in the environmental area, which shows an automatic agrometeorological data station with a voice command system. The results demonstrate an advance in the area of meteorology and IHC. The latter demonstrates the effectiveness of a chatbot developed for the Brazilian-Portuguese language.

Some tests were performed using a low-cost meteorological station powered by a solar tracker. All information on the panel's meteorological and electrical variables was tested and performed successfully.

The results presented in this work are an integral part of a project to study the formation of hail in the state of São Paulo, Brazil. The contributions obtained here will have primordial importance for the continuity of the project, integrating computational systems with large volume storage of surface and atmospheric data.

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# Evaluation of the Flexural Strength, Sorption, Rheological and Thermal Properties of Corncob Plastic Composites

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**Abstract**— Plastic composites were made from corncobs and high density polyethylene (HDPE) by extrusion and evaluated. The composites were manufactured using two different screened corncob particle size fractions (<2 mm and <0.5 mm) and tested for flexural properties, water sorption, melt flow and thermal properties. The melt viscosities at 190°C were  $18.0 \pm 0.8$  kPa·s (<2 mm) and  $24.0 \pm 0.6$  kPa·s (<0.5 mm). The results obtained indicated that the composites made with the smaller particle size fraction had higher flexural strength ( $31.7 \pm 1.7$  MPa) and modulus of elasticity ( $1.4 \pm 0.1$  GPa) than those made with the larger particle size fraction ( $21.2 \pm 1.4$  MPa and  $1.1 \pm 0.1$  GPa). Also, the composites made with the smaller particles and were more dimensionally stable. Corncob composites had thermal stability range of 259 – 274°C (onset degradation temperature). The corncob composites made with smaller sized particles possessed better properties in comparison with those made from the <2 mm. Particle size and density significantly affected the mechanical, physical and thermal properties of the composites evaluated.

**Keywords**— Corncobs, flexural properties, particle size, plastic composites.

## I. INTRODUCTION

The scarcity of timber supply in Nigeria, due to the increasing demand for solid wood and wood products, has necessitated the use of agricultural fibers for composites production [1,2]. This is because agricultural fibers such as cotton and maize stalks, groundnut and coconut shells, rice and corncobs are renewable natural resources, which are abundantly available and low-cost alternatives. Their advantages over traditional reinforcing materials such as glass fibers and mica are acceptable specific strength properties, low density, good thermal properties, reduced tool wear, thermal and respiratory irritation, ease of separation and biodegradability [3,4]. Incorporation of agricultural fibers in composites production can enhance

complete material utilization, offset wood shortage and foment the development of indoor and outdoor building components in developing countries like Nigeria [5,6].

Amongst the several agricultural crops cultivated in Nigeria, corn, a cereal crop remains the most popularly grown and consumed in all ecological zones [7]. Corn has an estimated cob residue of  $3.3 \times 10^6$  ton per year, which is used as fuel but most times litter the environment especially during the harvesting season from February to September [8,9]. The chemical composition of corncobs (35 - 46% hemicellulose, 18 - 40% cellulose, 12 - 23% lignin and 1 - 4% ash) makes it a suitable candidate as a candidate furnish for plastic composites [4,6,9-11]. Furthermore, corncob based polyethylene composites have been shown by several researchers to have good flexural strength (25 - 45 MPa) and modulus (1.3 - 2.7 GPa), tensile strength (11 - 36 MPa) and water absorption (0.75 - 6.0%) properties [3,4,6].

However, literature is sparse on the effect of corncob particle size on properties of high-density polyethylene (HDPE) composites with a coupling agent. This is because the incorporation of small sized particles (100 - 200 mesh) can increase the melt flow rate (MFR), a measure of processability, and flexural strength but resulted in reduction in toughness, stiffness and crystallinity of the composites [12,13]. This effect has been attributed to interfacial interaction between the plastic matrix and the lignocellulosic fibers [12,13]. Low interfacial bonding may sometimes occur between the hydrophilic fibers and hydrophobic plastic matrix. Therefore, coupling agents, such as maleated polyethylene (MAPE) is typically incorporated in the production process to enhance fiber-matrix compatibility and thus improve properties [14,15].

The aim of this study was to evaluate the use of corncobs particles of various size in HDPE based plastic composite by extrusion. The corncob particles were partially characterized (size and composition) and the composites

strength, thermal, rheological and physical properties were determined.

## II. MATERIALS AND METHODS

### 2.1 Production of corncob plastic composites

Corncobs collected from a local market in Oyo state, Nigeria were Wiley milled and screened to <2 and <0.5 mm particle size fractions. The milled particles were oven dried at 70°C to <0.5% moisture content (MC) prior to extrusion. HDPE (48% w/w) (Equistar Petrothene, LB 0100-00, MFI = 0.3 g/10 min, and density = 0.950 g/cm<sup>3</sup>), corncob particles (50% w/w) and MAPE (Polybond 3029, Crompton) coupling agent (2% w/w) were blended in 500 g batches and then compounded at 0.5 kg/h on an 18 mm co-rotating twin-screw extruder (Leistritz, L/D ratio of 40, 200 rpm) and extruded into a ribbon (3.6 x 50 mm<sup>2</sup>) [16]. The barrel and die temperature were 140 - 160°C.

### 2.2 Properties characterization of corncob reinforced plastic composites

#### 2.2.1 Corncob particle characterization

Air-dried samples of the corn cob particles (4-5 g) were Soxhlet extracted with dichloromethane (CH<sub>2</sub>Cl<sub>2</sub>, 150 mL) for a period of 20 h according to ASTM D1108-96 [17]. The CH<sub>2</sub>Cl<sub>2</sub> extract was then evaporated to a constant weight and extractives yield determined gravimetrically. The lignin content was determined on extractive free corncobs using the Klason lignin method according to ASTM D1106-96 [18]. Specifically, the dried extractive free corncobs (200 mg) was incubated in 72% H<sub>2</sub>SO<sub>4</sub> (2 mL) for 1 h at 30°C, then diluted into 4% H<sub>2</sub>SO<sub>4</sub>, and subjected to secondary hydrolysis in an autoclave (117 kPa and 121°C) for 30 min. The hydrolyzate was filtered to obtain Klason lignin content gravimetrically. The ash content was determined gravimetrically by furnacing the samples at 600°C for 16 h. All analyses were done in duplicate.

Optical microscopy was performed on screened particles on an Olympus BX51 microscope at 40× magnification equipped with a DP70 digital camera. Particle measurements (length and width) were performed on 160 particles for each sample using the Olympus MicroSuite software [19].

#### 2.2.2 Sorption, mechanical and melt flow properties of composites

Water absorption (WA) and thickness swell (TS) tests were conducted following a modified ASTM D570-95 [20] procedure. Five replicate specimens (3 × 20 × 50 mm<sup>3</sup>) for each sample were immersed in water at 23°C for 61 days and dimensions periodically measured. Weight gain and thickness swell were measured on a total composite basis for determination of WA and TS respectively. The diffusion coefficients ( $D_f$ ) of the

composites were calculated using equation 1 [21]:

$$D_f = \pi (h/4M_\infty)^2 (M/\sqrt{t})^2 \quad (1)$$

Where,  $M_\infty$  is the maximum moisture content (MC) (%) measured at the end of the test,  $h$  is the sample thickness (m) corresponding to  $M_\infty$ ,  $t$  is the time (s) and  $\delta M/\delta \sqrt{t}$  is the initial slope from the graph of MC versus  $\delta \sqrt{t}$  relation. Three point flexural tests (strength and modulus) were performed on extruded specimens (3.56 × 20.1 × 110 mm<sup>3</sup>, 5 replicates) according to ASTM Standard D 790-07 [22] with a crosshead speed of 1.31 mm/min and a span of 57 mm until specimen failure or 5% strain, whichever occurred first on an Instron 5500R-1132 universal test machine equipped with a 5 kN load cell. Data were collected and processed using Bluehill v3 software (Instron). Melt flow rate (MFR) and melt viscosity of molten plastic composites were measured in triplicate using a CEAST Model 7024.000 melt flow indexer according to ASTM D 1238-04C [23] through a 2.0955 mm Ø × 8 mm die, at 190°C, and load of 15 kg. Dynamic rheological measurements (elastic modulus ( $G'$ ), viscous modulus ( $G''$ ), and complex viscosity ( $\eta^*$ )) were performed on a Bohlin CVO 100 rheometer, using serrated parallel plates (25 mm Ø), in an oscillating mode with an extended temperature control module on disc (3 mm × 25 mm Ø) samples. Experiments were performed in the linear viscoelastic region. Measurements were carried out at 180°C in the frequency range of 0.01 to 100 Hz at an applied strain of 0.5% [24]. Data were analyzed using the Bohlin rheology v6.51 software.

#### 2.2.3 Thermal characterization

Thermo gravimetric analysis (TGA) was conducted using a Perkin Elmer TGA 7 instrument. Specimens (4-5 mg) were analyzed at a heating rate of 20°C/min from 50 to 800°C in a N<sub>2</sub> atmosphere (30 mL/min) and analyzed using Pyris v8 software (Perkin Elmer). Differential scanning calorimetry (DSC) was performed on samples (4-6 mg, in duplicate) using a TA Instruments model Q200 DSC with refrigerated cooling. The samples were (i) equilibrated at 70°C (3 min) then ramped to 180°C at 10°C/min, held isothermally for 3 min, (ii) cooled to 70°C at 10°C/min and held isothermally for 3 min and the cycles repeated [16]. Data were analyzed using TA Universal Analysis v4.4A software. The degree of crystallization of HDPE was calculated from the ratio of the melting enthalpy ( $\Delta H_f$ , 105-145°C) of the sample to  $\Delta H_f = 293$  J/g of 100% crystalline HDPE [25].

Dynamic mechanical analysis (DMA) was performed in 3-point bending mode (15 mm span) on rectangular samples (3 × 6 × 20 mm<sup>3</sup>) using a Perkin Elmer DMA-7 instrument (1 Hz and 0.1% strain) with refrigerated cooling from -50 to 115°C at a ramp rate of 3°C/min. Interfacial adhesion was evaluated by an adhesion factor



(A) determined from DMA data at 25 and 40°C according to Kubat et al. [26] as follows:

$$A = (1/(1-V_f)) (\tan \delta_c / \tan \delta_m) - 1 \quad (2)$$

where, c and m subscripts represent composites and HDPE matrix, and  $V_f$  is the fiber volume fraction:

$$V_f = (W_f \rho_m) / (W_f \rho_m + W_m \rho_f) \quad (3)$$

Where,  $W_f$  is weight of corncob,  $W_m$  is the weight of HDPE,  $\rho_f$  is the density of fibers and  $\rho_m$  is the density of HDPE (0.95 g/cm<sup>3</sup>). The  $\rho_f$  (<2 mm = 1.458 g/cm<sup>3</sup> and <0.5mm = 1.456 g/cm<sup>3</sup>) was determined by gas pycnometry (1.3 g, degassed for 1 h at 104 °C) using an Ultrapycometer 1000 (Quantachrome) with N<sub>2</sub>.

### III. RESULTS AND DISCUSSION

#### 3.1 Properties of corncob particles

The corncob samples had a CH<sub>2</sub>Cl<sub>2</sub> extractives content of 0.82% which is higher than that obtained by Pointner et al. (2014) at 0.3% but lower than 16% recorded by Ogah et al. (2015) who used a polar solvent system. Extractives can act as plasticizing agents and can reduce the MFR of the plastic composites [27], however, at this low level it is not likely to greatly influence MFR. The corncob lignin content was 15.2% while the ash content was 9.3%. The lignin value compared favorably with 11 - 23% obtained by Ogah et al. [11], Opara et al. [4], Pointner et al. [10] and Luo, et al. [6]. The ash content of 9.3% obtained in this study was higher than 1 - 4% recorded in the literature [4,6,10,11].

The lengths of the <2 mm and <0.5 mm screened corncob particles were 539 ± 500 µm and 271 ± 250 µm, respectively. The widths were 298 ± 290 µm and 140 ± 130 µm, respectively (Fig. 1). The calculated aspect ratios for the <0.5 and <2 mm fibers were comparable at 2.1 and 1.8, respectively.

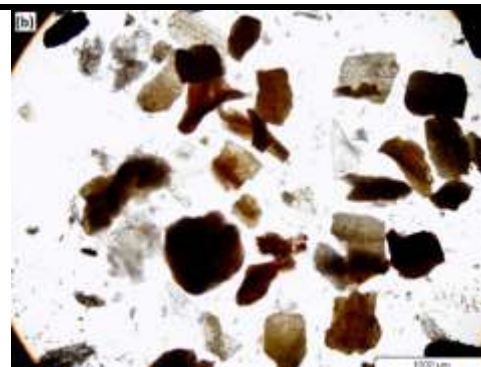


Fig. 1: Optical micrographs of screened (a) <2 mm and (b) <0.5 mm corncob particles (40×, scale bar 1 mm)

#### 3.2 Density and flexural properties

The densities of the composites are shown in Table 1. As shown, composites made from <2 mm particles was 17% lower than that made from <0.5 mm particles (1056 kg/m<sup>3</sup>). A similar decrease in density was observed in wood plastic composites (WPC) made with <2 mm versus <0.5 mm screened particles [19]. The lower density could be attributable to incomplete filling of the voids and/or lumens in the larger screened particles during extrusion. The results of the flexural tests on the corncob HDPE composites are shown in Table 1. As shown, the flexural strength of the <2 and <0.5 mm corncob composites were respectively, 21.2 ± 1.4 and 31.7 ± 1.7 MPa. While the flexural moduli were 1.1 ± 0.1 GPa (<2 mm particles) and 1.4 ± 0.1 GPa (<0.5 mm particles). The flexural properties were comparable to the literature (strength of 25 - 45 MPa and modulus of 1.8 - 2.7 GPa) for corncob-HDPE composites [4,6]. Composites made from <0.5 mm particles recorded significantly higher flexural strengths and moduli than those made from <2 mm particles. This observation could be ascribed to the higher density of the composites made from <0.5 mm particles which could have enhanced interfacial bonding between the cob particles and the plastic matrix (Table 1). This is more so since composites made from <0.5 mm particles have larger surface area and low stress concentration and will thus have higher strength properties [12,13]. The energy at maximum load (EML) of the composites were significantly different at 0.34 J versus 0.41 J (Table 1).

Table 1: Flexural properties and density of corncob plastic composites made with <0.5 and <2 mm particles

Composite	Density (kg/m <sup>3</sup> )	Strength (MPa)	Modulus (GPa)	Energy (J)
<0.5 mm particles	1056.4 <sup>a</sup> (38.1)	31.7 <sup>a</sup> (1.7)	1.4 <sup>a</sup> (0.1)	0.406 <sup>a</sup> (0.005)
<2 mm particles	879.7 <sup>b</sup> (23.0)	21.2 <sup>b</sup> (1.4)	1.1 <sup>b</sup> (0.1)	0.343 <sup>b</sup> (0.005)

Means with the same letters and columns are not

significantly different. Standard deviations are given in parentheses.

### 3.3 Melt flow and rheological properties

The melt processing behavior (MFR and melt viscosities) of the composite blends were determined using a 15 kg load in order to get a reasonable flow rate. The MFR were 3.1 and 4.0 g/10 min and melt viscosities were 24.0 and 18.0 kPa·s, for the composites made with <0.5 and <2 mm particles, respectively (Table 2). These values compared favorably with those reported for WPC (0.35 - 2.90 g/10 min; 12.7 - 107 kPa·s) [13]. Composites made from <2 mm particles recorded significantly higher MFR and lower viscosity than those from <0.5 mm particles. A similar observation was seen in WPC [19] and bamboo HDPE composites [24] made with <2 mm versus <0.5 mm screened particles. This phenomenon could be because of the lower density and an increase in the unfilled regions in the composites as observed by Stark and Berger [28].

Table 2: Melt flow rate (MFR) and melt viscosities of corncob plastic composites made with <0.5 and <2 mm particles

Composite	MFR (g/10min)	Melt viscosity (kPa·s)
<0.5 mm particles	3.1 <sup>b</sup> (0.10)	24.0 <sup>a</sup> (0.60)
<2 mm particles	4.0 <sup>a</sup> (0.17)	18.0 <sup>b</sup> (0.75)

Means with the same letters and columns are not significantly different. Standard deviations are given in parentheses.

Dynamic rheological measurements were also obtained on the corncob composites and HDPE melts at 180°C. Fig. 2 shows the  $G'$ ,  $G''$  and  $\eta^*$  as a function of frequency for the composites and HDPE at 180°C. For all melt samples  $G'$  and  $G''$  were shown to increase with frequency. The addition of <0.5 mm corncob particles to HDPE increased  $G'$  5-fold and  $G''$  4-fold (at 0.1 Hz). At lower torsional frequency, the  $G'$  was lower than  $G''$ , indicating a viscous response and the molten samples were more fluid. Incorporation of corncob particles in HDPE increased  $G'$  and  $G''$  and narrowed the gap between them at low frequency, because of the rigid character of the corncob fibers. Corncob particle size had a distinct effect on the dynamic rheological behavior of the composite melts. The cross-over point of  $G'$  and  $G''$  ( $G_c = G' = G''$ ) was shown to occur at a lower frequency for the corncob composites than for HDPE. The  $G_c$  decreased from 0.37 Hz for HDPE to 0.06 Hz for <2 mm corncob composites to 0.02 Hz for <0.5 mm corncob composites (Fig. 2), indicating that particle addition lowered the frequency at which the material transferred from viscous

to elastic behavior. This phenomenon was also observed in rheological measurements on WPC [29] and bamboo HDPE composite [24] melts.

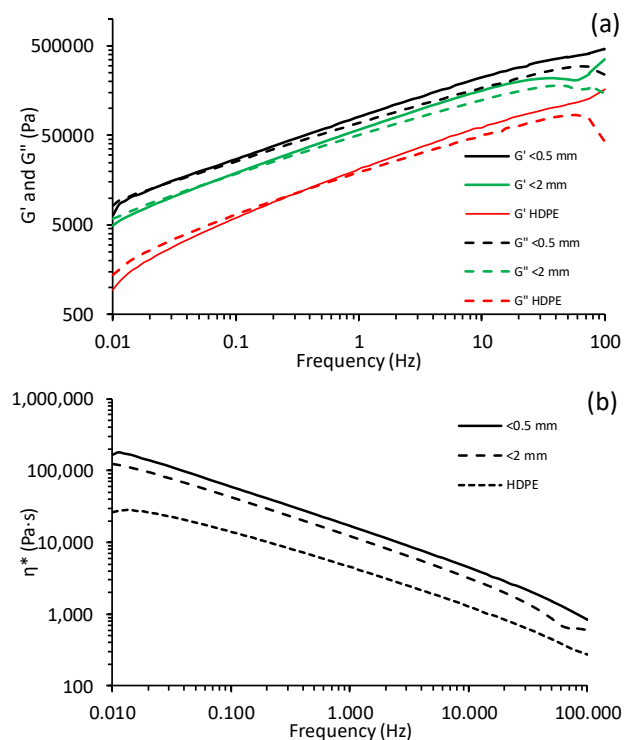


Fig. 2: Dynamic rheology showing (a) elastic ( $G'$ ) and viscous moduli ( $G''$ ) and (b) complex viscosity ( $\eta^*$ ) as a function of frequency for HDPE and corncob composites made with <0.5 and <2 mm particles at 180°C.

The flow curves showed that  $\eta^*$  decreased with an increase in frequency, showing a shear thinning behavior, for HDPE and the composite melts (Fig. 2). The  $\eta^*$  (at 1 Hz) was also increased from 4.54 kPa·s for HDPE to 12.2 kPa·s for the <2 mm corncob composites to 16.9 kPa·s for the <0.5 mm corncob composites. This observation of higher  $\eta^*$  for the <0.5 mm corncob composite melt is consistent with those obtained by MFR. The higher viscosity could be explained by a higher particle-matrix interaction in the melt due to a larger surface area. These same trends in  $\eta^*$  were observed for bamboo HDPE composites made with different particle sizes [24].

### 3.4 Water absorption and thickness swelling

The water soak (WA and TS) properties of the composites were measured with time (Fig. 3 and Table 3). Fig. 3 shows the WA of the corncob composites reaching a pseudo-equilibrium state in accordance with Fickian behavior [30]. The  $D_f$  for the composites made with <2 mm corncob particles ( $4.84 \times 10^{-9} \text{ m}^2/\text{s}$ ) was about 3-fold higher than that for the <0.5 mm particles. The respective WA of the <2 mm and <0.5 mm corncob composites was shown to increase from 4.04 to 33.6% and 3.82 to 15.1%

over 61 d. The TS of the <2 mm and <0.5 mm corncob particle composites was shown to increase 2.23 to 6.26% and 1.98 to 5.33%, respectively. These WA and TS values are similar to temporal increases from 1.9 to 22.4 % and 1.7 to 14.1% for WPC [23] and 1.3 to 28.0% and 0.36 to 4.9% obtained by Adefisan and McDonald [19], respectively. Corncob composites made with smaller particle size had the least sorption properties. This may be possibly due to the higher density and improved interfacial interaction with the plastic matrix which resulted in less moisture ingress. Also, the composites made with larger sized particles had 17% lower density and thus had more voids which could result in higher water content in the composites [31].

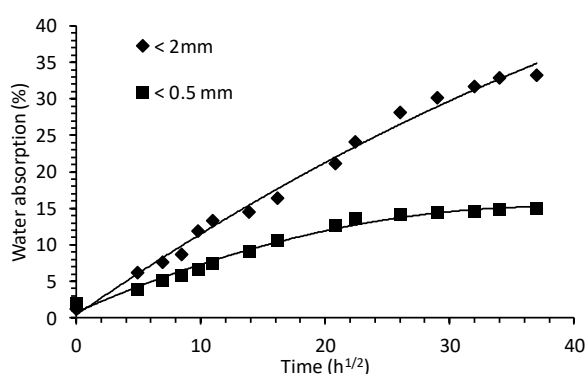


Fig. 3: Water absorption (WA) of corncob HDPE composites with time<sup>1/2</sup>

Table 3: Water soak properties of corncob HDPE composites made with <0.5 and <2 mm particles

Composite	WA (%)		D <sub>f</sub> (10 <sup>-9</sup> m <sup>2</sup> /s)	TS (%)	
	1 d	61 d		1 d	61 d
<0.5 mm particles	3.82 (0.91)	15.01 (4.99)	1.46	1.98 (0.18)	5.33 (0.54)
<2 mm particles	4.02 (0.19)	33.63 (1.04)	4.84	2.33 (0.41)	6.28 (1.15)

Standard deviations are given in parentheses.

### 3.5 Thermal Analysis

The thermal stability of the corncob HDPE composites was evaluated by TGA (Fig. 4 and Table 4). All thermograms show a small weight loss before 100°C, associated with water loss. The degradation stage <400°C of composites can be mainly attributed to the decomposition of chemical components such as hemicelluloses (150-350°C), lignin (250-490°C), extractives and cellulose (275-350°C) [16,18]. From the differential thermogravimetric (DTG) thermograms, the decomposition of HDPE occurred at > 460°C. Composites

made with larger sized particles generally degraded at higher temperatures (274°C) in comparison with those made from smaller sized particle (259°C) indicating higher thermal stability possibly due to mass transfer effects of the larger particles as observed in pyrolysis kinetic studies [34].

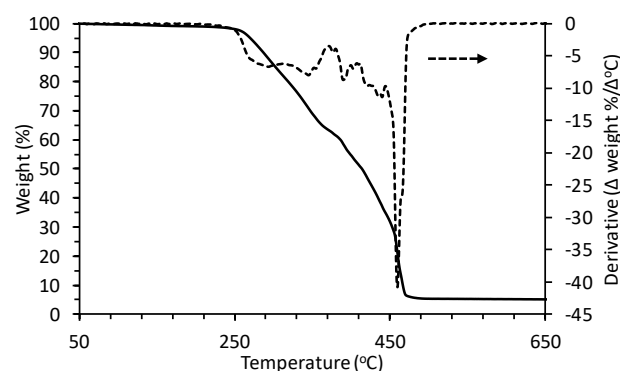


Fig. 4. TGA and DTG graphs of corncob plastic composites made with <0.5 mm particles

Table 4: Thermal degradation behavior of corncob plastic composites made with <0.5 and <2 mm particles

	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	Final
Corncob composite	onset	peak	peak	peak	decomposition
	t (°C)	k (°C)	k (°C)	k (°C)	-sition (°C)
<0.5 mm particles	259	274	343	392	460
<2 mm particles	274	301	360	457	494

The degree of HDPE crystallinity and transition temperature in the corncob plastic composites was determined by DSC and data presented in Table 5. These values were comparable to WPC [13,16,19]. The HDPE crystallinity in the composites made from <2 mm particles was 6% higher than that made from the <0.5 mm particles (65.9%). This may suggest that the larger particles induced more nucleation of HDPE crystals than the smaller particles. Gallagher and McDonald [13], observed a similar increase in crystallinity from 35 to 41% for 50% maple based WPC going from <73 μm to 150-178 μm sized particles. It is speculated that the composites made with <2 mm particles, with a lower packing density than the <0.5 mm fibers, may have more interstitial space to form spherulites and thus a higher crystallinity [33]. The melt temperature (T<sub>m</sub>) for the composites were the same at 132°C. The crystallization temperature were similar at around 119°C.



Table 5: Crystallization and melt temperatures and crystallinity of corn cob plastic composites made with <0.5 and <2 mm particles

Corn cob composites	T <sub>c</sub> (°C)	T <sub>m</sub> (°C)	Crystallinity (%)
<0.5 mm particles	118.4 (0.1)	132.2 (0.1)	65.9 (5.4)
<2 mm particles	118.9 (0.2)	132.1 (0.3)	70.3 (1.1)

Standard deviations are given in parentheses.

The storage modulus ( $E'$ ) of the corn cob composites and HDPE was determined by DMA and the thermograms are shown in Fig. 5 and values at 25°C are given in Table 6. The corn cob composites made with <0.5 mm particles had the highest  $E'$  (at 25°C) value at 56.8 MPa, followed by the composites made with <2 mm particle at 25.1 MPa, and HDPE had the lowest at 19.3 MPa. The damping factor ( $\tan \delta$ ) is also measured by DMA on viscoelastic materials and can be used to give information about the interface between different phases (particle-plastic) in composite materials that affect energy dissipation. The effect of the corn cob particle size on the strength of the particle-HDPE interface was evaluated using  $A$  and determined from DMA data ( $\tan \delta$ ) according to Kubat et al. [26]. The  $A$  values for the corn cob-HDPE composites at 25 and 40°C are given in Table 6. Low  $A$  values means a high degree of interaction (improved adhesion) between the two phases [24,26]. The corn cob composites made with <0.5 mm corn cob particles had the lowest  $A$  (0.28 at 25°C), or good interfacial interaction, compared to composite made with <2 mm corn cob particles (0.33 at 25°C). These results are consistent with the flexural properties and storage modulus ( $E'$ ) data. This trend of getting better adhesion (lower  $A$ ) using smaller particles was also observed in bamboo-plastic composites [24]. This could be attributed to an increased surface area with the smaller particles and not likely attributable to aspect ratio of the particles since they were similar (~2). However, these results are in odds with an increase in HDPE crystallinity for the composites made with the larger particles and cannot be explained.

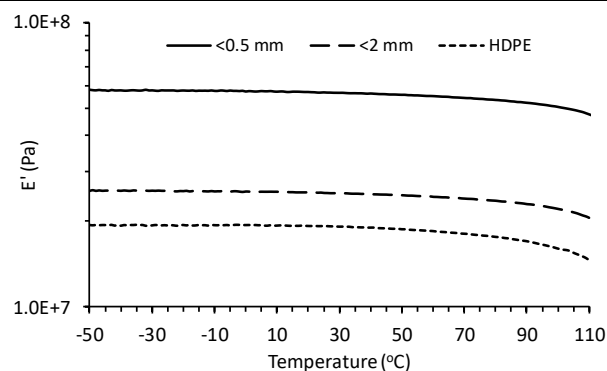


Fig. 5: DMA thermograms of storage modulus ( $E'$ ) of HDPE and corn cob plastic composites made with <0.5 and <2 mm particles

Table 6. Adhesion factor ( $A$ ) and storage modulus ( $E'$ ), determined by DMA, of corn cob plastic composites made with <0.5 and <2 mm particles.

Corn cob composite	$A$ at 25°C	$A$ at 40°C	$E'$ (Pa) at 25°C
<0.5 mm particles	0.28	0.25	$5.67 \times 10^7$
<2 mm particles	0.33	0.29	$2.51 \times 10^7$
HDPE			$1.93 \times 10^7$

#### IV CONCLUSIONS

Extruded natural plastic composites were successfully produced from different sized particle fractions of corn cobs. The extruded composites possessed moderate strength and sorption properties and were thermally stable. Differences in the densities of the composites and fiber size appeared to affect the properties of the fabricated corn cob plastic composites. Composites produced with smaller particle size (<0.5 mm) had superior strength and sorption properties attributable to enhanced interfacial bonding with the plastic matrix. The fabricated plastic composites corn cobs are suitable as building components in Nigeria and the region. For higher performing natural plastic composite materials smaller corn cob particles should be used.

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# Characterization of Soybean Cultivars for Biodiesel Production

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**Abstract**— Due to environmental issues involving the polluting gases emission, Brazil has adopted the policy of using oil and biodiesel. For biodiesel production, the main raw material used in Brazil is soybean oil. The development of the numerous genotypes of this culture has always considered quantitative aspects. The objective was to qualitatively characterize 12 soybean cultivars for biodiesel production. The experimental design was randomized blocks with three replicates. The cultivars were sown in December 2016, in no-tillage system, in Ponta Grossa, Paraná, Brazil (-25.093056, -50.063327 UTM). The analyzed variables were: oil and protein contents, acidity index and specific mass. It was concluded that there were no significant differences among the cultivars for oil and protein contents. For the variables acidity index and specific mass, there were significant differences among the cultivars, being below the limits established by the Brazilian legislation for vegetable oil, but with potential for biodiesel production.  
**Keywords**— acidity index, *Glycinemax*, oil content, protein content, specific mass.

## I. INTRODUCTION

In the global energy context, there is a growing discussion on alternative and renewable sources to traditional sources. The need to change the energy matrix aims to reduce the environmental impacts caused by the use of fossil fuels, especially in the greenhouse gases emission (Rathore et al., 2016).

The term biofuel refers to liquid, gaseous and solid fuels produced predominantly from biomass. They can replace, partially or totally, fuels derived from oil and natural gas in combustion engines or other types of energy generation. Biofuels include energy security

reasons, environmental concerns, foreign exchange savings, and socioeconomic issues related to the rural sector (Demirbas, 2008).

It is easy to predict that in the coming years biofuel will play an increasingly important role in the transport sector. The European Commission has set the proportion of biofuels in total transport fuel to 10% by 2020. In Brazil biodiesel might replace - in part or totally - the mineral diesel for light vehicles, trucks, tractors and generators; with the obligatory mixture expected to reach 10% of the fuel by 2019. The most common way to produce biofuel is through the vegetable oil transesterification (Righi et al., 2016; Souza et al., 2016).

Soybean crop contributes with about 25% of the world production of vegetable oil. It can be used in the human feeding, textile industry, manufacture of paints, cosmetics and biofuels (Rosa et al., 2014).

In the 16,472 accessions of the “EmbrapaSoja” (Brazilian Agricultural Research Corporation) germplasm bank, the oil content in the dry soybean grains ranges from 8 to 25% and the protein varies from 32 to 58%, with respective means of 18 and 44% (Pípulo et al., 2015).

Analyzing the grains chemical composition of nine soybean cultivars, Sbardelotto & Leandro (2008) found average oil values of 11%. The protein, on average, was 38%. Such differences in the chemical composition of the soybean cultivars interferes with the financial return of the processing industry.

Determining the characteristics of 21 soybean cultivars for the biofuel production at different sowing times, Barbosa et al. (2011) concluded that there were significant differences for the oil content among the

cultivars. Values ranged from 18.5 to 21.1%.

According to Administrative Rule N° 795 (December 15<sup>th</sup>, 1993), it is considered degummed oil the one that the phospholipids were extracted. The rule establishes as limit of acid value a maximum of 1.0 mg KOH g<sup>-1</sup> for oil type 1, up to 2.0 mg KOH g<sup>-1</sup> for type 2 and the limit of 3.0 mg KOH g<sup>-1</sup> for type 3; according to ordinance n° 795, MAPA/Brazil.

Evaluating chemical characteristics of 365 soybeans samples of different cultivars produced in three Brazilian states, Costa et al. (2001) stated that there were significant differences. The oil content varied from 18.6 to 19.8%, the protein was between 40.4 and 41.7% and the acidity index was 0.64 to 0.88 mg KOH g<sup>-1</sup>.

Regarding the specific mass, the Brazilian standardization recommends that the value for soybean oil must be between 919 and 925 kg m<sup>-3</sup>, at a temperature of 20 °C; according to normative instruction n°49, MAPA/Brazil.

Studying the thermal stability and thermomechanical behavior of the functionalized nanocomposite of epoxy/organo-clay modified with soybean oil, Sahoo et al. (2015) defined the oil density at 920 kg m<sup>-3</sup>.

Working on the physical-chemical and dielectric characterization of biodegradable oils, Silva et al. (2011) concluded that soybean oil had the acidity index of 0.2 mg KOH g<sup>-1</sup> and the density of 924 kg m<sup>-3</sup>.

Aiming to transpose the limited qualitative analysis of the components of soybean oil production, the objective was to qualitatively characterize grains of 12 cultivars for biodiesel production.

## II. MATERIALS AND METHODS

The experiment was carried out in field conditions, in Ponta Grossa city (PR, Brazil), crop 16/17, under geographic coordinates -25.093056, -50.063327 UTM, at 990 m of altitude, in no-tillage system. The climatological classification according to Köppen is Cfb (Garcia et al., 2000). The soil of the area had a medium texture, according to Table 1, and the routine chemical analysis shown in Table 2. The soil was classified as Cambisol Dystrophic.

The experimental design was in randomized blocks with twelve treatments and three replicates. The treatments consisted of 12 soybean cultivars. Each experimental unit (parcel) has an area of 15 m<sup>2</sup>.

The 12 soybean cultivars used were: 96Y90®, Brasmax Garra IPRO®, BRS 1001 IPRO®, BRS 1003 IPRO®, BS 2606 IPRO®, FTR 2155 RR®, M5705 IPRO®, M6410 IPRO®, NS 5959 IPRO®, NS 6906 IPRO®, TMG 7062 IPRO® and TMG 7262 RR®. They were chosen because they excel in cultivation in the “Campos Gerais” region (PR).

Sowing was carried out on December 9<sup>th</sup> 2016 with 350,000 ha<sup>-1</sup> seeds. The climatic conditions favored the culture development. The harvest was performed with an automated harvester of WINTERSTEIGER® experiments on April 27<sup>th</sup> 2017.

The analyzed variables were: oil and protein contents, acidity index and specific mass. For all the analyzed variables triplicates were made to increase the data reliability.

The grains oil content was determined based on the method presented by IAL (2005). The soybean grain samples were ground in a Marconi® mill, model MA 630/1. For the oil extraction, the mass was measured between 5.0 and 8.0 grams per repetition. The extraction was carried out through the Soxhlet® assembly, using hexane as solvent in a continuous process. The duration of the extraction was 360 uninterrupted minutes, under heating temperature of 80 °C. Values have been converted to percentages.

The protein determination in percentage was based on the calculation of total nitrogen content. The semi-micro-Kjeldahl digestion method, consisting of sulfur digestion, the samples distillation and titration was used (Lima Filho & Malavolta, 1997).

The acidity index was defined based on the volumetric-titrametric method presented by IAL (2005). Such method determines the values of the acidity index in mg KOH g<sup>-1</sup> of oil.

The specific mass was calculated in kg m<sup>-3</sup>, using a DMA 4500M digital densimeter of Anton Paar® brand. The analysis was performed at a temperature of 20 °C, following the ASTM D5002 standard.

The data were subjected to Hartley test to verify the homoscedasticity of the variances and the Shapiro-Wilk test to examine the data normality. The measured variables were subjected to the Fisher-Snedecor and Scott-Knott tests, with a confidence level higher than 95% of probability.

## III. RESULTS AND DISCUSSION

The Hartley test pointed to the homoscedasticity of the variances and the Shapiro-Wilk test confirmed the data normality, for all the studied variables. There was no difference for blocks for all the analyzed variables, demonstrating the homogeneous conditions in which the soybean cultivars were developed.

When analyzing the oil content, the mean content was 17%. Even with cultivars with different characteristics, there was no significant difference in the analysis of variance among the treatments (Table 3).

The values are lower than the average of 19.2% of oil content in the soybean grains presented by Costa et al. (2001), 18.0% presented by Pípolo et al. (2015) and the 18.5% tabulated by Barbosa et al. (2011). However, they



are higher than the average of 11% determined by Sbardelotto & Leandro (2008) when analyzing the grain chemical composition of nine soybean cultivars.

The results of this experiment contradict Costa et al. (2001) and Barbosa et al. (2011) who, when studying the behavior of several soybean cultivars in order to produce biofuels, concluded that there were significant differences in the oil content among the samples. The similar and lower data, obtained in this work, can be attributed to the low soil fertility where the soybean was cultivated (Tables 1 and 2).

In the same way as the oil content, the protein content did not differ among the cultivars, with a confidence level higher than 95% of probability. The average result was 49%.

The mean obtained protein content is higher than the 44% determined by Pípolo et al. (2015), 38% measured by Sbardelotto & Leandro (2008) and the 41% calculated by Costa et al. (2001).

The differences among the results of the reviewed papers and from this experiment can be attributed to genotypic and phenotypic issues, evidencing the importance of evaluating the qualitative characteristics of soybean grains in order to analyze the impact on the financial return in the processing industry.

The data collected on the acidity index highlighted the highest value of the NS 5959 IPRO® cultivar with 15.7 mg KOH g<sup>-1</sup>. Second, M6410 IPRO® (11.7 mg KOH g<sup>-1</sup>) and BRS 1001 IPRO® (11.0 mg KOH g<sup>-1</sup>) followed by Brasmax Garra IPRO® (7.0 mg KOH g<sup>-1</sup>). Values dropped to 4.7 (FTR 2155 RR®) and 4.0 mg KOH g<sup>-1</sup> (96Y90®). The other cultivars did not differ significantly from each other, with an average of 2.2 mg KOH g<sup>-1</sup>.

Based on the Administrative rule N°. 795 (December 15<sup>th</sup> 1993), none of the cultivars could be classified as degummed oil of type 1. Only three cultivars would be at the limit of type 2 and two cultivars below 3.0 mg KOH g<sup>-1</sup> for type 3; according to ordinance n° 795, MAPA/Brazil.

The data obtained in the experiment also overcame those presented by Costa et al. (2001), which were 0.64 to 0.88 mg KOH g<sup>-1</sup> and the 0.2 mg KOH g<sup>-1</sup> acidity index indicated by Silva et al. (2011).

Thus, degummed oils from the cultivars could be used for biodiesel production, provided that there was basic catalyst consumption in the transesterification reaction, as stated by Righi et al. (2016) and Souza et al. (2016).

The specific mass of the cultivars was 96Y90®, Brasmax Garra IPRO®, BRS 1001 IPRO®, BRS 1003 IPRO®, FTR 2155 RR®, M5705 IPRO®, M6410 IPRO®, NS 5959 IPRO®, NS 6906 IPRO® and TMG 7262 RR®; with an average of 919 kg m<sup>-3</sup>. The lowest values were presented by cultivars BS 2606 IPRO® and TMG 7062

IPRO®, with an average of 916.

The highest results were at the lower limit of Brazilian standardization, which recommends the specific mass variation between 919 and 925 kg m<sup>-3</sup>; according to normative instruction n° 49, MAPA/Brazil. Likewise, they did not reach the 920 kg m<sup>-3</sup> reached by Sahoo et al (2015) nor the 924 kg m<sup>-3</sup> presented by Silva et al. (2011).

#### IV. CONCLUSIONS

There were no significant differences among the cultivars for oil and protein contents, with mean values of 17 and 49%, respectively.

For the variables acidity index and specific mass there were significant differences among the cultivars, falling below the limits established by the Brazilian legislation for vegetable oil, but with potential for biodiesel production.

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Table.1: Sand, silt and clay contents of the soil where the experiment was carried out. Ponta Grossa (PR, Brazil)

Sand (g kg <sup>-1</sup> )	Silt (g kg <sup>-1</sup> )	Clay (g kg <sup>-1</sup> )
615	85	300

Table 2: Soil chemical analysis of the field trial area, Ponta Grossa (PR, Brazil), in the harvest season 2016/2017<sup>1</sup>

pH	C	Al <sup>3+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	K <sup>+</sup>	H+Al	CEC	V	P
CaCl <sub>2</sub>	g dm <sup>-3</sup>	.....cmolc	dm <sup>-3</sup> .....					%	mg dm <sup>-3</sup>
4.3	25.0	1.7	1.7	0.4	0.3	9.0	12.1	26.4	49.8

1 - C organic = Walkley-Black; H + Al = buffer solution SMP; Al, Ca, Mg exchangeables = KCl 1 mol L<sup>-1</sup>; P and K = Melich 1 and effective CEC

Table.3: Oil and protein contents, acidity index and specific mass (20 °C) of soybean cultivars [*Glycine max* (L.) Merrill] in the harvest season 2016/2017, Ponta Grossa (PR, Brazil)<sup>1</sup>

Cultivars	Oil content (%)	Protein content (%)	Acidity index (mg KOH g <sup>-1</sup> )	Specific mass (kg m <sup>-3</sup> )
96Y90®	16 a <sup>2</sup>	51 a	4.0 d	919 a
Brasmax Garra IPRO®	16 a	45 a	7.0 c	921 a
BRS 1001 IPRO®	17 a	48 a	11.0 b	920 a
BRS 1003 IPRO®	18 a	51 a	2.5 e	920 a
BS 2606 IPRO®	18 a	49 a	1.6 e	917 b
FTR 2155 RR®	16 a	49 a	4.7 d	920 a
M5705 IPRO®	17 a	51 a	3.2 e	918 a
M6410 IPRO®	18 a	49 a	11.7 b	921 a
NS 5959 IPRO®	18 a	50 a	15.7 a	919 a
NS 6906 IPRO®	17 a	49 a	1.8 e	919 a
TMG 7062 IPRO®	17 a	49 a	1.8 e	915 b
TMG 7262 RR®	17 a	47 a	2.6 e	919 a
Coefficient of variation (%)	5.1	7.3	24.3	0.1

1 - Not significant for blocks by the Fisher-Snedecor test, for all the analyzed variables (p > 0,05).

2 - Means followed by the same letter in the column do not differ by the Scott-Knott test (p > 0,05).

# External Corrosion of the bottom plate of Petroleum and Derivative Storage tanks on Compacted Soils

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**Abstract** —Inspections carried out on petroleum and derivative storage tanks on compacted soils have shown external corrosion on the bottom plates of the tanks despite cathodic protection by an impressed current. The holes or cavities in the outer plates of the bottom of the tank (in contact with the soil) result in oil leakage, thereby having significant environmental impacts. The objective of this paper is to show, in laboratory experiments, that cathodic protection is not reliable when there are voids or spaces between the plates and the soil. In addition, it proposes the application of a thermal spray with aluminium in the parts of the bottom plates that are in contact with the soil to protect these plates from localised corrosion. It is important to note that the welding temperature was 320°C, without affecting the aluminium coating applied by the thermal spray.

**Keywords** — corrosion, oil storage tank, compacted soil, cathodic protection, laboratory experiment.

## I. INTRODUCTION

The petroleum storage tanks evaluated in this study are subjected to near-atmospheric pressure, which is why they are also known as “atmospheric storage tanks”, made of plate carbon steel, cylindrical, vertical and supported on compacted soils. They are built from 100 barrels (16 m<sup>3</sup>) to large tanks with approximately 550,000 barrels (87,500 m<sup>3</sup>) [1-3].

Figure 1 shows a scheme of a storage tank supported on compacted soil, with the bottom plates being protected by cathodic protection system by an impressed current (inert anode).

The most widely used technique for tank bottom protection is impressed current cathodic protection, being predicted in international standards of storage tanks, such as API RP 651: 2014 [4].

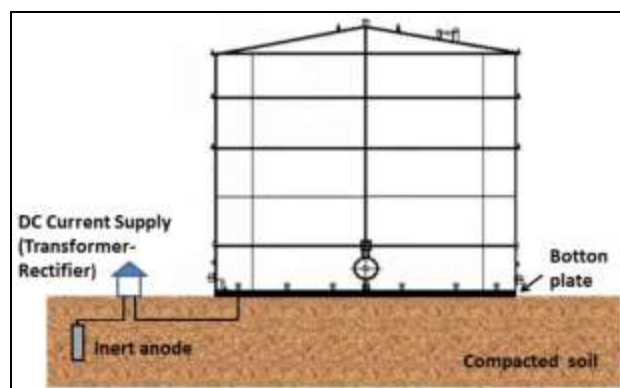


Fig. 1 - Scheme of a storage tank supported on compacted soil with the bottom plates protected by cathodic protection system

The difficult access to the area under the bottom of the tanks for the periodic measurement of the protection potentials obtained through the use of cathodic protection impedes the monitoring of its effectiveness. In order for the impressed current cathodic protection to be effective as anticorrosion protection, it is necessary that the surface is protected and the anode is in contact with a continuous electrolyte [5-7].

Corrosion in the storage tank bottom is detected through inspections carried out periodically.

Figure 2 shows the results of the loss of thickness of the bottom plate of a 40-m diameter diesel storage tank supported on compacted soil by non-destructive inspection, the so-called MFL (Magnetic Flux Leakage). This technique consists of the detection, evaluation and measurement of the magnetic flux due to the presence of discontinuities in the carbon steel plate, such as loss of thickness and corrosion holes [8, 9].

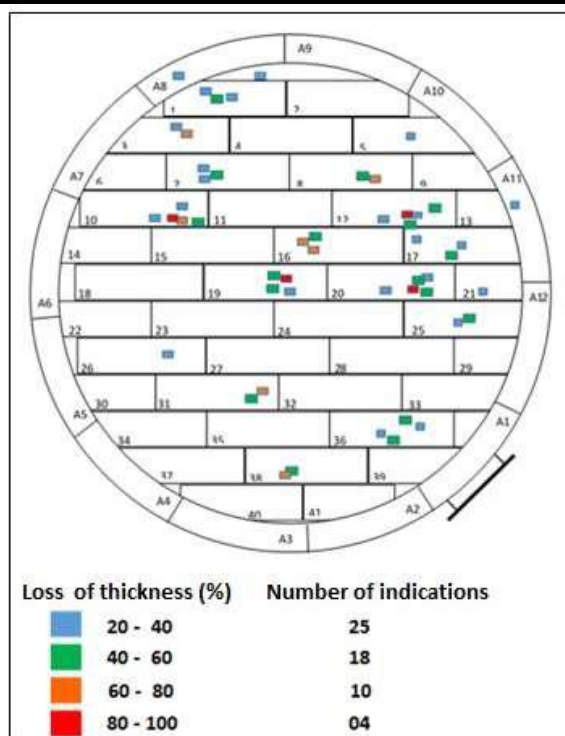


Fig. 2 - Loss of thickness (%) in carbon steel plates of the bottom of a diesel storage tank by the non-destructive inspection (method Magnetic Flux Leakage).

Figure 3 shows the circular cut made on the bottom plate, which reveals that there are voids or gaps between the plate and the soil due to the undulating behaviour of the bottom plates and any possible soil settling.



Fig.3: The void or gap between the bottom plate and the soil.

Figure 4 shows the external localised corrosion and the loss of the thickness of the cut carbon steel plate, demonstrating that cathodic protection was inefficient.

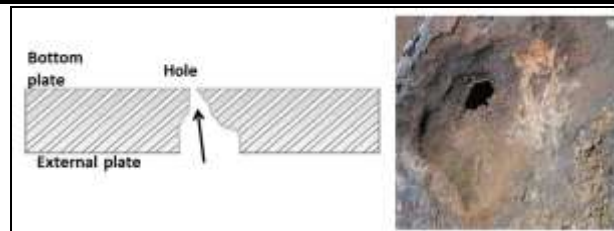


Fig. 4: External localised corrosion and loss of the thickness of the cut carbon steel plate.

This paper aims to demonstrate the inefficiency of impressed current cathodic protection when there are voids or spaces between the bottom plates and the compacted soil. It was also evaluated the application of the aluminium thermal spray on the outer faces of the bottom plates to inhibit or interrupt the localized corrosion.

## II. MATERIALS AND METHODS

For practical verification of the possible reason for the ineffectiveness of the cathodic protection system by impressed currents, and to analyse the use of aluminium thermal spray as anticorrosion protection for the external face of the bottom plates of oil storage tanks, the laboratory tests described below were performed.

### 2.1 Evaluation of impressed current cathodic protection

This experiment consisted of the application of an impressed current on a carbon steel plate (20 x 30 cm, thickness 6.35 mm) uncoated and supported on sand moistened with 3.5% sodium chloride solution. The use of the wet sand, representing the compacted soil, had the purpose of increasing the conductivity, aiming at the development of accelerated tests. For the application of the electric current to the carbon steel plate, a DC rectifier was used and a graphite anode was inserted in the sand (Fig. 5). As seen in Figure 5, the sand was removed from underneath the steel plate to simulate a space or void without electrical conductivity to demonstrate the lack of cathodic protection in this region

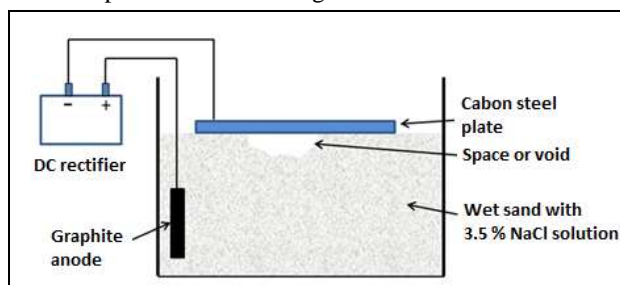


Fig.5: Evaluation of impressed current cathodic protection.

After assembly of the steel plate on the wet sand, the direct current was applied through a rectifier until a



potential plate/electrolyte of 0.91 V was obtained, which was more negative than -0.85 V, measured with the reference electrode (Cu/CuSO<sub>4</sub>) as shown in Figure 6, illustrating the experiment in progress. The duration of this experiment was 30 days. After the experimental period, the carbon steel plate was evaluated.

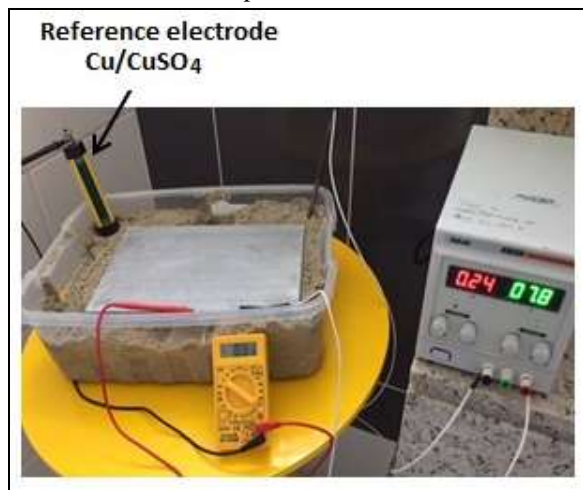


Fig. 6: Evaluation-impressed current cathodic protection

## 2.2 Determination of the temperature in the overlapping plate during welding

This experiment was performed in the workshop and on a small scale, consisting of the welding of the overlapping plate to represent the tank bottom in order to verify the maximum temperature reached on the outer face of the plates. Via measuring this temperature, was able to determine whether the applied aluminium anticorrosive coating could be damaged during the welding process, as shown in Figure 7.

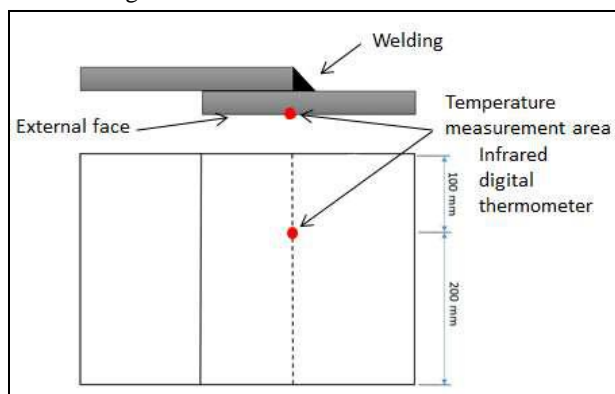


Fig. 7: Temperature measurement. Side view and bottom view of plates with overlapping joints.

Were used 6.35 mm carbon steel plates to represent the plates used at the bottom of the oil tanks. Temperature measurements were taken during the welding, using an infrared digital thermometer.

For welding, an E-7018 coated electrode was used in two passes. For the first pass, a current of 80 A and a voltage of 24 V was used; for the second passage, a current of 120

A and a voltage of 24 V was used. Welding speed was measured during the execution of the passes, with a value of 2.3 mm/s for the first pass and 2.6 mm/s for the second pass. In this way, the welding energy of the first pass was 643 J/mm, while that for the second pass was 852 J/mm, considering an efficiency of the process of 77%.

## 2.3 Evaluation of aluminium thermal spraying on carbon steel plates immersed in sodium chloride solution

The ASTM 283C [10] carbon steel specimens were initially prepared with abrasive blasting with aluminium oxide to achieve the Sa3 cleaning degree. Thermal sprinkling of aluminium was done via the Arc Spray Process, which consists of forming an electric arc as a heat source that can reach 4,000°C to melt and sprayed the two aluminium wires, 3.2 and 1.6 mm in diameter, with a velocity of 10 cm/min with a jet of compressed air directed to the arc area by projecting the atomized aluminium particles onto the carbon steel surface, forming a 600 µm thick aluminium coating.

A 2 cm strip was removed from the surface coated with the aluminium thermal spray to evaluate the galvanic protection exerted by the aluminium with the carbon steel plate. The other side and the sides were coated with a thick epoxy resin layer as shown in Figure 8, considering that this sample will be immersed in 3.5% sodium chloride solution. The function of the epoxy paint is to insulate the exposed surface of the carbon steel, which was not evaluated in this study.

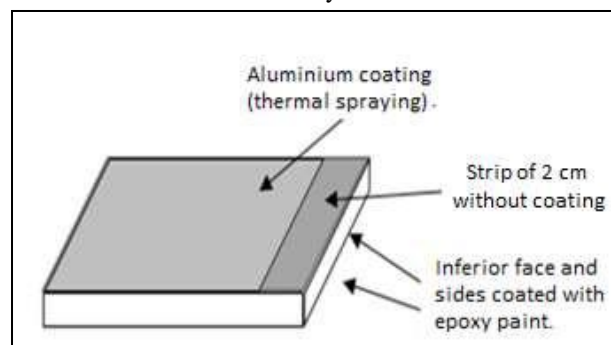


Fig.8: Aluminium-coated sample prepared for immersion in 3.5% NaCl solution.

The samples were immersed in saline solution for 3 months to accelerate the corrosive process and to provide qualitative information on the performance of aluminium-coated plates.

## III. RESULTS AND DISCUSSION

As shown in Figure 9, the sample investigated after 30 days showed that the area that was not supported by the sand suffered intense generalised corrosion, while the other part was totally protected via cathodic protection by the impressed current. This suggests that the causes of



ineffective tank bottom plates are linked to the continuity of the contact of the plate with the compacted soil. According to Gentil [11] and Mainier et al. [12], the electrical connection and the electrolyte continuity are the basic and fundamental requirements of cathodic protection. Any voids or spaces may lead to a loss of corrosion protection.

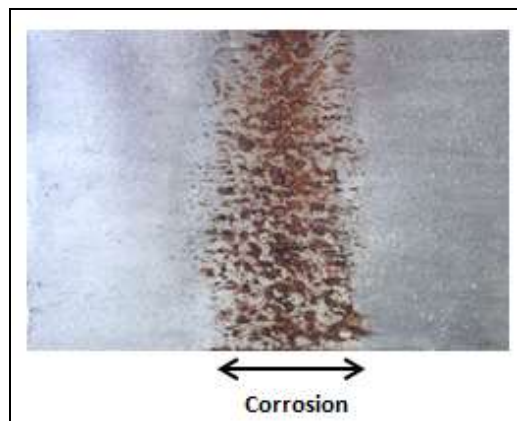


Fig. 9: Aspect of the area of the plate that was not supported in the experiment described in Figure 5.

The temperatures obtained in the welding of the carbon steel plates were 295°C in the first pass and 320°C in the second pass. This test aims to represent the welding of the bottom plates in the construction of an oil storage tank. According to the Petrobras Standard N-2568: 2011 [13], thermal spray aluminium coatings can be used at temperatures of up to 600°C, meaning that welding would not damage the anticorrosive performance of this coating. Figure 10, below, illustrates the immersion of the aluminium-coated carbon steel plate in 3.5% NaCl solution for 3 months, showing the good performance of the galvanic protection exerted by the aluminium in relation to the 3 cm strip which was not coated and had no localised corrosion.

Figure 11 shows another plate of aluminium-coated steel, also immersed in 3.5 % NaCl solution, where phenolphthalein solution droplets were added to show the efficient cathodic protection of the aluminium as evidenced by an intense pink coloration, based on the following electrochemical reactions:

Anodic reaction:  $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}^{3+}$

Cathodic reaction:  $2 \text{H}_2\text{O} - 2 \text{e}^- \rightarrow \text{H}_2 + 2 \text{OH}^-$  (intense pink colour).

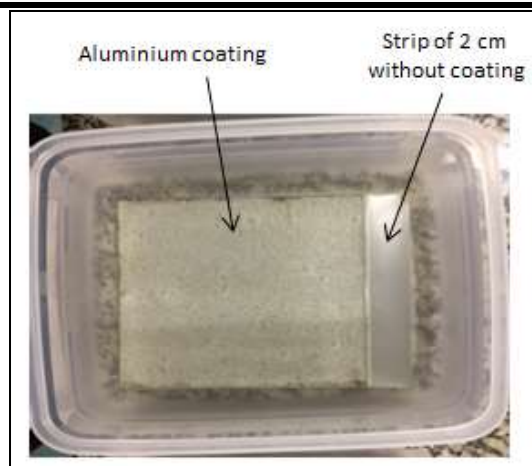


Fig. 10: Carbon steel plate coated with aluminium in 3.5% NaCl solution.

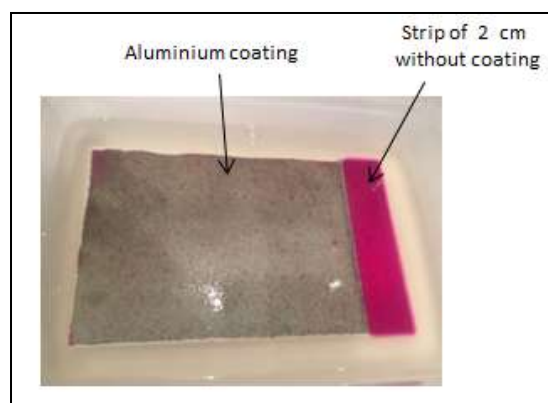


Fig. 11: Carbon steel plate coated with aluminium in 3.5% NaCl solution with phenolphthalein solution droplets.

#### IV. CONCLUSIONS

Analysis of the cathodic protection by impressed current as anti-corrosion protection for the outer face of the bottom plates of oil storage tanks indicates that a possible reason for its inefficiency is the absence of a continuous electrolyte in contact with the entire surface of the bottom plate. Such a scenario can be generated by distortions of the bottom plates as a function of welding; causing some areas of the plates not rest directly on the compacted soil, impeding cathodic protection.

The highest welding temperature of 320°C was observed during the execution of the second pass. This allows the use of plates coated with aluminium thermal spray that are not altered by welding temperatures and at the same time are protected against corrosion.

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# Modeling Architectures and Reference Models: Development and Maintenance Open Source ERP

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**Abstract** — *The adoption Enterprise Resource Planning (ERPs) by small and medium-sized businesses may not possible its cost. At same time, whenever adapt ERP specific needs company, user becomes dependent developers due to the lack access and knowledge respective code. Free and open source software can promote advantages companies, however, for their adoption, it is necessary to develop techniques tools facilitate implementation and maintenance code. This article highlights the importance of defining modeling architectures and reference models for development and maintenance open source ERPs, especially the ERP5 project.*

**Keywords** — *ERP. open code. business modeling.*

## I. INTRODUCTION

Organizations today must vigilant keep up market developments increasingly competitive environment. Options for companies plan their resources a better planning of processes is implementation Management Information Systems, also called ERPs (Enterprise Resource Planning), which can material and human resources company.

However, the price of such systems may be a deterrent to small and medium-sized businesses wishing to obtain this feature. Also, the adequacy of ERP modules according to each organization's characteristics may become important

for their competitiveness, but closed systems make companies dependent on the payment of these services to the system's proprietary developers for adaptations.

Open free software can alternative for small and medium-sized businesses reduce costs, example by using open source ERPs. Another advantage is the possibility of adapting the software, allowing users to adjust processes or modules of the system to the reality of their organization by changing the open source, without being dependent on proprietary developers of closed codes.

However, there are some difficulties for the adoption in practice of these ERPs related to the generation of these codes and the implantation of the systems in the company. These difficulties have been addressed in the ERP5 project (Carvalho, 2003). One of the proposals is the use of a modeling architecture and reference models, since the documentation and the good understanding of business processes and the flow of information, which were considered when defining requirements and generating original codes, are essential facilitate definition requirement an enterprise to change relative codes.

This article aims to highlight the need to define modeling architectures and reference models to facilitate the change of open source ERP codes. Thus, after this introduction, a brief evolution of production management support systems and the ERP5 project is presented. The following

are some comments about software engineering, modeling architecture, reference models for companies and the UML language. Finally, it is presented Aggregate Planning modeling shows a prototype generated from the UML modeling, followed by the final considerations.

## II. EVOLUTION COMPUTER SYSTEMS PRODUCTION MANAGEMENT

MRP (Material Requirements Planning), Also called MRP I, proposed Joe Orlicky in the early 60's and came up the purpose of computationally executing materials planning activities, this system being the flow of base material (GOULART, 2000).

Nevertheless, in the 1970s, this system evolved alongside the development of information technology. A computational system emerged with a broader scope, performing the main activities of production planning and control, and was renamed MRPII (Manufacturing Resources Planning).

MRP II is considered system which decision making highly centralized and based basic principle that all programs established the system fulfilled as faithfully as possible, becoming less flexible to the variation of work by the labor (CORRÊA et al., 2000).

For Goulart (2000) MRP II be a hierarchical management system, since the long-term plans are level of successive detailing, this system can reach specific components and machines.

In the United States from 1990 onwards and in Brazil after 1996 emerged ERPs (Enterprise Resource Planing) with the main purpose of integrating several areas of the company. According to Heizer and Renzer (2001) MRP II systems that connect customers to suppliers are called ERPs. When we implement an ERP, rather than putting a new program on the company's computers, you are defining or adopting a work methodology, a workflow.

## III. ENTERPRISE RESOURCE PLANING 5

The case of Compiere ([www.compiere.com.br](http://www.compiere.com.br)) and the ERP5 project ([www.erp5.org](http://www.erp5.org)). The latter is a free-code ERP project that aims to offer a high-tech, low-cost solution for SMEs. The ERP 5 System is currently developed by a group of companies and educational and research institutions from France and Brazil. This system uses the Zope platform and is totally object-based, workflow and Web technologies.

According to Carvalho (2003) it has five innovative technologies:

- Multi-system is multi-user, multi-organization, multi-language, multi-currency, multi-cost and multi-scenario;
- Meta- provides several levels of detail for the same management process;

- Distributed - uses advanced synchronization mechanisms that allow the distribution and sharing of data without the need for permanent connection to the network;
- Object-based - the use of a set of objects allows modeling and implementation of complex decision support systems;
- Free - all information generated, technologies and methodologies developed, are freely available from the project website.

According to Solanes and Carvalho (2003), the ERP5 architecture incorporates advanced concepts such as object-oriented database and content management system, synchronization of data between different installations, and a clear method modeling method and, consequently, of source code generation.

ERP5 defines an abstract business management model, and this model is based on five classes (SOLANES and CARVALHO, 2003):

- Resource: describes an abstract resource in a business process (such as individual skills, products, machines, etc.). Relationships between nodes define bundles of materials as well as prototypes.
- Node: can receive and send resources. They may be relative to physical entities (such a manufacturing facility) or abstract entities (such a bank account). Metanodes contain other nodes, such as companies.
- Movement: describes a movement of resources between given moment for a given duration. Example a move might send raw material from stock to factory.
- Path: describes way that node accesses features that needs. They are abstract, being used planning.
- Item: physical instance asset.

ERP5 is based on a template that can link anything to a category. Some examples include a category of resources (such as services, raw materials, skill or money) or a category of organizations (such as a group of companies, a group of people or a retail chain) (SOLANES and CARVALHO, 2003).

For the development of a good Information System, as well as for the development of ERP 5, it is necessary to use adequate techniques of Software Engineering.

## IV. ENGINEERING SOFTWARE AND ANALYSIS REQUIREMENTS

According Azevedo (2003), first definition software engineering proposed Fritz Bauer establishment and use of solid engineering principles that software can be obtained economically is reliable works efficiently in real machines.

For Pressman (2003) software engineering encompasses three fundamental elements: methods, tools and

procedures. Independent software development model, development process contains three generic phases:

1. Definition Phase - where the software developer tries to identify what information needs processed, functions and performance are desired, interfaces should establish, what design constraints, and what validation criteria required to define successful system. In definition phase, the methods applied vary according function model, but there are three specific steps: (i) system analysis, which defines the role of each element in a computer-based system; (ii) software project planning, which addresses risk analysis, cost estimates and task definition and work scheduling; (iii) requirements analysis, which details the scope through an analysis of the information domain and software functions.
2. Development Phase - defines how the data structure and software architecture have to be designed, the project will be translated into a programming language and how the tests have to be performed.
3. Maintenance phase - which focuses changes that associated error correction, adaptations functional improvement software.

The analysis of requirements as already mentioned is a step that is always present in the software definition phase, being formed by a set of techniques used to collect, detail, document and validate the requirements of a software product (PETERS & PEDRYCZ, 2001).

For a long time there has been a concern the analysis of software requirements, leaving in background the proper analysis business requirements, does not contribute an effective link between the needs of business process computerization and software design.

Analyzing and documenting business and software requirements through templates is essential for the development of open source ERPs, making appropriate techniques and tools necessary. In this sense, a modeling architecture that adequately contemplates the modeling of all aspects of business processes, including other aspects related to software development, can facilitate reuse, better functionality, better performance, system comprehensibility, resulting in savings of effort and resources.

## V. MODELING ARCHITECTURE AND REFERENCE MODELS

According to Pidd (1998), a model is a representation of part of the reality seen by the person who wants to use that model to understand, change, manage and control part of that reality. Vernadat (1996) defines model as an abstraction of reality expressed by some formalism defined by a modeling method in function of the objective of the user. Enterprise modeling is related to the following issues: what (refers to the operations and objects processed by the company), how (refers to the way things are done), when (provides a notion of time and is associated with (for example, economic aspects), who (refers to resources or agents) and where (logistic aspects, for example).

Organizational modeling allows not only better understanding organizational requirements that will interfere with systems, but also identify alternatives to the various processes of the organization, facilitating efforts during the development of the information system and allowing organizational analysis to be better integrated into processes of system development (PÁDUA et al, 2002).

For Scheer (1998) reference models can be developed in real or theoretical situations and document the know-how of a process that can be used by others.

For Keller & Teuffel (1998) reference models can be applied to accumulate experience in a business type or to business process solutions implemented and executed in business management software.

The CIMOSA (Computer Integrated Manufacturing Open System Architecture) model considers two parts (VERNADAT, 1996): (i) a architecture and (ii) a reference architecture (Figure 1). Private architecture is a set of templates documenting the business environment. Reference architecture is used to assist business users in the process of constructing their own architecture as a set of models describing the various aspects of the enterprise at different levels of modeling (Figure 2). The reference architecture is separated into two layers: a generic layer providing generic building blocks (relative to the modeling language) and a layer of partial models consisting of a library of partial models classified and reusable for some industry sector, or models that can be adapted to the specific needs of the company.



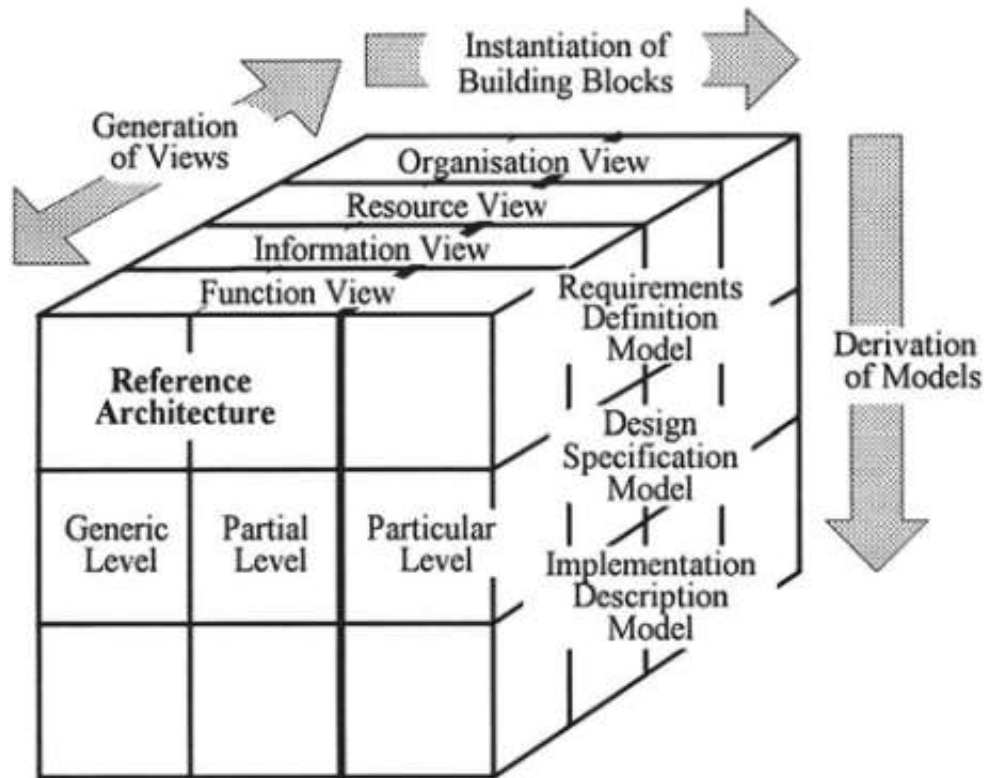


Fig. 1: CIMOSA modeling framework (adapted from VERNADAT, 1996).

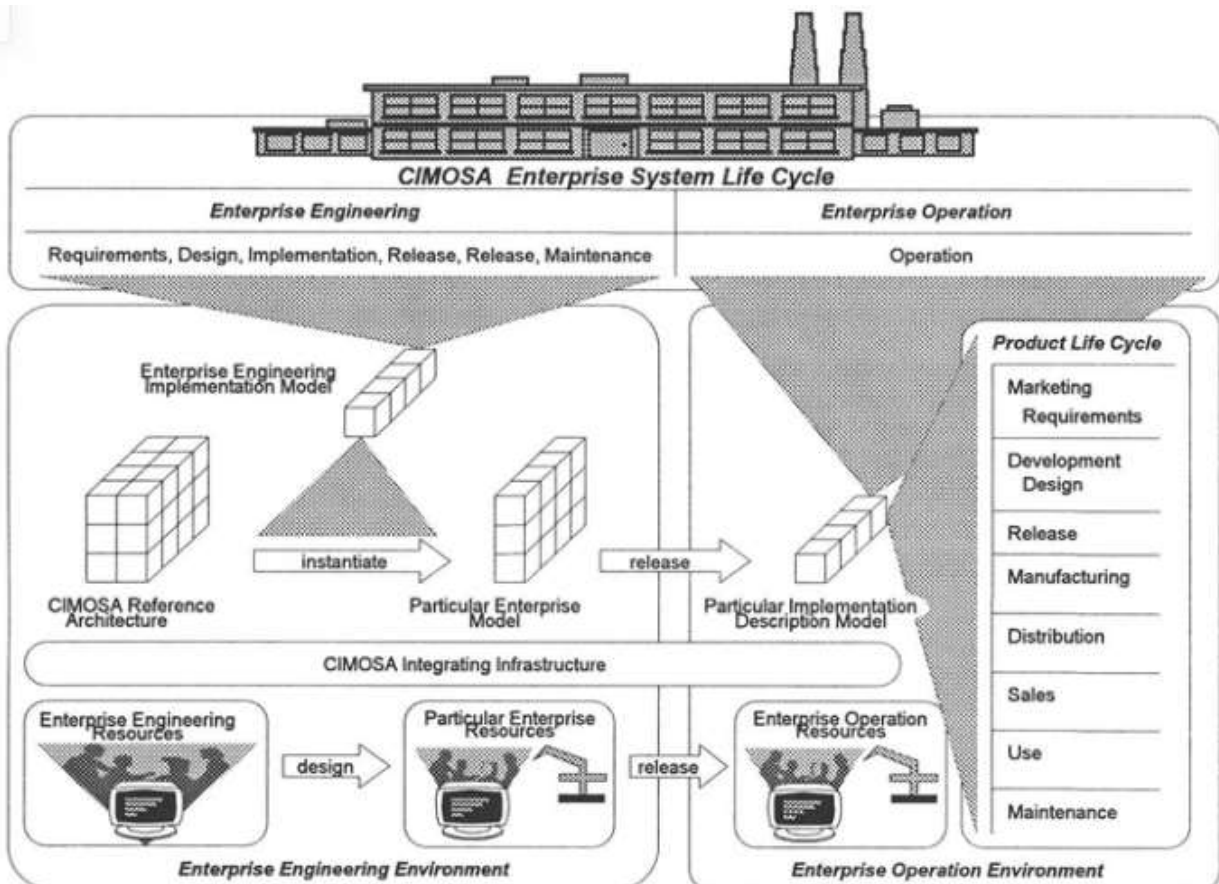


Fig. 2: CIMOSA Architectural Structure (adapted from VERNADAT, 1996).

In addition to this principle of Particularization of models (from reference models), the CIMOSA modeling structure has the principles of Derivation and Model Generation.

The Derivation principle model firms according to three successive modeling levels (iterations between these levels are, of course, allowed):

- a) definition of requirements to express the needs of the business as perceived by users;
- b) project specification to build a formal, conceptual and executable system model of the company (time is considered);
- c) description of the implementation to document implementation details, installed features, exception management mechanisms, and consider non-deterministic systems.

The Generation principle, which recommends modeling manufacturing companies according to four basic and complementary viewpoints (other views can be defined):

- a) the function view that represents the functionality and behavior of the company (ie, events, activities and processes) including time aspects and exception management;
- b) the information view, which represents objects of the company and its information elements;
- c) the resource view, which represents the company's means, its capabilities and management;
- d) the organizational view, which represents organizational levels, authorities, and responsibilities.

As already described, modeling architectures and reference models aim to facilitate modeling work and provide a common understanding of enterprise systems.

For the description of the models a modeling language is necessary.

## VI UNIFIED MODELING LANGUAGE (UML)

UML is a graphical language for specification, construction, visualization and documentation of a software system (BOOCH, et al., 2000).

The UML used the State Diagram, Class Diagram, Object Diagram (from which the Collaboration Diagram appeared), the Process Diagram (giving the Implementation Diagram) and the Module Diagram (resulting in the Component Diagram). The Fusion method also had its collaboration with the Object Interaction Graph. And Harel's statecharts contributed to the creation of the Activity Diagram (LARMAN, 2000).

The UML diagrams (LARMAN, 2000 and FURLAN, 1998) are described below:

It can be said that the main objective of the UML is to define a visual and expressive modeling language, in the sense of providing facilities in the visualization, that is, the full understanding of the functions of a system from diagrams that represent it, in the management of complexity, allowing a simplified representation of the activities of the system, that is, that each functional aspect of it is represented in specific models and finally in the communication, unifying the communication of the development team in the form of diagrams. The modeling of aggregate planning that is defined by Heizer Render (2001) as an elaborated activity among the commercial sector, production sector, purchasing and management of the company is shown below.

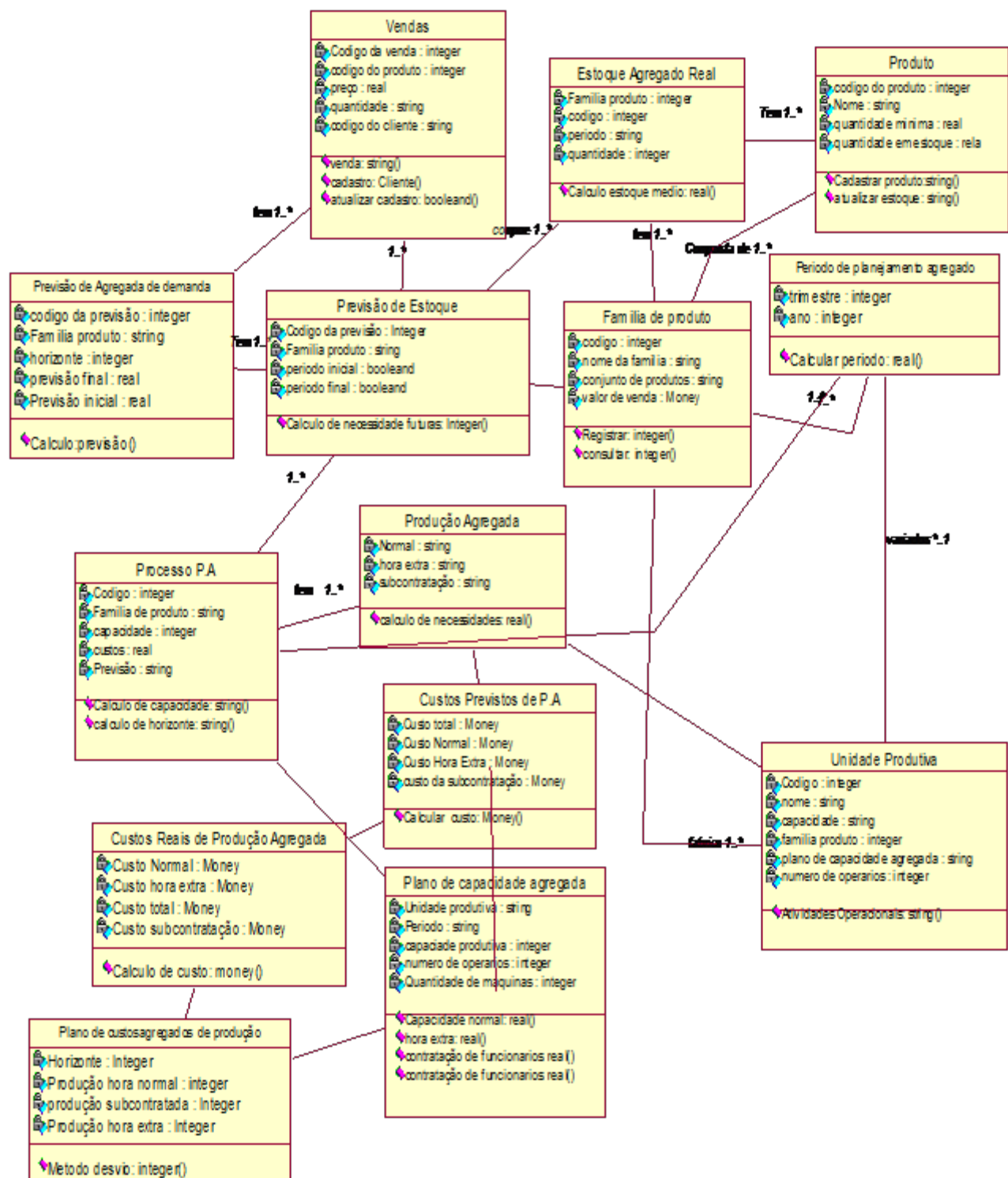


Fig. 3: Modeling Aggregate Planning UML.

With respect to the UML modeling, it was possible to generate code generating a prototype in Delphi with the

following characteristics.

Fig. 4: Diagram Class Proposed Aggregate Planning ERP Model 5

## VII. FINAL CONSIDERATIONS

An ERP system can help companies quest for competitiveness, adoption is hampered due to their cost of purchase dependency supplier company for possible adaptations system due lack access and knowledge changes code. Free and open source software, such ERP systems, advantageous alternative, adoption practice necessary to develop and use techniques and tools that facilitate implementation modification this software.

A modeling architecture and reference models is essential enable development, deployment and change open source ERPs. For definition a modeling architecture RP5 project study possibility using CIMOSA modeling framework concepts and architecture proposed Eriksson & Penker (2000).

Reference models for ERP5 system modules should be generated in order to "map" and document (ie model) generic processes and information, which can serve basis adaptations (or particularizations) through new codes. In ERP5 Project UML language adopted, which became facto standard, worldwide accepted and used, which facilitates diffusion models and codes. Currently works module Planning, Programming and Production Control.

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# Analysis of the quality of life in Brazilian offshore companies

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**Abstract** — *The offshore labor regime is very common in companies operating in the Campos Basin, due to the large number of companies that operate in the petroleum exploration and production processes, including companies that support these operations, which also require the professionals to work on board. The life quality is directly linked to the results, because it interferes in behavioral aspects important for individual and collective productivity. This research aimed to study and analyze the aspects of this work regime that has peculiar characteristics, and the relation with the quality of life of the professionals that work on board, so that positive and negative points could be identified, and to seek possible improvements. The methodology used to develop the study involved an exploratory research in consonance with the bibliographical study. As an instrument for data collection, a questionnaire with closed questions was used, aimed at professionals working on board. This issue is relevant for organizations, since the life quality affects the physical and psychological condition and also, the satisfaction of professionals, interfering in the performance and consequently in the results.*

**Keywords** — *Quality, life at offshore.*

## I. INTRODUCTION

The theme "life quality" (LQ) has been gaining space and repercussion in society. Studies in this area aim to facilitate and help organizations find ways to meet the needs of the worker in developing their activities, after all, people are more productive as they are more satisfied (RAQUEL E SALOMÃO, 2011).

Soto (2005) conceptualizes LQ such as the dynamic and contingent management of physical, technological and socio-psychological factors that affect culture and renew the organizational climate, reflecting on worker well-being and corporate productivity. As organizations and people constantly change, this is a subject that must be dealt with in a dynamic and contingent manner, as it depends on the reality of each organization and the context in which it is inserted. In addition, it is necessary to be attentive to the physical, sociological and psychological factors because all these interfere in the satisfaction of the individuals.

The offshore work regime has its own characteristics, different from the other work regimes, and have a different impact on the lives of professionals who are in this condition, confined for a long period of time, on the high seas, away from society, and in a space, so this topic deserves special attention from organizations.

The petroleum sector is becoming more prominent in the Brazilian scenario, tending to increase with the evolution

of deepwater extraction technology. In this way, we will increasingly have professionals working on platforms and ships.

The objective of this work is to analyze the quality of life in confinement environments, identifying what is already being applied by the organizations and what needs to be improved. The life quality is reflected in personal, social and family life, and also has an impact on employee productivity and consequently on the performance of an organization, and therefore is a subject of great relevance for organizations.

As for the approach, the research can be qualitative or quantitative. A qualitative research is not turned to numbers, but to aspects that can not be quantified. For Santos (2014), qualitative research works with the universe of meanings, motives, aspirations, beliefs, values and attitudes, which corresponds to a deeper space of relationships, processes and phenomena that can not be reduced to the operationalization of variables.

In a quantitative survey the data can be quantified. This type of research uses mathematical language to describe the causes of a phenomenon. For Gil (2008), quantitative research is used to quantify both the collection and treatment of information using statistical techniques, aiming at results that avoid possible distortions of analysis and interpretation, allowing a greater margin of safety.

## II. LIFE QUALITY

Chiavenato (2002), presents the three phases by which organizations have passed. The first phase, Classical Industrial Age (1900 at 1950), was focused on industrial relations, with centralization, focus on traditions, static and predictable, where people were considered factors of production, subject to strict rules and regulations. The second phase, Era of Neoclassical Industrialization (1950 at 1990), emphasizes departmentalization, focus on the present, and intensification of change, considering people as organizational resources that need to be managed. The third phase, Information Age (after 1990), is flexible and totally decentralized, focused on change, considers people to be proactive human beings with intelligence.

After several researches and experiments, several theories have emerged, such as Lewin's Field Theory and Maslow's Hierarchy of Needs, showing that man is motivated not only by economic stimuli but also by social stimuli, symbolic and not materials. "The life quality (LQ) represents the degree to which the members of the organization are able to meet their personal needs through their experiences in the organization " (CHIAVENATO, 2009, p. 59).

LQ is the democratization of the work environment and satisfaction of the worker, humanizing the labor relations

in the organization. It is a set of actions that involves diagnosis and implementation of improvements in and out of work aimed at providing full conditions of human development. Several sciences contribute to the development of this theme, such as health, ecology, ergonomics, psychology, sociology, economics, administration and engineering, among others.

Life quality involves good salaries, benefits, profit sharing, but goes far beyond this, including respect for human beings, health, moral, physical and psychological integrity, the promotion of training with the purpose of developing employees, praise, demonstrations of trust, etc., because in fact, what the employee wants is to be involved in the work, to feel valued and to be recognized. According to Wagner and Hollenbeck (1999), people do not just want to fulfill a routine of tasks and duties. They want to be part of the business.

The improvement of the quality of life in the work leads to the adaptation of the person to the work, being also necessary, a continuous adaptation of the work to the person. According to the scribe Chiavenato (2010, p.17) "When adaptations are made - the person's adequacy to work and the work's adequacy to the person - the person-work relationship becomes more productive and happier."

## III. SATISFACTION AND MOTIVATION

Satisfaction and motivation are two concepts that are interconnected, since satisfaction leads individuals to feel motivated. "Satisfaction at work is a pleasant feeling that results from the perception that our work accomplishes or allows the realization of important values relative to the work itself", (WAGNER; HOLLENBECK, 1999, p.119).

There are three key components to satisfaction: values, importance, and perception. Values are "subjective requirements," existing in the mind of the human being, is what "a person wishes to obtain consciously or unconsciously." People also differ in the degree of importance they attach to values, what is most important to one individual may not be so important to another. And perception is how we see the current situation in relation to our values (MARÇAL; MELO; NARDI, 2013).

A study conducted in 1930 by Professor Elton Mayo, known as the "Hawthorne Effect," led to the conclusion that people's performance is much more related to behavioral or emotional factors than to working methods (MARÇAL; MELO; NARDI, 2013).

Marras (2005, p.33) says that "each develops distinct motivational forces at different times and that these forces directly affect the way they view work and their own lives."

Hunt and Osborn (2002), believe that regardless of theories, what should be kept in mind is that they are people and their behavior is not always predictable.

Intrinsically or extrinsically, true motivation is only effectively achieved when employees are able to fulfill their needs and life goals, both within and outside the company, motivation is an internal force responsible for the level, direction and persistence of the effort expended.

In the following figure, Hunt and Osborn (2002) observe that performance and job satisfaction are isolated but potentially interdependent results.

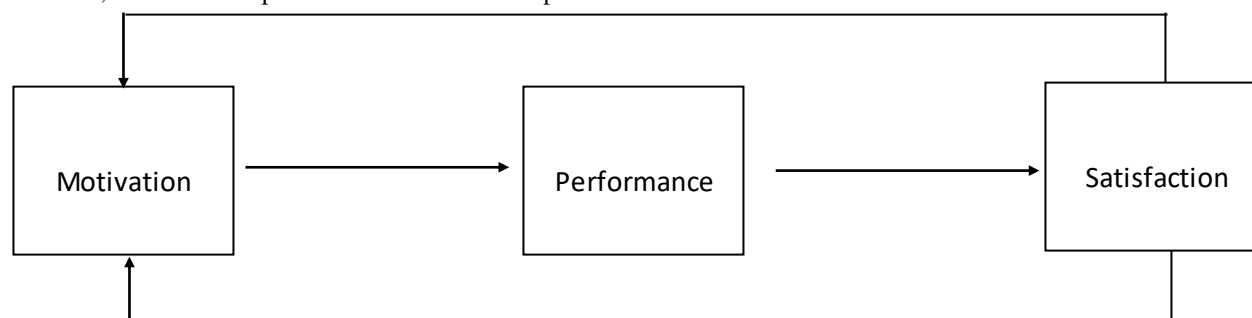


Fig. 1: Relationship between Motivation, Performance and Satisfaction

If the employee does not find the means at work to meet his expectations and achieve his goals, he will feel that he is being exploited, not in a relationship of exchange. The balance between work and the person has positive consequences for both the organization and the employee. Today, more than ever, organizational effectiveness depends on people working in teams (MARÇAL; MELO; NARDI, 2013). In this way, the motivation for the work must be analyzed at the individual, group, sectoral and organizational levels, thus a whole, comprising the micro, meso and macro levels.

#### IV. STRESS AT WORK

Hans Selye in 1926 used the term occupational stress for the first time, defining it as "a set of reactions that the organism develops by being subjected to a situation that requires effort to adapt." Occupational stress refers to workplace stimuli that require responses from the worker and that exceed their ability to cope with a private situation.

Stress can be said to be a change of the organism to react to a situation of pressure, tension and oppression. Stress is a process, because once a person is subjected to a source of stress, a long biochemical process sets in, causing symptoms such as tachycardia, excessive sweating, muscle tension, back and neck pain, tiredness excessive, sleep and digestive problems, decreased libido, among others (HENZ, 2013).

Stress in society worries due to its consequences for health, quality of life and also the implications it has for business and society, this wear and tear entails symptoms that impair the performance and daily activities of the individual. It can also lead to a drop in productivity, demotivation, lack of concentration and unhappiness in the personal sphere, generating high costs for the person and for the company (HENZ, 2013).

Some jobs are stressful in and of themselves and it is not very realistic to think about reducing or eliminating all these risk factors. In such circumstances it makes sense to teach employees to deal with the necessary conditions of work (HENZ, 2013).

#### V. SAFETY AT WORK

Attention issue of occupational safety has increased several countries in recent decades. In Brazil, in part, this result of legislative evolution with actions labor, criminal, social security, civil, administrative and tax liability those responsible for damages caused to workers (BRIDI; FORMOSO; PELLICER; FABRO; CATELLO; ECHEVESTE, 2013).

Regarding above, is important to highlight, addition to occupational safety professionals, the professionals who work area important "tools" in construction of safety measures, since know-activity and can often have Therefore, organizations must take account opinion of professional activity when elaborating security measure.

Regulations, norms and procedures are necessary devices for the management of occupational hazards, "but being conceived without any participation or auscultation of those who must comply with them, are often subject to [legitimate] resistance on the part of the workers" (HENZ, 2013).

Analyzes that turn to the complexity inherent in these productive processes identify a series of factors related to working conditions and organizational aspects (shift work, fatigue, long journeys, outsourcing, precariousness, poor training, low quality and efficient PPE, collection for productive goals that are not compatible with the nature of the tasks) as elements that predispose the worker not to carry out his activities safely.

According to NR-33 (Regulatory Standard nº 33 - Health and Safety in Confined Space Work), subitem 33.1.2, confined space is: "Any area or environment not designed

for continuous human occupation, which has limited means of entry and exit, whose existing ventilation is insufficient to remove contaminants or where oxygen deficiency or enrichment may exist." Thus, the environment platforms and ships considered confined spaces.

Accidents confined spaces often fatal and therefore special care needed to avoid tragedies. In 2006, the Ministry of Labor published the NR-33, which establishes requirements evaluate and recognize certain space confinement, in addition to having rules and procedures to be followed by companies and your employees.

The accidents Campos basin primarily related very nature tasks performed sector and working conditions offshore oil exploration platforms, since complex, continuous, confinement and isolation, among other characteristics. Such characteristics make this environment a source of extreme adversity, potentially harmful health and safety of workers (SOARES; ALVAREZ; FIGUEIREDO, 2008).

Faced with great risks fatal accidents platforms and ships, companies have sought disseminate the concept of job security their employees, that due importance given this issue.

## VI OFFSHORE WORK

The activities exploration, drilling, production and transfer from the sea are governed by Law 5,811 / 72. For this, working offshore platforms has very specific characteristics regards remuneration, working time and rest periods.

Rodrigues (1998, p.204) describes offshore work platforms and ships, as follows: "Workers confined space, isolated all sides by the sea. Within prism are many limitations movement, constituted risk areas where only workers that area must circulate ".

The platforms and ships operate the coast, which requires certain degree autonomy, requiring a service such as food and lodging crew, electricity supply, compressors and pumps, water, transport the coast (helicopters or boats), means loading and unloading, telecommunications, medical services, lifeboats and other life-saving appliances (FREITAS et al., 2001).

Brazil there two scale type activity, 12-hour shift relay, where the worker follows a 14x14 scale (14 days on board and 14 days off), and warns, where the worker only embarks when the need for him to be on board. Often there is a need to perform the fold, which happens when a professional need to replace another professional. For employees (bankrupt) of the company Petrobras differential, scale is 14x21 (14 days on board and 21 days off) (CARVALHO, 2014).

The 12-hour shift relay scale most aggressive because,

addition to being onboard for 14 days, workers work into the week daytime period and in the other week during the night, affecting health, sleep, life familiar and social, performance and productivity professional.

According to Santos (2002), confinement main generator job dissatisfaction due the fact they stay 14 days or more away from family and social life. According author, main adversarial factors offshore work confinement at sea, shift work, lack partnership with society, accumulation domestic problems pre-shipment stress, exposure a high-risk environment safety, health and the gap between expectations created compensations obtained.

Rest hours limitation becomes more present, since the worker must stay house or walk through heliport, atmospheric conditions movement aircraft allow. Another relevant aspect proximity between workplaces house (cabins, TV rooms, cafeteria, etc). This makes difficult workers disconnected, during their feeding, leisure time, work activities (RODRIGUES, 1998, p.204).

For leisure on board, available: gym, sauna, table games, swimming pool, internet, cinema, music room, video game, etc. (these items may vary by platform / ship). But their restrictions, such as noise, because people workplace. Developing good relationships with other professionals on board is important to help in these moments of rest and to ease the absence of family members.

The intense relation with the work, makes the workers have a chronological notion of the time differentiated, both in the period in which they are embarked, as in their days off. It is as if every day embarked on Monday, and every day on land were weekends.

For maritime activity, there specific collective labor agreements, given the special conditions which work carried out. These agreements drawn up jointly with Trade Unions.

After some accidents on platforms the Brazilian society became aware of the conditions of offshore work. However, regarding the mental wear and suffering caused by these activities, they have not always been given adequate attention. On the one hand, major accidents and episodes of environmental damage do not go unnoticed, but the mental health of offshore professionals is not always glimpsed.

## VII QUALITY LIFE OFFSHORE WORK ANALYSIS

The objective study is the quality life offshore work analysis, and from the results, to be able to evaluate what needs to be improved, so that the professionals of the branch have adequate conditions to carry out their activities on platforms or ships, so that the damage to their physical and mental health is minimized.

## VIII. OFFSHORE PROFESSIONAL PROFILE

Firstly, we sought to elaborate the profile of the offshore professional. In Figure 2, referring to the Age Group, it can be observed that 81% of respondents are between 23 and 30 years old, and 19%, more than 30 years.

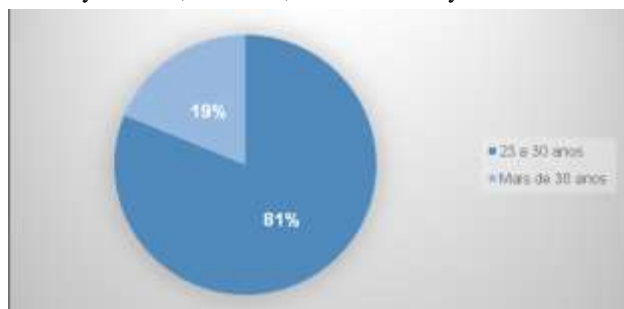


Fig. 2: Age Group

Figure 3 shows the Degree of Instruction of the professionals. This graph shows that 19% of respondents have Incomplete Higher Education, 25% have Complete Higher Education and the vast majority, 56%, have Technical Training. This result is consistent with the reality in the region, taking into account that most of the positions related to the oil exploration, production and drilling process are Technical Level positions.

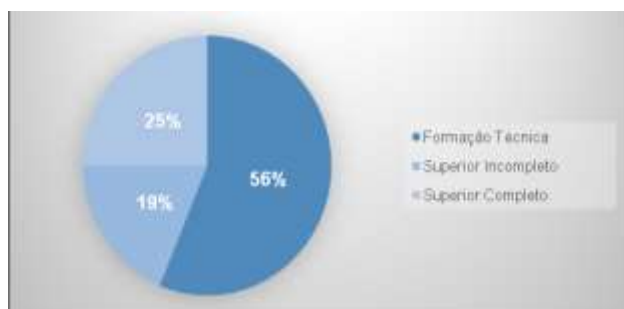


Fig. 3: degree of education

In Figure 4, referring to the offshore work time of professionals, it can be observed that most of them, 50%, work from 3 to 8 years under offshore regime, 37% work from 0 to 2 years and a minority, 13%, have been working for more than 8 years.

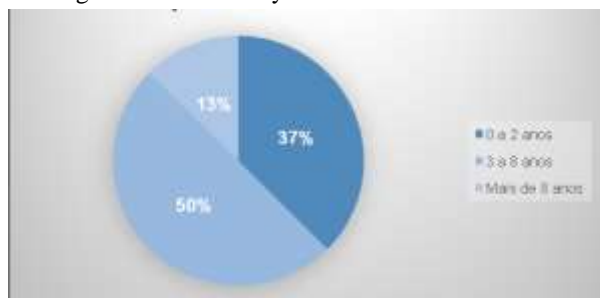


Fig. 4: Offshore Working Time.

Figure 5 presents information about the workplace of the professionals interviewed. 31% of professionals board

only on Petrobras platforms / ships, 25% of professionals only board Privately / Multinational companies / platforms and 44% board both on Petrobras platforms / vessels and Private / Multinational companies.

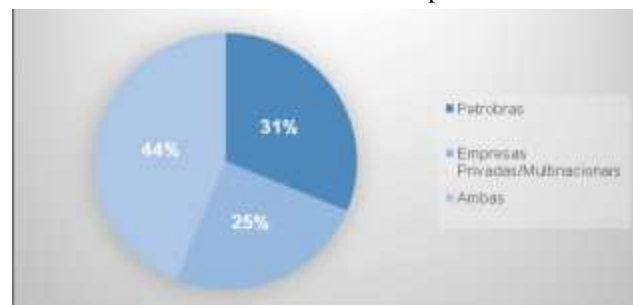


Fig. 5: Platform / Ship you board.

Figure 6, referring to the embarkation regime of the professionals interviewed, shows that 56% of them work with a fixed scale of 14x14 or 14x21, and 44% work under the regime of sobre aviso.

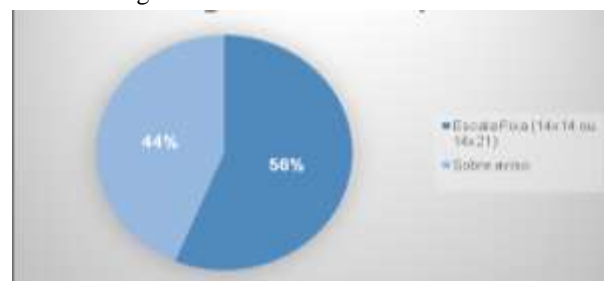


Fig. 6: Boarding Regime.

### 8.1 LIFE QUALITY PLATFORMS AND SHIPS

Life quality very individual concept, looking issue and implementing improvements is not an easy process. But the goal of this research is to evaluate and present critical points that need to be improved.

As discussed in figure 7, 66% of professionals prefer to work on land and 34% of professionals prefer to work onshore.

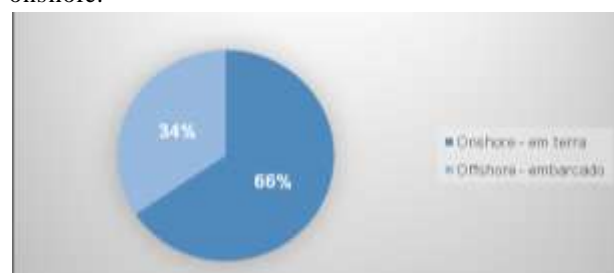


Fig. 7: Preference Boarding Regime.

The confinement situation is very uncomfortable for any individual. Being away from people you like, not being able to go where you want, or doing what you want, missing commemorative dates alongside family and friends, not being able to get completely off work, as they remain in the work environment, among many others, are



negative points of the offshore regime, and which influence the professional when choosing the work regime.

But still, many professionals choose to work on-board. Figure 7, related to the motivation to work on the job, shows that 69% of the professionals interviewed see their main motivation to work on the salary, and 31% consider the work regime, which provides days off equal to the days worked, to main motivation.

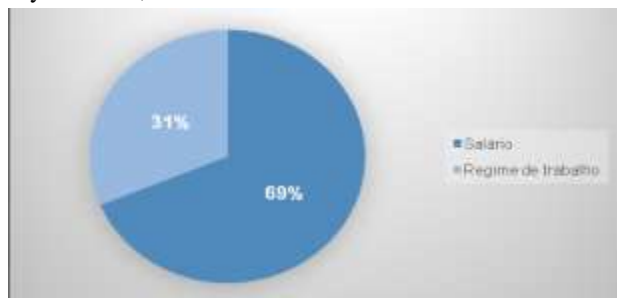


Fig. 8: Main motivation to work boarding.

A minority sees in the work regime the main motivation to work on the high seas, because despite having negative points, this regime provides more free days than work ashore. But the main motivation for carrying out shipments is still salary. Due to the peculiarities of this work regime, the companies pay the additional professionals of insalubridade, dangerousness, etc., that make the salary of these professionals above the salary paid to the professionals who work in the land. According to Thielmann (2013), the specific percentage of salary comparison varies from time to time, but, according to data released in March 2013, the remuneration of these offshore workers corresponded to values 58% above the national average.

Figure 9 presents the opinion of the professionals interviewed about the structure of the platforms and ships on which they embark. According to the Ergonomics Research Society "Ergonomics is the study of the relationship between man and his work, equipment and environment, and particularly the application of the knowledge of anatomy, physiology and psychology in the solution that emerged in this relationship".

Maritime units have jobs that cause fatigue and induce more postures. In addition to having working environments with high temperatures and also work in height.

As shown in figure 8, 6% of respondents consider the structure of the platforms and ships they are embarking on excellent, 19% consider it very good, 56% consider it good and 19% consider it as regular.

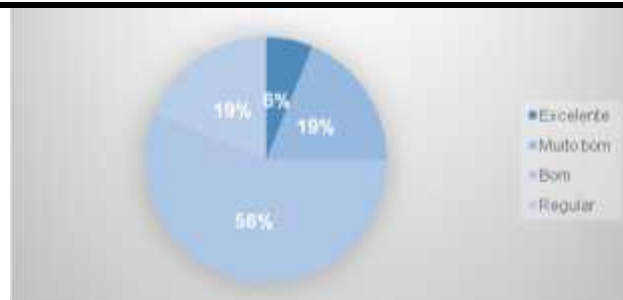


Fig. 9: Physical structure ships / platforms.

The human being needs to communicate, and in situations of confinement this need becomes even greater, in order to avoid the feeling of loneliness.

Most platforms / vessels do not allow the use of mobile (on-board) handsets, and for professionals to communicate with the outside world, internet access and landlines are available, but there is a maximum period for use, making this communication limited. In addition, there are few resources (computers and phones) for many people. Due to the distance from the shore, often these means of communication do not function satisfactorily making communication difficult with the family and friends.

In figure 10, which refers to the quality of the external means of communication available on the platforms and ships, it can be observed that 50% of professionals consider regular, 25% consider good and 25% consider very good.

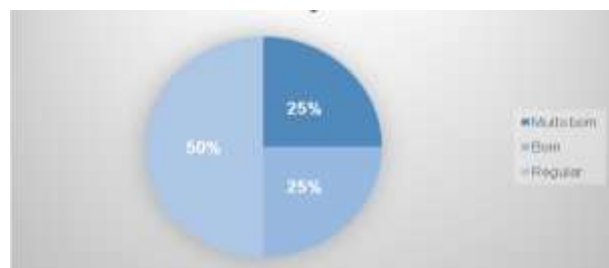


Fig. 10: External media.

Shift work routinely requires the worker to perform his or her work at times when he or she would normally be resting, in leisure or sleeping, and to practice leisure, rest or sleep at times when he or she should be working (RODRIGUES, 2001, 36). ).

Figure 11, regarding the leisure structure provided on board, shows that 69% consider this structure regular and 25% consider this structure good and only 6% consider the structure very good.

It can be observed that the vast majority of professionals are dissatisfied with what companies make available for leisure time. Realizing the importance of leisure so that the individual can actually get away from work, pressures and concerns, this is a point that needs to be improved by

organizations.

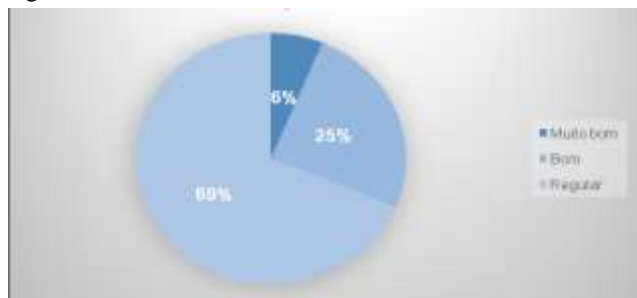


Fig. 11: Leisure on board structure.

Balanced meals help decrease tiredness and increase disposition at work. Those who eat healthier produce more, have less risk of accidents at work, and better health. Important benefits for both professionals and organizations.

Balanced meals help decrease tiredness and increase disposition at work. Those who eat healthier produce more, have less risk of accidents at work, and better health. Important benefits for both professionals and organizations.

Irregular lifestyle for mealtimes caused by shift work may also reflect metabolic disorders increasing the risk of developing obesity, diabetes, cardiovascular disease, digestive problems, sleep disorders, depression etc.

In figure 12 it can be observed that 56% of the professionals consider the feeding provided on board to be very good, 31% consider good and 13% consider regulating the feeding.

Companies seek to provide quality food of great variety, but it is important to guide and educate professionals about nutritional issues so that they can eat in a healthy way.

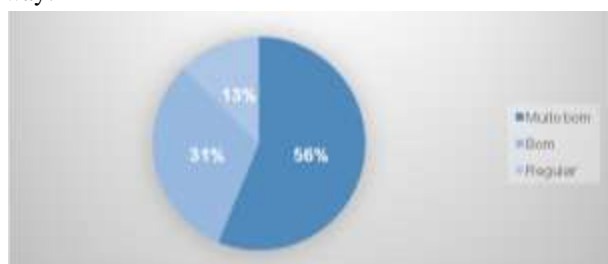


Fig. 12: Food provided on board.

Organizational climate refers to the degree of material and emotional satisfaction of people in the work environment. Therefore, it is extremely relevant to seek to keep it favorable, in view of the influence on the motivation and interest of the employees for the organization's operation (RACHEL, SOLOMÃO, 2011, p.5).

There are complaints about the relationship between "oil tankers" and "contractors" on Petrobras platforms, because there is discrimination or abuse of "power", and

this is seen as a problem for the organizational climate, which exacerbates the problems already faced by workers on the platforms, where there should be relationships of trust and solidarity between individuals, so that they can survive in this environment that is already hostile in itself (PENA, 2002).

Figure 13 shows 44% consider the weather very good, 50% consider it good and only 6% consider it regular, which leads us to believe that despite the difficulties faced on board, the organizational climate is satisfactory.

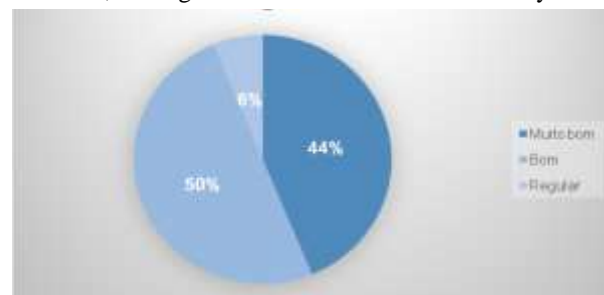


Fig. 13: Organizational climate on board.

The effects of stress are negative for people and businesses. Due to competitiveness, companies end up creating situations of emotional pressure on their employees, which pressure is not only experienced in the work environment, but also in life in general.

Figure 14 shows that 94% of professionals sometimes experience moments of stress, and 6% reported that they always experience situations of stress.

The stress directly affects the performance of the professional research it was observed that the professionals face situations of stress very frequently, being thus, this is a point that must be seen and treated seriously by the companies, as well as causing damages to the professional, affects the outcome of their work.

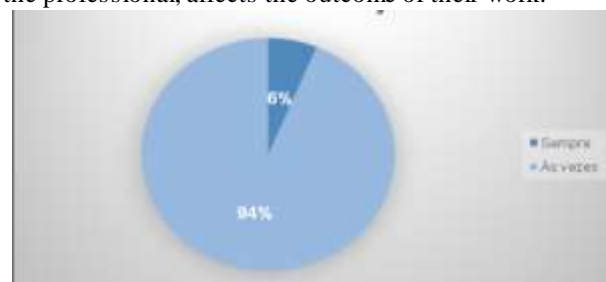


Fig. 14: Experience of stress situations.

Security within platforms and ships is a matter of paramount importance. The activities carried out within these facilities are dangerous and can cause minor accidents to major catastrophes. Are campaigns and meetings to raise awareness of the workforce, and mandatory rules and procedures to be followed by all.

Oil exploration and production platforms and vessels are complex systems in relation to risks as they are linked to

the processing of flammable hydrocarbons, the use of toxic chemical compounds, and the use of equipment that can cause major accidents (FREITAS; SOUZA; MACHADO, 2001).

Figure 15 shows the vision that professionals have regarding safety in marine units. 56% consider security care very good and 44% consider it good. Despite the already implemented precautions, there is still a lot to be done to improve safety in oil exploration and production activities.

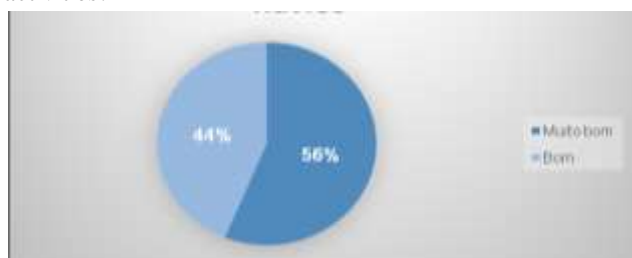


Fig. 15: Platforms and Ships Security.

In figure 16, referring to the state of health of the professionals who work on board, it can be observed that 19% consider their health excellent, 75% consider it very good and 6% consider it good.

Offshore work requires a lot from the professional, both physically and psychologically. Extensive days of work, movement of loads, excessive displacement within the unit, excessive time in which the professional has to remain standing, difficulty sleeping, confinement, feeling of loneliness, among others, are factors that directly affect the health of the that can be perceived in the short, medium or long term.

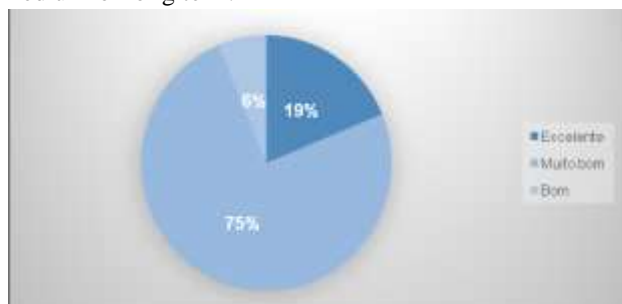


Fig. 16: Health status professional.

## 8.2 IMPROVEMENT PROPOSITIONS ANALYSIS

Based above, we can observe most interviewees prefer work on land and that the main motivation to work on board is wages, higher than the wages paid in other work regimes.

The structure of ships and platforms are considered regular by most of the interviewees. Companies should seek to improve the structure of ships / platforms from an ergonomic point of view, seek to reduce noise pollution, provide more spacious, cozy and en suite cabins - as some do not have a bathroom. Hygiene issues are also the

subject of complaints from professionals, who do not consider hygiene in bathrooms, especially in collective toilets, and complain of the fact that some units do not allow personal clothes to be washed, only clothes used for work.

The means of communication available so that people can communicate with their family and friends do not meet the needs of professionals, the quality and the availability of these communication channels must be improved in order to ease the discomfort caused by confinement. The leisure structure provided on board should be re-evaluated and improved taking into account its importance in helping professionals to get out of work and also as a way to approach and integrate people in moments outside work.

The food on board is a point considered very good by the professionals, showing concern of the organizations with their health, as a proposal for improvements I suggest only the incentive to carry out healthy meals, since although the food provided is considered good, there is a control or incentive for the professionals to feed well, where many the emotional state of the professional can lead him to feed himself ill.

In spite of a constant experience with stress situations the interviewees generally evaluate well the organizational climate on board. Organizations should always seek ways to make the organizational climate pleasant and seek ways to minimize stress, since in the medium and long term they can cause health problems for professionals. There must be constant action to encourage teamwork, respect between workers independent of the position held and punishments for abuse of power. Training and development actions are also important for the professional to feel valued for the work he does and thus stay motivated.

The professionals interviewed consider the safety of ships and platforms to be very good, but I believe this is a point that must be constantly improved, since even with all the existing technology and worry, accidents continue to occur. Accidents on ships and platforms can cause major catastrophes, destroy dreams and families, so, with respect to professionals facing all the difficulties of work on board, safety improvements should never stop.

## IX. FINAL CONSIDERATIONS

The term Quality of Life must be created and maintained through the values of the organization, with respect to the human being, health, moral, physical and psychological integrity and the rights of the people. It must also be pursued through people's maintenance systems in organizations, with living wages, training and development, primarily aimed at their growth and psychological maturation, preparing them to accept

responsibilities and make decisions, involving them in achieving the results of the organization and especially giving them the freedom of choice, thereby reducing alienation at work (CARVALHO, 2014).

In Chapter 5, the realization of this study reaffirmed that the oil sector organizations, with activities that involve offshore work, still need to develop more actions to provide their employees with a better quality of life at work, considering the peculiarities of this work regime. Carvalho (2014) believes that the organization should provide adequate conditions so that people do not feel uncomfortable and unable to do an excellent job. On the other hand, people should also be aware of this aspect, seeking a better balance between the professional and the personal side.

It is concluded that there are many points that need to be improved so that there is quality of life at work on board ships and platforms. It is necessary to diagnose and implement measures and possible improvements. Organizations must see that this is a two-way street, where satisfied professionals produce more and better, thus contributing to the achievement of desired outcomes by organizations.

As proposals for future work, suggest the topics: "The social relations of people working under offshore regime" and "The psychological impacts that the offshore regime has under the professionals".

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# Recycling of Red Ceramics Industry in Precast Concrete Production

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**Abstract**— During the manufacture of bricks in the ceramic industry, a waste volume with aggregate characteristics is generated. This study intends to verify the feasibility of the use of this material in the confection of the concrete used in the shoe of the vigota to manufacture precast slabs. To prove this feasibility, five concrete traces corresponding to five different percentages of residue addition were defined, molding test bodies and beams and analyzing their physical behavior. The results obtained in the tests demonstrated that the addition resulted in a decrease in concrete strength and increase in volume, which did not affect the structural performance of the beams, satisfying the characteristics required for their use in shoes in the production of precast concrete slabs.

**Keywords**— Recycling. Vigotas. Preformed.

## Reciclagem De Resíduo Da Indústria De Cerâmica Vermelha Na Produção De Concreto Pré-Moldado

**Abstracto**— Durante a fabricação de tijolos na indústria cerâmica, é gerado um volume de resíduo com características de agregados. Este estudo pretende verificar a viabilidade do uso desse material na confecção do concreto utilizado na sapata da vigota para fabricação de lajes pré-moldadas. Para comprovar, essa viabilidade, foram definidos cinco traços de concreto correspondentes a cinco diferentes porcentagens de adição de resíduo, moldando corpos de prova e vigotas e analisando seu comportamento físico. Os resultados obtidos nos ensaios demonstraram que a adição resultou na diminuição de resistência do concreto e aumento de volume, o que não afetou no desempenho estrutural das vigotas, satisfazendo as características solicitadas para a sua utilização em sapatas na produção de lajes pré-moldadas.

**Palavras Chave:** Reciclagem. Vigotas. Pré-moldados.

### I. INTRODUÇÃO

O gerenciamento de resíduos sólidos tem como objetivo diminuir a quantidade dos resíduos gerados, e assim tendo um conjunto de ações exercidas, como coleta, transporte, transbordo, tratamento e a destinação ambientalmente adequada conforme o plano municipal de gerenciamento de resíduos sólidos (BRASIL, 2010).

É esperado que o tratamento de resíduos sólidos possa movimentar a economia gerando empregos pela necessidade de beneficiamento, transporte e outros instituída por lei (ANDRADE, 2013). A reciclagem já vem sendo praticada em países de primeiro mundo, mas pouco difundida em países subdesenvolvidos.

Uma das maiores preocupações atualmente na execução de obras é com a quantidade de resíduos que serão gerados e o que será feito com os rejeitos, visto isso, a Lei de Política Nacional de Resíduos (BRASIL, 2010) prioriza nesta ordem a não geração, redução, reutilização, reciclagem, tratamento dos resíduos sólidos e disposição final ambientalmente adequada dos rejeitos.

Chen et al (2003), desenvolveram concretos com agregados reciclados de tijolos e concretos. A alta taxa de absorção de água dos agregados é um ponto a ser discutido. Por ser um agregado mais poroso, obviamente irá precisar de mais água para ter a mesma



trabalhabilidade que concretos com agregados convencionais. Baseados nessa teoria, muitos autores realizam misturas de concretos variando a quantidade de água para que o abatimento e a trabalhabilidade sejam satisfeitos. Dessa forma, a relação a/c é alterada e a classe de resistência desses concretos também acaba se alterando.

A ABNT NBR 9062:2017 estabelece parâmetros para a fabricação de componentes pré-fabricados em concreto. Ela preceitua, por exemplo, que a resistência mecânica do concreto nos elementos pré-fabricados não deve ser inferior a 18 MPa. Para os elementos que a norma define como pré-moldados, esta resistência não deve ser inferior a 15 MPa.

Os principais produtos padronizados são os pilares, as vigas e as lajes de piso. Eles são produzidos em fôrmas pré-estabelecidas, podendo o projetista escolher o comprimento, as dimensões e a capacidade de carga, dentro de alguns limites.

Existem lajes nervuradas que são formadas por elementos pré-moldados correspondentes às nervuras, as chamadas vigotas pré-moldadas. Estas são constituídas basicamente de:

- elementos lineares (vigotas) pré-moldados dispostos espaçadamente em uma direção;
- elementos de enchimento (lajotas cerâmicas, cimentícias, EPS) colocados sobre os elementos pré-moldados, e
- concreto moldado no local CML, na execução chamado de capa de concreto

Podem ser utilizadas vigotas com armação treliçada. Neste caso, é possível obter lajes armadas em duas direções. (EL DEBS, 2000).

As vigotas pré-moldadas têm sua resistência obtida da associação do concreto com armaduras. Em sua aplicação, o elemento linear pré-fabricado e a capa trabalham como uma só peça, formando a seção resistente da laje, que para efeito de cálculo é admitida como tendo a forma de um T. (LOPES, 2015). Nas armaduras treliçadas, as seções formam uma placa de concreto que envolve parcialmente a armadura treliçada de aço.

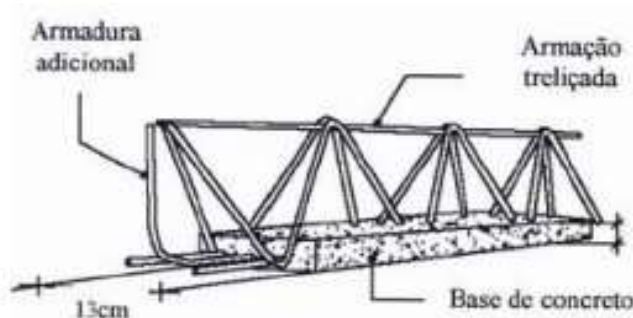


Fig.1: Representação de uma vigota treliçada em perfil

Fonte: Adaptada de SANTOS, 2016 apud PEREIRA (2002).

Na análise estrutural de vigas, o esforço de flexão é o que solicita a maior resistência. Ao se dimensionar vigas a flexão, a NBR 6118/2014 afirma que deve se considerar que o elemento esteja dentro das características aceitáveis de estado limite deformação e do estado limite último de resistência. Através das equações de equilíbrio e de compatibilidade é possível determinar o comportamento das deformações de acordo com as características do material.

## II. MATERIAIS E MÉTODOS

### 2.1 Produção do concreto e corpos de prova

O concreto para este estudo foi confeccionado utilizando os insumos obtidos na região de Manaus: Cimento Portland Pozolânico CP IV-32, fabricado por MIZU - Cimentos Especiais, areia lavada, seixo e água limpa.

O material semelhante ao resíduo de indústrias de cerâmica vermelha foi obtido através da trituração de tijolos comuns de dimensões 9x19x19 cm. Definiu-se que seria utilizado somente o material que passa pela peneira #19mm e fica retido na peneira de #12,5 mm.

Antes da produção do concreto, foi executada uma série de ensaios tecnológicos em laboratório para a caracterização dos agregados e do resíduo de olaria.

Foi definido o traço de referência (sem adição) 1:2:3, em massa, com fator 0,55 de água-cimento. Traço conhecido no cotidiano de obras geridas ou executadas pela empresa que auxiliou nos estudos com  $f_{ck}$  esperado de 30 MPa aos 28 dias.

Os demais traços foram compostos a partir do traço de referência aumentando a porcentagem de adição do tijolo conforme a Tabela 1. O fator água-cimento foi corrigido para melhorar a consistência.

Tabela 1 – Porcentagem de adição de cada traço

Traço	Adição de Tijolo	a/c
Referência	0%	0,55
T1	10%	0,55
T2	15%	0,60
T3	20%	0,60
T4	25%	0,60
T5	30%	0,60

Fonte: Autor, 2018.

Após a retirada do concreto da betoneira, realizaram-se os ensaios de abatimento do Tronco Cone (*slump test*), conforme as recomendações da NBR NM 67. Verificou-se um abatimento entre 80 mm e 120 mm.

Após a verificação da fluidez do concreto, moldaram-se seis corpos de prova cilíndricos, com as dimensões de 10cm de diâmetro por 20cm de altura. Também foram moldados 2 corpos de prova prismático, com dimensões de 15cm x 15cm x 50cm para ensaios de tração e a enchida com concreto a camada inferior de 3cm (sapata) de 2 vigotas com 2,10m de comprimento. Esse conjunto de corpos de prova foi confeccionado para cada um dos traços necessários para a pesquisa.



Fig.2: Corpos de prova

Fonte: Autor, 2018.

Para a ferragem da vigota, foi utilizado a armação treliçada, composta de 1 fio de Ø6,3mm (fio do banzo superior), 2 fios de Ø4,2mm (fios da sinusóide) e 2 fios de Ø4,2mm (fios do banzo inferior): Modelo TG8L da Gerdau.

Para a concretagem da parte superior das vigotas (capa), esperou-se 28 dias, e concretou-se todas as amostras de vigota com o mesmo concreto (Figura 4), sem a adição de resíduos de tijolos, fazendo com que todas as amostras tivessem rigorosamente a mesma resistência na parte superior onde o esforço da vigota é predominantemente a compressão.



Fig.3: Enchimento das capas das vigotas pré-moldadas

Fonte: Autor, 2018.

## 2.2 Dimensionamento das vigotas

No caso particular deste trabalho, a estrutura foi considerada no estágio II de cálculo onde despreza-se a resistência de tração do concreto na zona da secção

transversal onde a peça é tracionada, seguindo a NBR 6118.

Para a análise de resultados, levou-se em conta que os carregamentos que as amostras suportaram representam uma carga aplicada P central medida pela célula de carga da máquina. Também foi considerada a carga distribuída referente ao peso próprio da vigota. Neste caso, o momento fletor é máximo onde ocorre a deformação máxima (flecha) para tal carregamento.

No estudo foi analisado somente a adição tijolo na parte inferior da vigota, ou seja, na zona abaixo da linha neutra. Teoricamente o concreto poderia ter uma resistência insignificante, mas vale ressaltar que o mesmo tem que ter aderência o suficiente para transmitir os esforços resistentes pelo aço, para a estrutura trabalhar como um todo.

Na treliça utilizada teremos duas barras de Ø4,2mm na região comprimida do concreto e uma barra de Ø6,3 mm a uma distância de 8cm acima. Pela quantidade baixa de aço na parte inferior da vigota, verificou-se que a linha neutra estava acima da barra de aço superior. Neste caso foram consideradas as seguintes equações para o cálculo da posição da linha neutra (1) Momento de Inércia I (2) e do Momento Resistente da vigota (3) para determinação da flecha resultante de cálculo.

$$\frac{b}{2}x_2^2 + (\alpha_e - 1)(A_{s1} + A_{s2})x_2 - (\alpha_e - 1)(A_{s1}d + A_{s2}d') = 0 \quad (1)$$

$$I_{II} = \frac{b \cdot x_2^3}{3} + (\alpha_e - 1)A_{s1}(d - x_2)^2 + (\alpha_e - 1)A_{s2}(d' - x_2)^2 \quad (2)$$

$$\mu_{\max} = A_{s1} * f_{yd} * (d - 0,4x_2) + A_{s2} * f_{yd} * (d' - 0,4x_2) \quad (3)$$

Onde:

$\mu_{\max}$  – Momento máximo resistente de projeto

$A_{s1}$  – Área de aço do banzo inferior da vigota

$A_{s2}$  – Área de aço do banzo superior da vigota

$f_{yd} = f_{yk}/\gamma_s$  – Resistência à tração minorada do aço

$d'$  – Distância da borda mais comprimida até o eixo

da ferragem superior

$d$  – Distância da borda mais comprimida até o eixo

da ferragem inferior

$b$  – Base da peça

$I_{II}$  – Momento de Inércia no estágio II

$x_2$  – Posição da linha neutra no estágio II

$\alpha_e$  – Coeficiente de norma

No dimensionamento de vigas bi apoiadas, o cálculo da flecha máxima em função de uma carga distribuída e uma carga concentrada no centro do vão, será realizado através da Equação (4).

$$W = \frac{1}{EI} \left( \frac{5ql^4}{384} + \frac{Pl^3}{48} \right) \quad (4)$$

Onde:

$W$  – Deformação máxima no centro da vigota (Flecha)

$E$  – Módulo de Elasticidade do Material

$I$  – Momento de Inércia da seção

$q$  – carga distribuída devido ao peso próprio da vigota

$l$  – vão livre entre os dois apoios da vigota

O Momento de Inércia utilizado para o cálculo da flecha foi o obtido pela equação (2). O módulo de elasticidade a ser utilizado nas análises elásticas de projeto segundo a NBR 6118 deve ser o módulo de elasticidade secante  $E_{CS}$ , especialmente para determinação de esforços solicitantes e verificação de estados limites de serviço, ou seja, na determinação da flecha máxima. O módulo foi estimado através da Equação (5) da Norma.

$$E_C = E_{CS} = 0,85 * 5600 * f_{ck}^{1/2} \quad (5)$$

Para determinação das propriedades físicas foi utilizado neste trabalho a Máquina Universal Mecânica controlada por software próprio com capacidade de 60KN da Marca Contenco Pavitest do Laboratório de Resistência do Instituto Federal do Amazonas – Campus Manaus Centro. A máquina utilizou células de cargas para a determinação da carga aplicada e extensômetros digitais para a obtenção da deformação.

Nesta máquina foram realizados os ensaios de Resistência à compressão, Resistência à tração na flexão (Figura 4), Módulo de elasticidade do concreto (Figura 5) e determinação das flechas nas vigotas (Figura 6).



Fig.4: Máquina Universal de Ensaios/Ensaio de Resistência à tração na flexão.

Fonte: Autor, 2018.

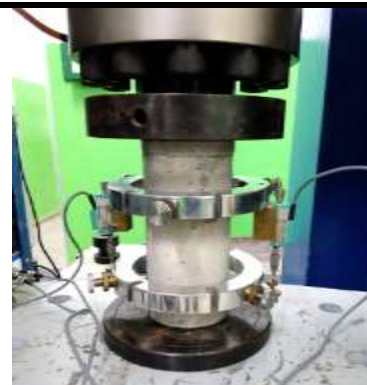


Fig.5: Corpo de prova com compressômetro utilizado para determinação do módulo de elasticidade.

Fonte: Autor, 2018.



Fig.6: Ensaio de determinação das flechas nas vigotas.

Fonte: Autor, 2018.

### III. RESULTADOS E DISCUSSÃO

#### 3.1. Ensaios Com Agregados

A Tabela 2 ilustra os resultados do ensaio de composição granulométrica da areia. O módulo de finura foi determinado pelo cálculo preconizado pela norma ABNT NBR 7217/1987 tendo como resultado o fator 2,18 podendo assim ser classificado como areia fina. Na Figura 4.1 é apresentada a curva granulométrica do agregado miúdo.

Tabela 2 – Composição Granulométrica dos agregados miúdos.

Abertura (mm)	Massa retida (g)	% retida Individual	% retida Acumulada	% passante Acumulada
9,5	0	0,00	0,00	100,00
6,3	2,1	0,22	0,22	99,78
4,76	3	0,31	0,53	99,47
2,38	10,7	1,11	1,64	98,36
1,19	7,3	0,76	2,40	97,60
0,6	242,9	25,25	27,66	72,34
0,3	565,8	58,83	86,48	13,52
0,149	125,6	13,06	99,54	0,46
FUND	4,4	0,46	100,00	0,00

OS				
TOTA	961,8	100,00	-	-
L				

Fonte: Autor, 2018.

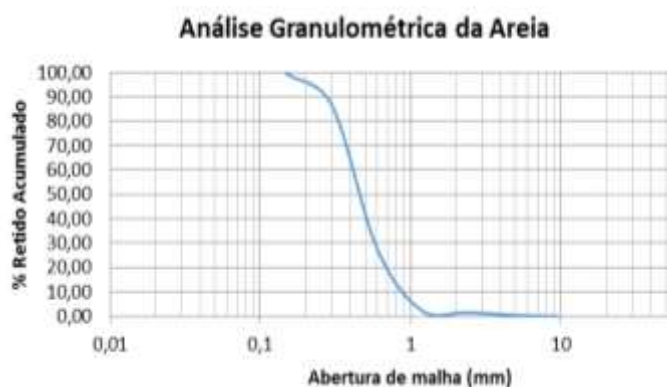


Fig.4: Gráfico da granulometria do agregado miúdo.

Fonte: Autor, 2018.

Realizando-se o ensaio conforme a norma ABNT NBR 7251/1982, a massa unitária da areia foi de 949,551 kg/dm<sup>3</sup>.

Abaixo, verificam-se os resultados dos ensaios com amostras de tijolos depois de quebrados e selecionado o material retido na peneira de abertura Ø12,5mm.

Tabela 3 – Massa Unitária do agregado proveniente do tijolo.

Massa Unitária em Estado Solto Seco - NBR 7251	
Determinação	#12,5 mm
Volume do Recipiente (dm <sup>3</sup> )	4,908,75
Massa do Recipiente (g)	1036
Massa do Recipiente+agregado (g)	6294
Massa do Agregado (g)	5258
Massa Unitária solta do Agregado (kg/m <sup>3</sup> )	1071

Fonte: Autor, 2018.

Tabela 4 – Absorção do agregado proveniente do tijolo.

Malha	Massa material seco (g)	Massa material saturado (g)	Absorção (%)
#12,5	1000	1168	16,8

Fonte: Autor, 2018.

Tabela 5 – Massa específica do agregado proveniente do tijolo.

Malha	Massa material seco (g)	Leitura inicial (ml)	Leitura final (ml)	Massa específica (g/ml)
#12,5	1000	1000	1380	2,63

Fonte: Autor, 2018.

Tabela 6 – Composição Granulométrica dos agregados graúdos

Abertura (mm)	Massa retida (g)	% retida individual	% retida acumulada	% passante acumulada
50	0	0,00	0,00	100,00
25	0	0,00	0,00	100,00
19	324,3	3,24	3,24	96,76
12,5	4017,3	40,19	43,44	56,56
9,5	2716,8	27,18	70,62	29,38
6,3	2265,8	22,67	93,29	6,71
4,8	419,2	4,19	97,48	2,52
2,4	231,1	2,31	99,80	0,20
FUNDO S	20,4	0,20	100,00	0,00
TOTAL	9994,9	100,00	-	-

Fonte: Autor, 2018.



Fig.5: Gráfico da granulometria do agregado graúdo.

Fonte: Autor, 2018.

### 3.2 – Ensaios de Resistência à Compressão

Tabela 7 – Resultados dos ensaios de compressão nos traços

Corpo de Prova	Fck 7 dias (MPa)	Fck 28 dias (MPa)
TR	CP1	21,31
	CP2	22,87
T1	CP1	22,72
	CP2	21,09
T2	CP1	19,4
	CP2	21,35
T3	CP1	17,73



T4	CP2	16,05	28,33
	CP1	15,58	25,26
	CP2	12,89	25,05
T5	CP1	15,45	22,49
	CP2	14,14	24,99

Fonte: Autor, 2018.

Como esperado, quanto maior a porcentagem de adição do tijolo no traço, menor foi a resistência à compressão final obtida pelo concreto. Este resultado é mostrado graficamente na Figura 7. Mesmo com a diminuição da resistência temos em contrapartida com a adição do resíduo de tijolo, o aumento de volume do concreto para produção da base das vigotas. Este aumento de volume é mostrado na Tabela 8 em relação ao volume produzido no traço de referência. Os volumes foram determinados através de cálculos de composição e verificados após a produção dos corpos de prova de concreto.

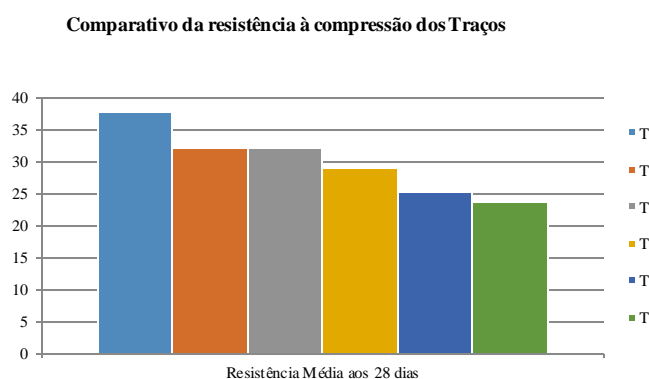


Fig.7: Gráfico comparativo das resistências de cada traço

Fonte: Autor, 2018.

Tabela 8 – Ganho de Volume com a adição de tijolo.

Traço	Adição de Tijolo	a/c	Slump (cm)	Volume traço /Volume de Referência	Ganho de Volume (%)
TR	0%	0,55	-	1,00	0
T1	10%	0,55	14,5	1,12	12
T2	15%	0,60	18	1,14	14
T3	20%	0,60	18	1,16	16
T4	25%	0,60	13,5	1,18	18
T5	30%	0,60	3,5	1,21	21

Fonte: Autor, 2018.

Quanto ao concreto utilizado para a confecção da capa da vigota, nos resultados do ensaio de resistência à

compressão de 6 corpos de prova foi obtida uma resistência média de 22,29 MPa. Este resultado foi utilizado para a determinação do Módulo de Elasticidade através da equação (5) estabelecida pela NBR 6118.

### 3.3 – Resistência à tração na flexão – CP prismático

Tabela 9 – Resultados da resistência à tração na Flexão.

Traço		Resistência (Mpa)	Resistência Média (Mpa)
T	CP1	3,94	3,85
	CP2	3,76	
1	CP1	3,76	3,785
	CP2	3,81	
2	CP1	3,6	3,705
	CP2	3,81	
3	CP1	3,52	3,655
	CP2	3,79	
4	CP1	4	3,66
	CP2	3,32	
5	CP1	3,85	3,67
	CP2	3,49	

Fonte: Autor, 2018.

Observa-se que é pequena a variação da resistência à tração na flexão conforme o aumento da porcentagem de adição de tijolo. Desta forma, é reduzida também a sua influência na formação de fissuras durante o ensaio de flexão.

### 3.4 - Determinação do módulo estático de elasticidade

Para efeito de comparação com os valores obtidos pela norma, o módulo de elasticidade de cada traço de concreto produzido foi determinado através de ensaio conforme a norma ABNT NBR 8522:200. Os resultados foram reunidos na Tabela 10 e os diagramas obtidos durante o ensaio são apresentados na Figura 8.

Tabela 10 – Determinação do módulo de elasticidade dos concretos

Traço		Tensão de Ruptura (MPa)	Módulo de Elasticidade (Gpa)	Média (GPa)
T	CP1	31,78	32,7	33,3
	CP2	33,94	33,9	
1	CP1	31,82	38,4	40,35
	CP2	32,68	42,3	
T	CP1	28,23	35	35,1
	CP2	28,23	35	



2	CP2	27,89	35,2	
T	CP1	28,91	31,6	30,95
3	CP2	29,99	30,3	
T	CP1	22,84	27,7	27,45
4	CP2	22,31	27,2	
T	CP1	23,05	30	27,95
5	CP2	25,09	25,9	

Fonte: Autor, 2018.

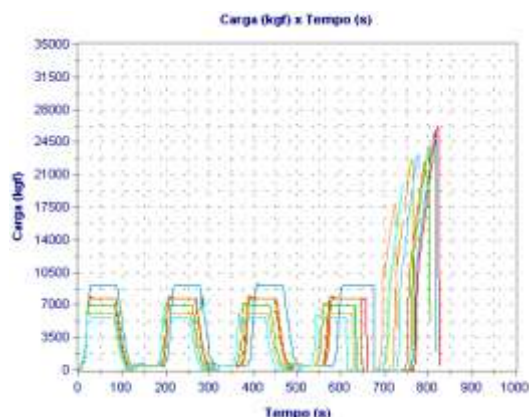


Fig.8: Gráficos obtidos do ensaio de Elasticidade.

Fonte: Autor, 2018.

### 3.5 – Cálculo e Determinação da Flecha

Considerando o Estado Limite de serviço, a viga não poderia exceder uma flecha de  $L/250$ . O vão de ensaio foi de 2,0m, logo, o valor máximo da flecha é de 8 mm. Utilizou-se a Eq. (2) para o cálculo do momento de inércia equivalente e, para a determinação da flecha em função da carga aplicada, utilizou-se a Eq. (4) adaptada em função da carga central  $P$  aplicada. O cálculo da flecha em função de  $P$  é mostrado na equação (6).

$$W = 0,1745 + 0,0033P \quad (6)$$

Para a deformação máxima de 8mm, a carga máxima aceitável de cálculo é obtida na equação (7)

$$W \leq 8\text{mm} \therefore 0,1745 + 0,0033P \leq 0,8\text{cm} \rightarrow P = 189,2 \text{ kgf} \quad (7)$$

A partir da Eq. 6 é possível construir uma reta da flecha esperada em função da carga  $P$  aplicada. Foram calculadas as flechas em função das cargas de ensaio. Os resultados foram apresentados na Tabela 11 e na Figura 9 juntamente com os valores reais obtidos durante o ensaio de flexão das vigotas.

Os valores de flecha medidos durante o ensaio de flexão (em destaque) para a faixa de carga calculada na equação (7) estão abaixo do valor previsto calculado pela norma de utilização, podendo ser utilizadas nesta faixa de carga calculada dentro da aceitabilidade sensorial.

Tabela 11 – Resultados do Ensaio de Flexão nas Vigotas.

Controle de Carga (Kgf)	Flecha calculada Eq.(4) (mm)	Flecha Medida (mm)					
		TR	T1	T2	T3	T4	T5
6	1,93	0,91	1,56	1,11	1,13	0,72	0,82
12	2,13	1,71	2,52	2,41	2,05	1,24	1,73
25	2,58	2,05	3,02	3,35	2,45	1,60	2,29
51	3,42	2,55	2,72	4,33	3,45	1,95	2,94
75	4,21	2,98	3,00	4,87	3,83	2,25	3,47
99	5,03	3,42	3,28	5,17	4,17	2,55	3,70
125	5,87	3,89	3,56	5,45	4,43	2,82	3,98
150	6,70	4,37	3,86	5,69	4,71	3,11	4,33
175	7,52	4,84	4,17	5,97	4,99	3,38	4,66
198	8,27	5,30	4,51	6,21	5,31	3,67	4,98
224	9,16	5,89	4,89	6,47	5,75	3,97	5,30
249	9,98	6,50	5,33	6,77	6,11	4,44	5,63
275	10,84	7,05	5,78	7,09	6,57	5,24	6,24
300	11,65	7,52	6,39	8,01	7,19	5,78	7,20
324	12,47	8,26	7,05	8,71	7,79	6,82	7,98
350	13,32	8,98	7,72	10,13	8,89	7,49	9,02
376	14,16	9,91	8,73	10,93	9,63	8,49	9,71
400	14,95	10,69	9,39	12,01	10,33	9,30	10,64

Fonte: Autor, 2018.

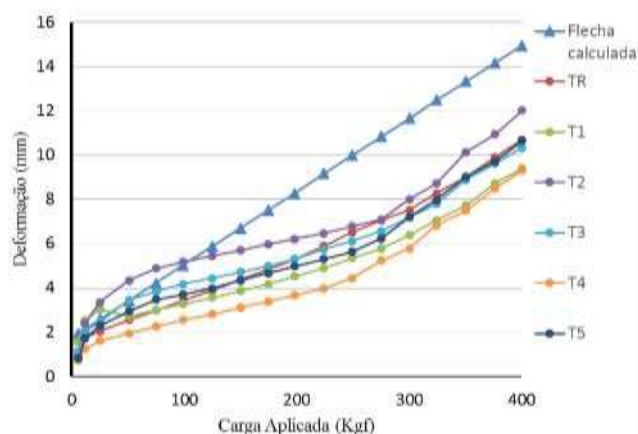


Fig.9: Gráficos obtidos do ensaio de Elasticidade.

Fonte: Autor, 2018.

#### IV. CONCLUSÃO

O estudo de dosagem dos concretos com a adição de resíduo de tijolo foi feito utilizando o método proposto na produção de concreto para sapatas de vigotas. Os métodos aplicados obtiveram resultados satisfatórios que chegaram a apresentar resistências à compressão mínima requerida de 22 MPa 28 dias de idade.

Constatamos que ao adicionarmos o resíduo de tijolos com os percentuais determinados nas proporções de 10, 15, 20, 25 e 30 por cento, houve uma ligeira diminuição da resistência com um ganho de volume, o que viabiliza o trabalho de produção de vigotas pré-fabricadas e servindo de opções para outros trabalhos.

Observou-se que com a adição do resíduo do tijolo os ensaios de resistência das vigotas não apresentaram grande diferença em seus resultados o que também ocorreu nos ensaios de tração e elasticidade do concreto, onde todos os valores de trabalho superaram as expectativas solicitadas.

A Norma estabelecia uma flecha máxima igual ou inferior a 8 mm de acordo com o vão definido. As flechas obtidas na execução dos ensaios de carga feito nas vigotas para o carregamento calculado apresentaram valores muito inferiores ao da Norma.

Para o valor de cálculo de 189 kgf não foram aplicados coeficientes de segurança, e a média dos valores da flecha não atingiram o máximo, chegando somente a 5,0mm. Salientamos que as lajes produzidas com as vigotas com adição de resíduo de tijolos, foram calculadas para o estágio II de deformação, onde o material utilizado independe da resistência da mesma, já que, para efeito de cálculo é desprezada a resistência do material que cobre o aço na zona de tração constatando-se que o resultado dos ensaios são positivos.

Verificamos que as vigotas suportam cargas superiores as encontradas no dimensionamento,

apresentando ao mesmo tempo deformações inferiores às de cálculo. Concluímos então que, mesmo considerando as condições menos favoráveis, as vigotas apresentam um melhor comportamento real.

Em termo de custo verificou-se que até mesmo na condição da adição de 10% de resíduo de tijolo, haverá um aumento de 12% do volume do concreto, o que acarretará em uma economia de 12% no custo final do concreto, o que viabiliza economicamente seu uso na produção de vigotas.

Neste trabalho comprovamos que a utilização do resíduo do tijolo é viável para que seja usado na fabricação de vigotas pré-fabricadas.

Conclui-se que a utilização do resíduo do tijolo deverá ser de grande utilidade para a construção civil. Existe uma grande quantidade de material rejeitado devido a defeitos na produção e também quantidade de quebras indevidas no transporte. Comprovadamente este pode ser utilizado em vigotas de laje pré-fabricadas onde não compromete o funcionamento da estrutura dentro dos Estado Limites Ultimo e de Serviço.

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# Effects of Manual Lymphatic Drainage Massage Associated with Physical Exercise Program in Morphological-Functional Blood Pressure Parameters

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**Abstract**— The objective of this study was to investigate the effects of Manual Massage Lymphatic Drainage (MMLD) performed in association with an Aerobic Physical Exercise Program (APEP), in the arterial blood pressure (PSA) values of hypertensive subjects submitted to pharmacological treatment. The population of this study was composed of hypertensive subjects of both sexes and patients from SESI Clinic of the Municipality of Cacoal in Rondônia / RO, with the sample consisting of 28 subjects in the age group from 45 to 60 years and under pharmacological treatment to control hypertension arterial hypertension (SAH). Experimental Group 1 (GE1), composed of 14 individuals of both sexes (Age:  $53.57 \pm 7.20$ , Body Weight:  $74.15 \pm 15.85$ , height:  $166.1$

$\pm 61$ ), which during 8 weeks were submitted weekly on alternate days, to three MMLD sessions in parallel to a APEP with intensity controlled by the subjective sensation of effort; and b) An Experimental Group 2 (GE2), also composed of 14 subjects of both sexes (Age:  $53.57 \pm 7.20$ ; Body Weight:  $74.15 \pm 15.85$ ; Height:  $166.1 \pm 61$ ); which during 8 weeks were also submitted to three weekly sessions of the same MMLD maneuvers applied in GE1, but were not submitted to PEFA. At the end of the procedures the statistical analysis allowed to observe that the PASS scores presented by GE1 and GE2, both indicated the same statistical significance ( $p = 0,000$ ), with mean values being reduced by 8.1 mmHg for GE1 and 6,5 mmHg for GE2, representing a functional

improvement of 6.3% and 4.9%, respectively. A similar behavior was found when analyzing the values of PASD, which at the end of the experimental procedure presented similar results for both study groups, statistical significance at the level of  $p < 0.05$ . Mean values were reduced by 5.5 mmHg for GE1, and 3.8 mmHg for GE2, representing a functional improvement of 6.3% and 4.3%, respectively. It is also observed that the results of the GE1 are higher than those of the GE2, and this can be attributed to the realization of the MMLD in parallel to the APEP, which seems to have potentiated the effects presented by the GE1. The results found in this research suggest that Manual Lymphatic Drainage Massage may be a valuable nonpharmacological auxiliary therapy in the control of arterial hypertension, also indicating that when performed in association with a regular program of aerobic physical exercises, it significantly increases the reduction of values blood pressure of hypertensive subjects.

**Keywords—** Hypertension, Manual Lymphatic Drainage Massage, Physical Exercise.

## I. INTRODUCTION

Manual Lymphatic Drainage Massage (MLDM) is the way to drain the cell interstitial and lymphatic vessels by massaging specific techniques performed without significant injury to the body's muscular tissues, which increase the production and movement of the lymph within the cell interstice, causing the content present inside the lymphatic vessels to circulate more rapidly. Thus, the gas and nutritional changes inside the cell are facilitated, as a result of the greater blood supply inside the cell, as well as the elimination of catabolites due to cellular catabolism (DA SILVA, 2004).

MLDM is used for therapeutic, aesthetic and even muscle relaxation purposes and is universally recognized for its vascular benefits, since its maneuvers stimulate the physiology of the blood circulation and the autonomic nervous system, providing acute relief to muscle stress in general (SINGI, 2004).

In this aspect it is known that the production of lymph in the human organism occurs whenever the cell interstice gets a very large load of toxins due to the metabolic chemical reactions, or when it receives an adverse external pressure and opens to the lymphatic capillary, promoting the emptying of the interstitial fluid and forming new lymph. Once produced, the lymph is transported via specific capillaries to the lymphatic vessels, whereby larger ducts carry it into the subclavicular veins carrying with it the remnants of the chemical reactions resulting from cellular catabolism, whose weight or molecular size is very large and does not can flow through a venule (SINGI, 2001).

In this way the lymph goes out through specific capillaries passing through ganglionic chains, its macro-molecules being phagocytosed with the purified lymph returning to the venous blood before reaching the heart. Considering that such macro-molecules are formed by proteins, toxins, salts, hormones and lymphocytes that participate in the organic defense in the ganglionic chain, it is assumed that lymph has as basic function to defend and to clean the cellular interstice (BALESTRO, 2002).

It is understood that MLDM can be a valuable aiding tool in this venous and lymphatic return mechanism, since contrary to the cardio-circulatory system in which the heart functions as a contractile-propelling pump pushing blood through the blood vessels, the lymphatic system does not own this property. Thus, for lymph to circulate like blood, MLDM's technical maneuvers exert gentle pressure on muscle tissues without reaching deeper anatomical structures, accelerating the return of lymphatic fluid to the heart, thus stimulating the elimination of toxins, even substances derived from infections, inflammations, muscle spasms and other similar processes (BALESTRO, 2002; DA SILVA, 2004).

The lymphatic system extends throughout the body in the form of a network, beginning with the lymphatic capillaries that converge to form the prefrontal collectors (afferent vessels). Several of these collectors go to the lymph nodes and form the lymphatic trunks, which will make up the lymphatic ducts forming the vessels of the final portion of the lymphatic drainage, which in turn lead to the venous system (SINGI, 2001).

For AIRES (1999), the lymphatic system is an important auxiliary of the venous system, whose function is to complete the extravascular circulation of fluids and proteins, thus ensuring homeostasis and tissue volume, causing approximately 50% of plasma proteins to return to the system circulatory. The concentration of these proteins varies from region to region and depends on aspects such as: a) The coefficient of vasoconstriction of exchange vessels in each tissue cell; b) The size of the molecules transported; c) The individual charge of each protein; and d) Capillary filtration rate.

Still AIRES (1999) suggests that there are about 10 to 12 liters of fluid in the interstitial space of an adult subject, which acts as a reservoir for the plasma compartment. If this volume of fluid is increased by urinary retention or infusion, the excess can pass into the interstitium, increasing its volume and space consequently increasing the interstitial pressure, a process technically called "edema", which once established has as a consequence retardation in the gas and nutritional exchanges that occur physiologically between the cells and the blood plasma.

For the aforementioned author, the subcutaneous tissues are extremely favorable to the appearance of edemas,



which are caused by heart failure of the right ventricle, and are not clinically detected until the interstitial volume has increased above 100%, possibly due to the deficiency in cellular nutrition, cause some complications in the body as: skin ulceration, discomfort and difficulty of locomotion, among others.

On the subject in question, it is known that edema develops when the rate of capillary filtration exceeds the lymphatic drainage rate for a certain period. That is, the pathogenesis of edema involves an increase in filtration rate or decrease in lymphatic flow caused by capillary pressure, which is secondary to venous pressure caused by ventricular failure, which in turn increases post capillary resistance and may lead to dysfunction of the venous valves and consequently increase the pressure in both the venous capillaries of the skin and limbs, around 20 to 40 mmHg (AIRES 1999; Da Silva, 2004).

According to the aforementioned authors, another cause for the genesis of edema is the formation of inflammatory processes, which alter the properties of the capillary walls causing an increase in the hydraulic conductance and the selective permeability to the proteins, thus facilitating the development of edema. Considering that these two elements (fluid and protein) pass into the interstitial space, the only way of removing them from said site is through the lymph, where proteins that have not flowed into the venous return can return to the blood plasma, called lymphoedema.

This situation causes a fibrotic / greasy growth causing congestion of the capillary network, having as consequences: a) increase of the filtration pressure; b) arteriolar dilatation; c) venular constriction; d) increased venous pressure; e) heart failure; f) incompetent valves; g) venous obstruction; h) increase in the total volume of the extracellular fluid; and i) reduction of osmotic pressure through the capillary network (AIRES 1999).

Congestion in the capillary network increases the hydrostatic blood pressure (PHS), which leads to excessive movement of fluids into the interstitial spaces. Similarly, high blood pressure within the veins may cause an increase in PHS within the capillaries and allow the formation of edema. Conversely, improvement in venous blood flow reduces blood pressure, which in turn lowers PHS and avoids or decreases edema (AIRES, 1999).

In this sense, AIRES (1999) adds that the addition or subtraction of the effect of gravity on PHS, makes the arterial blood pressure (PSA) greater than the pressure in the tissues that surround them. Homeostasis of body fluid volume and PSA regulation are closely related via the mechanism of feedback of kidneys / body fluids, with the central component of this mechanism being the effect of PSA on the renal excretion of sodium and water, a phenomenon known as the mechanism of pressure /

natriuresis / diuresis, which allows PSA maintenance to be achieved in the long term. The abnormality of this mechanism can cause disturbances in the level of PSA, which is the pressure exerted by the blood inside the blood vessels as a function of the systole and diastole of the heart, that is, the contraction and relaxation of the cardiac muscle and the vascular resistance opposite to the blood flow (ALMEIDA, 2003).

According to some authors, the high values of PSA constitute a phenomenon academically known as Blood Hypertension (SAH), and this is one of the main factors for the occurrence of cardiovascular diseases in human populations in general. This fact, according to epidemiological data, has been, for a long time and now more than ever, a global public health problem, with millions of people around the world presenting high PSA values (PITANGA, 1999, ALMEIDA et al., 2018) .

For Shoji and Forjaz (2000), control of this pathology can be done through pharmacological and non-pharmacological treatments, and drug therapy is indicated for moderate / severe hypertensive patients, and for those with risk factors for cardiovascular diseases and / or significant lesion of target organs, and despite its proven efficacy in reducing PSA values, it is necessary to consider its high cost and possible side effects.

On the subject, Da Silva (2004) has published non-pharmacological interventions such as alcohol restriction, smoking cessation and regular physical activity, as they promote changes in personal lifestyle to prevent or halt the evolution of SA, have been reported for their effectiveness, low cost and minimal risk, and Pitanga (1999) reports the latter, the regular practice of physical activities, as currently the main prophylactic tool against such pathology.

Martin, Dubbert & Cushman (1990) further corroborate and affirm that the incidence and severity of SAH is inversely related to physical fitness levels, as well as that many studies confirm the reduction of PSA in subjects who are part of regular aerobic exercise programs , to which Almeida et alli (2018) attribute to occur due to the sympathetic neural reduction, which decreases basal sympathetic tone and contributes to improving SAH.

These statements do not necessarily constitute academic novelties on the subject, with several studies already demonstrating at some time the effectiveness of physical activity in reducing PSA levels (HAGBERG, 1988; OSIECKI, 1996; PITANGA, 1999; ROBERGS & ROBERTS, 2009 (1998), in which all of the data are presented in this paper.

On this subject, Almeida (2003) warns of the importance of detailed planning of the practice of physical activity, showing four basic aspects during its execution: intensity or quality, volume or duration, frequency and repetition

of the stimuli. In this view, Almeida et al. (2018) suggest that an optimized state of an individual's systemic organic functional condition will only be achieved when the variables mentioned above are adequately planned, and wrapped in a scientifically methodalized work system regarding the prescription and control of training loads, what the author calls "physical exercise".

In view of the above, and considering that hypertension is a relevant risk factor for cardiovascular complications that may lead to death (BRANDÃO et al., 2003), this study intends to collaborate in the development of non-drug strategies that are shown efficient in the therapy of such pathology, investigating the effects of Manual Lymphatic Drainage Massage (MLDM) performed in parallel with an aerobic physical exercise program (PEFA), in the PSA values of hypertensive subjects and submitted to pharmacological treatment.

## II. MATERIAL AND METHODS

### 2.1. Population and sample

The population of this study was composed of hypertensive subjects of both sexes and patients from SESI Clinic of the Municipality of Cacoal in Rondônia / RO, with the sample consisting of 28 subjects in the age group from 45 to 60 years and under pharmacological treatment to control hypertension arterial blood.

Initially, a first personal contact was made with the aforementioned institution, and the nature and relevance of the research was explained at the time, as well as authorization for the study. Subsequently a lecture was given to the subjects interested in voluntarily participating in the experiment, explaining details about the subject to be investigated, and informed at the time that individuals who were absent from any PEFA session would be excluded from the study.

Finally, after identifying the subjects with vascular risk (cardiac failure, thrombosis and decompensated hypertension), or even under chemotherapeutic treatment, two experimental groups were randomly structured to develop the study:

a) Experimental Group 1 (GE1), consisting of 14 individuals, 7 men and 7 women, who during 8 weeks underwent 3 sessions of MLDM every other day, which were organized in a way not to hinder their daily activities. Thus, 6 subjects performed 1 session on Monday, another on Wednesday and the last one on Friday, with the other participants performing the sessions on different days (Tuesday, Thursday and Saturday), all of which were performed between 06:00 and 08:00 in the morning. On the same days of the MLDM sessions, during the night time between 7:00 p.m. and 8:00 p.m., the same subjects also performed three sessions of a PEFA; and

b) Experimental Group 2 (GE2), also composed of 14 subjects, 7 men and 7 women, who during 8 weeks were also submitted to three weekly sessions of the same MLDM maneuvers applied in GE1, only on different days (Tuesdays, Thursdays and Saturdays), which are held during the night between 7:00 p.m. and 8:00 p.m., but are not subject to PEFA.

In order to avoid possible failures during the experimental procedure, the MLDM maneuvers were performed by massage therapists, and both in the data collection of the dependent variables and in the application of the PEFA, there were academics of the Physical Education Undergraduate course of the Faculty of Medical Sciences of Cacoal / RO,

### 2.2. Analysis variables, equipment and standardization of measurements

In this study, the anthropometric parameters were measured: a) Total Body Weight (PCT); and b) Stature (EST), used here only to characterize the sample. Then, the arterial blood pressure (PSA) measurement was performed, which represents the dependent variable of this study. The following equipments and standards are used for this purpose:

a) The PCT, which was accepted as the amount of body structure matter expressed in kilograms (kg), was measured using a Filizola brand electronic scale, with a capacity of up to 150 kg and a precision of 1g. The measurement was performed with the equipment positioned on level ground, being evaluated standing in the center of the platform, in an upright posture and with backs to the measurement scale, with the horizontal head, the legs slightly distant lateral and the arms relaxed to the length of the body (PITANGA, 2000);

b) The EST, understood as the vertical linear length between the plantar region and the vertex (highest point of the head), expressed in centimeters (cm), was measured using a portable stadiometer of the Avanutri brand and with a precision of 1mm. The measure was obtained with the subject barefoot, the heels, buttocks, the shoulder girdle and the occipital in discreet contact with the perpendicular ruler. According to standardization, a transverse slider was slid by the ruler to the support at the vertex at a right angle. The reading was performed with the maximum inspiration and head directed to the Frankfurt plane (PETROSKI, 1999); and

c) The PSA, understood as being the force with which the blood is released inside the arteries, and its values expressed in mmHg, was measured using a HEIDJI stethoscope, model Dusonic, and also 2 sphygmomanometers of the brand HEIDJI, aneroid model, 1 for individuals with arm circumference measuring 27 to 34 cm and another for subjects with measurement in said segment between 35 and 44 cm. For

the measurement, evaluating him before physical activity and without having ingested caffeine in the last 60 minutes, he was seated for 5 minutes with his back straight and supported, his left forearm in semi-extension, his hand open and relaxed, both on a table of adjustable height and the left arm completely naked at the height of the precordial region.

In order to perform the measurement the evaluator positioned the sphygmomanometer occluder cuff on the left brachial artery closing the valve of the pump of inflation, and with the index and middle fingers united palpated the brachial artery to feel the cardiac pulse. Then he inflated the occlusive cuff until he could no longer feel his heart beat, then he placed the ear-cup of the stethoscope in his ears with the olives facing forward.

Finally, he placed the instrument bell in the antecubital fossa about 2.5 cm from the elbow fold over the brachial artery, and gently opened the air control valve by reducing the cuff pressure. The first and last sounds heard corresponded to the systolic and diastolic components of the PSA, respectively. Two measurements were taken at intervals of 60 seconds between them, adopting the lowest measured value as the final result, which was corrected by the arm circumference evaluating, this measurement is performed at the meso-humeral point of the left arm. (MION, SILVA & MARCONDES, 1986).

### 2.3. Treatment of study-independent variables

#### a) The Aerobic Physical Exercise Program (PEFA)

The PEFA was composed of physical training sessions with a total duration of 60 minutes each, being divided pedagogically as follows:

1) Preparatory Part: Total duration of 10 minutes, the initial 3 used to activate the blood circulation and to increase irrigation in the muscular tissues in general, using a continuous dynamic stimulus, performed in the form of moderate walking. The remaining 7 minutes were used to lengthen the muscle groups to be most requested in the sequence of physical activity, and for this purpose stagnant exercises were actively located, in which the individuals were in search of the limit of joint mobility in the anteroposterior, (Nunes, 1998), which is the most common type of joint in the joint, and is the most commonly used joint in the articulation of the wrist, elbow, shoulder, hip, knees and ankle. .

2) Main: With a duration of 40 minutes, it aimed to promote functional improvements in the cardiovascular system. For this purpose, a continuous type dynamic stimulus performed as a vigorous walk was used, and the intensity of physical activity was controlled by the subjective sensation of fatigue (ACSM, 1995; Almeida et alli, 2018). During the physical exertion of the walk the subjects placed the perception of fatigue in the first week of work at level 6 (moderate), which progressed weekly

in a unit until reaching level 8, remaining in this for 4 weeks, reaching level nine 9) - strong from the seventh week of training and holding it until the end of the experiment.

3) Final part: With duration of 10 minutes, the first 3 intended to promote the physiological return of the subject to the initial levels of the training session. A continuous type dynamic stimulus performed in the form of a gentle walk was used. The remaining 7 minutes were used to lengthen the most requested muscle groups during the training, using the same methodology and the same exercises prescribed in the preparatory part.

#### b) The technical maneuvers of Manual Lymphatic Drainage Massage (MLDM)

The MLDM sessions were individual and had a total duration of 45 minutes each, the maneuvers consisting of linear movements invariably performed in the direction of the inguinal and axillary lymph nodes (GODOY & GODOY, 2004), with three repetitions sequenced in the region of the lower limbs, upper limbs, abdomen and posterior of the trunk, with the subjects in ventral or dorsal decubitus, according to the requirement of the body area to be massaged.

To perform the maneuvers, a massage table TMDMB model, manufactured by TANDER equipment, measuring 186 x 68 cm and designed in solid wood with a reclining headrest, rubber-lined feet, padded with 5 cm thick foam and coated in varnished varnish, also having adjustable height between 60 and 80 cm and capacity to withstand up to 250 kg.

### 2.4. Statistical analysis

In this experiment the data were analyzed through the following procedures: a) the descriptive statistics were initially performed to characterize the sample, and later, in order to detect possible significant differences between the GE1 and GE2 scores, Student's t-test for independent samples; and b) Finally, to compare the PSA values in the pre and post-test of the experimental period, the Student's t-test for dependent samples was used.

Data were processed and analyzed using the Statistica for windows version 4.3 software package from Starsoft Incorporation, with a significance level of  $p < 0.05$ .

## III. RESULTS AND DISCUSSION

In order to characterize the sample, the analysis of Student's t-test for independent samples of the mean values and their respective standard deviations of the variables: Age (ID), height (EST) and total body weight (PCT) of GE1 and GE2 at the beginning of the experiment. The statistical treatment showed significant differences between the scores of the variables: EST ( $p = 0.04$ ) and PCT ( $p = 0.03$ ), demonstrating the heterogeneity of the sample.

Table.1: Physical characteristics of the sample

VARIÁVEIS	GRUPOS EXPERIMENTAIS			
	GE1	GE2	t	P
PCT (Kg)	74,15 ± 5,85	69,47 ± 5,34	2,20	0,03*
EST (cm)	166,1 ± 5,61	171,1 ± 6,50	-2,13	0,04*
IDADE (anos)	53,57 ± 7,30	52,40 ± 7,36	0,41	0,68

\* Significant at p &lt;0.05 level

In accordance with the objectives of this study, Table 2 presents the analysis of the Student's t-test for samples dependent on the mean values and their respective standard deviations of the following variables: Systolic

Blood Pressure (PSAS) and Diastolic Blood Pressure (PSAD) of GE1 and GE2 at the beginning and end of the experiment.

Table.2: Values of arterial blood pressure components of GE1 and GE2, pre and post-test.

GRUPOS DE ESTUDO	PRESSÃO SANGÜÍNEA ARTERIAL SÍSTÓLICA – PSAS - valores em mmHg -				PRESSÃO SANGÜÍNEA ARTERIAL DIASTÓLICA – PSAD - valores em mmHg -			
	PRÉ TESTE	PÓS TESTE	t	P	PRÉ TESTE	PÓS TESTE	t	P
GE1	128,2	120,1	16,19	0,000*	86,4	80,9	20,19	0,000*
	±	±			±	±		
	3,82	0,39			1,91	1,38		
GE2	132,4	125,9	10,51	0,000*	86,6	82,8	2,73	0,017*
	±	±			±	±		
	6,36	5,31			3,88	3,26		

\* Significant at the indicated level.

When analyzing this table, it is observed that between the beginning and the end of the experiment the PSAS scores presented by GE1 and GE2 both indicated the same statistical significance (p = 0.000), and their mean values were reduced by 8, 1 mmHg for GE1 and 6.5 mmHg for GE2, representing a functional improvement of 6.3% and 4.9%, respectively.

A similar behavior was found when PSAD values were observed, which at the end of the experimental procedure indicated statistically significant differences for both study groups at the p <0.05 level between pre and post tests, with their mean values being reduced in 5.5 mmHg for GE1, which performed the PEFA in parallel with the MLDM, and in 3.8 mmHg for the GE2, which performed only the MLDM, representing a functional improvement in the levels of SAH in 6.3% and 4.3 %, respectively.

The results found in this experiment in relation to the PEFA to which the experimental groups were submitted are similar to those of other studies in the sense of corroborating the existence of positive correlations between the reduction of the arterial blood pressure levels of hypertensive subjects and the improvement of the

physical condition resulting from such improvement, it seems, in the regular practice of physical exercises, especially when performed aerobically.

In this sense, Almeida et alli (2018) observed after 8 weeks of physical exercises performed in 3 weekly sessions at an intensity between 6 and 9 of the subjective sensation of physical exertion, a reduction of 6.5% and 4.0 for blood pressures systolic and diastolic, respectively. Seals and Hagberg (1984) reviewed 12 studies with different methodologies and concluded that the reduction of arterial blood pressure was between 6 and 15% for systolic and between 6 and 14% for diastolic, similar values to those found in this study. In addition, ACSM (1993), corroborating with other studies (Martine, Dubbert & Cushman, 1990, Eemon, 1995, Nieman 1999, Almeida et alli, 2018) showed a mean reduction of 10 mmHg in arterial blood pressure in subjects who practice regularly aerobic exercises.

Finally, analyzing the scores of the groups studied, it is observed that even though both are statistically significant in terms of improvement (p <0.05), the results of the GE1 are significantly higher than those of the GE2, and this

fact can be attributed to the achievement of MLDM in parallel to the PEFA, a fact that seems to have potentiated the effects presented by GE1 in relation to the GE2, thus attesting the positive effect of the same.

#### IV. CONCLUSIONS

The results found in this research suggest that Manual Lymphatic Drainage Massage may be a valuable non-pharmacological auxiliary therapy in the control of arterial hypertension, also indicating that when performed in association with a regular program of aerobic dynamic physical exercises, it significantly increases the reduction of values of blood pressure of hypertensive subjects.

Thus, considering the existence of several gaps in this study, and still being a research that focuses on a subject that is lacking in more academic investigations, it is believed to have contributed with the scientific community in another option for non-pharmacological control therapy of arterial hypertension. In view of these findings, it is suggested to carry out new studies with a larger sample and to use new experimental designs, in addition to ratifying the results of this research, also extend this line of research.

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# Solar Photovoltaic Power with Control Strategies and Applications: A Review

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**Abstract**—Growing concerns about environment issues, photovoltaic (PV) power is widely gaining importance all over the world. Use of this solar electric power is increasing day by day in many countries. This paper presents a review on applications of solar photovoltaic power for domestic purposes, irrigation purposes as well as for the grid purposes. Solar photovoltaic (PV) system works under variable solar irradiations and thus various control strategies to utilize this solar power in an efficient manner are also reviewed in this paper.

**Keywords**— Solar PV Array, Induction Motors (IM), MPPT, Grid, Efficiency.

## I. INTRODUCTION

Environment issue is a major problem in the present time. The major portion of problem arises from the use of nonrenewable resources especially coal, diesel etc. in order to cope for the energy demand. Furthermore the increase in the population and alarming use of these resources, the non-renewable energy resources which are available to us are going to get extinguish which is a major cause of concern. Due to extinguishing of these non-renewable resources, energy problems are going to be more and more serious. In order to overcome this problem, the use of renewable energy resources especially solar photovoltaic (PV) has become more and more popular. Solar energy is one of the most promising candidates available to us in plentiful amount and is going to be widely accepted by all. The annual photovoltaic (PV) power generation is currently around 37 TWh in 2010, it is estimated to be reached to 1247 TWh by 2030, 2907 TWh in 2040 and to 4572 TWh by 2050 [1] as shown below in bar graph form.

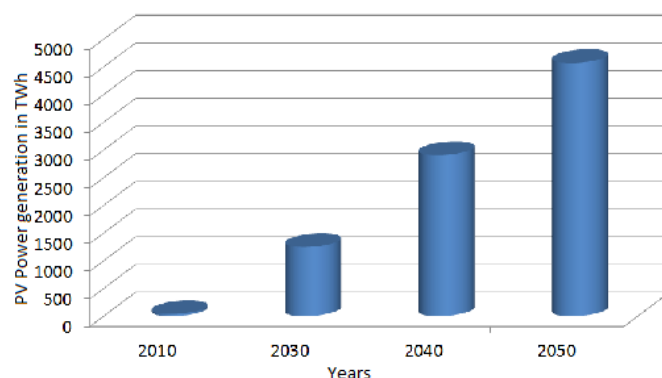


Fig.1 Showing PV power generation scenario in the world by International Energy Agency (IEA).

The cumulative installed PV capacity that was around 27 GW in 2010 had raised up to 30.4 GW in 2011 and 31.1 GW in 2012 and now it is expected to rise 872 GW by 2030 and 3155 GW by 2050, while this value was around 3.145 GW in 2003 as shown below in bar graph form [2].

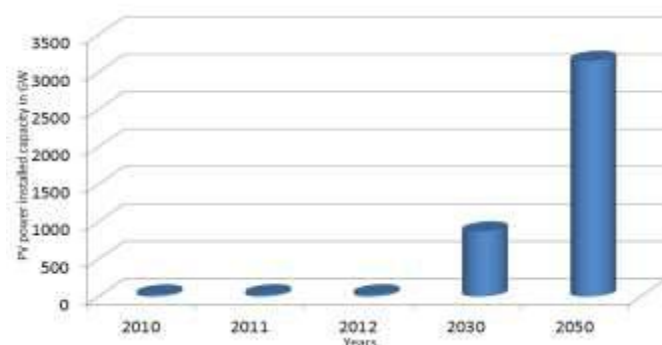


Fig.2 PV installed capacity scenario in the world by European PV Industry Association (EPIA).

The advantage of using the photovoltaic (PV) solar energy is that it is free and produces no greenhouse gases. Traditionally photovoltaic array were used for lightning, pumping and ventilation purposes because motors used for (pumping and ventilation) such purposes were the DC motors and the power generated was also DC, thus no conversion was required. Therefore major work was done

to improve the photovoltaic (PV) array output characteristics. But with the advancement in the AC induction motors (IM) the use of DC motor becomes less, because of IM reliability and maintenance free operation. Whereas the DC motors have brushes and commutator which requires proper maintenance after regular time period [3-4]. Due to numerous advantages of induction motors over DC motors these are widely used for different purposes in industrial, residential and agricultural such as water pumping, lifting, cooling, etc. Besides of these advantages of induction motor (IM), using the photovoltaic generated power for the pumping system led to the inefficient operation of the Induction motor, because the solar radiation and the temperature do not remain the same throughout the day and varies with the direction of the sun. Due to this, there occurs the power imbalance between the power generated and the load and hence give rise to the inefficient operation of the machine. Many control strategies are employed by researchers to control the motor operation under changing solar irradiations.

Besides the applications of the PV array with motors, these are now also used in grid connected mode and are also integrated with other power generation sources so that power demand can be overcome and carbon emission can be reduced. In this paper the work done by different researchers is reviewed keeping in view the application of solar PV generation in:

(i). Isolated grid mode

(ii). Grid connected mode. Especially feeding DC/AC motor load. These are described below one by one.

## II. ISOLATED GRID MODE

Isolated grid mode application of PV array was used about 54 years ago since the first operational silicon cell was demonstrated [5]. In this mode PV arrays were not connected to the grid and supply power directly to the load. Isolated grid application of the PV array was used to supply power to residential/village loads, DC/AC motor load for pumping, cooling etc. Handling such load connected with isolated grid mode was very tough and requires proper knowledge of handling such load with variable solar irradiations. Thus many researches in this field have started to handle such problems. [6] Had proposed the efficient operation of the PV array connected with the residential load and hence found that efficient operation can be achieved. A.M. Sharaf et al. in [7] had also proposed a scheme to track the maximum photovoltaic solar energy and maximum energy utilization scheme to cope with the varying resistive load and the solar radiation under standalone mode. The various other applications of PV power and control techniques of different researchers in standalone mode are discussed below:

### 2.1. Solar PV Array Applications for DC Motors

First DC motor was invented by the British scientist William Sturgeon in 1832. With this invention many researchers started their work that how to improve characteristics, application etc of DC motors. Later on first practical DC motor was invented by Frank Julian Sprague in 1886 which work with constant speed under variable loads [8]. With the advancement in technologies these motors were used for different application such as cooling, pumping traction etc. Among these applications PV water pumping system was used by many countries since 1977 [9]. Earlier motors used for pumping were supplied with constant voltage source. But later on with the advancement of renewable resources such as solar photovoltaic (PV) these motors were also fed from variable voltage source. These variable voltage sources give rise to the inefficient operation of the DC motors. Thus in order to operate the DC motors efficiently many control techniques were introduced by the researchers. [10-11] observed that the efficiency of separately excited DC motor when fed from solar PV array was increased from 29% to 75% when armature winding control and field winding control were applied. With the advancement in research field of the photovoltaic (PV) power generation, [12-13] had observed that smooth operation of the DC motor can be achieved with the use of DC-DC converter, thus protecting the motor from higher currents and voltages. Later on, it was observed that output power of the DC motor can be increased by proper selecting the parameters of the DC motor's magnetization characteristics and hence it was formulated that improved matching between PV array and DC motor can be achieved without any interfacing unit between them [14-15].

### 2.2. Solar PV Array Application for A.C Induction Motors

In the earlier period DC motors were generally connected to the PV array for many applications because they use the DC power and need not any conversion i.e. from DC to AC. However use of DC motors has some disadvantages as it requires regular maintenance. Also the DC motors were very costly [16]. On the other hand, use of induction motors has increased tremendously after its invention in 1885 [8]. Reason of its popularity can be because of its simplicity in design, cost effectiveness and robust construction. Furthermore these motors are more reliable than dc motors. Beyond these advantages, if induction motors are supplied from normal supply, they work with maximum efficiency but if the same motor is supplied from the PV array its operation becomes inefficient [17-18]. Thus in order to operate the motor efficiently with variable power source many techniques and methods were suggested by researchers.

The induction motor connected to variable power source PV system does not work at its maximum efficiency. This problem was overcome by [19] in which a control method was introduced. In this method, frequency of the inverter PWM control signal was adjusted according to the change in the solar irradiation and temperature. This method proved to be efficient because efficiency and operation of the induction motor was improved. Later on another method was introduced by [20] in which it was observed that the efficient operation of the induction motor can be achieved by the vector control method. In this method torque and the flux producing component of the motor was controlled. This work was carried out with the help of the digital chip signal processing. Furthermore with the advancement in solar technology, [21] had showed a new random inverter control technique for the motor drive application. This technique works on randomizing the inverter switching frequency without invoking any modification to the sampling and modulation. In this research work, experimental results derived from a microprocessor-based experimental drive system were presented to confirm the theoretical analysis. This technique shows that the calculations required for high switching frequency control, in comparison with the conventional space vector modulation technique can be reduced.

The various control strategies described above, help in achieving the efficient operation of the induction motor but also there are some control strategies which are cost effective and energy efficient in controlling induction motor. The method mostly used to achieve the efficient operation of induction motor generally use maximum power point tracking technique (MPPT) to track maximum power output of PV array [22-25]. In the conventional PV connected induction motor generally a DC-DC boost converter was used to boost up the voltage up to the desired limit. This technique however led to the cost inefficient operation. In order to overcome this problem [25] had proposed a technique in which DC-DC converter is eliminated from the circuit. In this control strategy output parameters of the PV array were used to trigger the inverter gates.

and IM was operated at maximum efficiency by optimizing the array terminal parameters by using genetic algorithm. In this technique it was proposed that for 100% isolation, dc link voltage obtain is about 360 volts and frequency obtained from equation is 58 Hz. Similarly for 80% isolation DC voltage is about 310 volts and corresponding frequency is about 54 Hz. From the above it was concluded that PV array feeding induction motor without boost converter led to the inefficient operation as proposed by M.A Elgendy et al. [27] although it reduces the number of switching circuit. For constant torque and speed control the efficient power utilization methods described

above were not utilizing the PV array output power efficiently. However some methods which were using these methods show some transient response. In order to overcome the problem of power matching between the load and the PV array [28] had introduced a speed controller method in which power change give rise to the change in speed of the induction motors. This control strategy was designed for constant head constant torque load. In this, as the load torque is constant then the load power will depend only on the speed of the induction motor. Thus the power mismatch between the load and the generated power give rise to the control strategy.

### III. SOLAR PV ARRAY GRID CONNECTED MODE

Solar panel used in the ancient time were of small rating and are used for small load. Furthermore these panels were very much costly which ultimately led to uneconomical operation. But now with the advancement in the field of solar technology these panels cost has declined with a high rate. And now in the present time photovoltaic power is widely used in almost all over the world. PV power generation has increased from few watts to many kilowatt rating. Due to this increase in power generation PV array are now connected to the grid in order to overcome the energy demand. In present time PV panels are available in higher rating and are of good quality which can operate for many years without any problem. Cost of the PV modules and the inverter used to connect with the grid has significantly decreased [29]. In this system power can flow in both forward as well as in reverse direction.

The main equipment of the PV array connected to the grid were: PV array, DC-DC boost converter with controller attached to it, DC-AC converter with a controller attached to it, filters to remove harmonics, transformer and the grid system [30]. In grid connected PV array, many problems related to the transfer of power occurs. In order to overcome such type of problem generally two converters were used. First converter was used to track the maximum power point (MPP) which was triggered by the maximum power point controller algorithm. This controller tracks the maximum power point of the PV array. Second converter is a DC-AC converter which was used to convert the DC power into AC power which was the form required by the grid. In grid connected system many algorithms were used to track the maximum power point of the array such as incremental conductance algorithm, P&O algorithm, Hill climbing, Fuzzy logic etc. each of these methods has its own advantages and disadvantages as described by [31-32]. Now presently research is going on to extract the maximum power from the PV. [33] Had presented a reconfiguration strategy. In this strategy efficient operation of the array was obtained by inserting a switching matrix

between the inverter and the PV generator. The main advantage of the electric array reconfiguration (EAR) technique was that it offer greater output as compared to the PV system having static configuration but this system also led to the disadvantage that it led to large complexity and cost[34]. On the other hand, it was also presented by many researchers that inverter triggering can be used to transfer the power in the most efficient way. Certain methods were being employed such as Adaptive current hysteresis band control scheme [35], vector control techniques, Line commutated inverter [36] etc. With the advancement in PV array, these were also integrated with the other generation sources such as Diesel power plant, Wind power plant in order to overcome the problem of load demand and to reduce the carbon emission into the atmosphere with suitable integration and to reduce the cost of the power[37]. [38-39] had employed a variable speed control technique for wind turbine whereas MPPT was employed for the PV system and dynamic and control performance of wind/PV system was simulated. Later on with the advancement in the field of solar power, introduction of induction motor connected to the grid system was introduced. In this system, a single inverter was used which can draw the power either from the single phase ac supply coming from the grid or from the solar energy input coming from the panels. [40] Had proposed that bidirectional flow of power can be achieved by adding an inductor in one phase of the inverter, thus making a phase difference between two wave forms. Also in this research power flow and output voltage regulation had been presented and it was seen that theory and result match each other.

#### IV. CONCLUSION

Solar energy is in abundant form available to us and can be used in different applications with the most efficient ways. This source of energy can play great role in the upcoming time as power demand is going to increase with the increase in population and with the depletion of the non-renewable resources. This PV power can be used for domestic purposes as well as for the industrial purposes depending upon the requirement. As from the above it becomes clear that in future PV power generation can overcome our power demand. Special control strategies can help us in achieving our goals in power sectors especially with the PV power.

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# Local Power as the Basis of the Understanding of the Federative Pact

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**Abstract**— The research aimed to describe the existing problems in the relationship between City, State and Federal Government, through the Brazilian Federative Pact, mainly for municipalities with population of less than 50,000 inhabitants. The research is structured from a qualitative perspective. The theoretical framework was built from the local power of the discussion based on the understanding of the federal pact and local interest and the municipality in Brazil. The paper argues that the federal pact is little debated, discussed, much less questioned by society in general, it only strengthens the lack of a legal and institutional framework for

coordination and cooperation among federal entities in the country, which results in public policy fragmented the territory and without direction, causing waste of public resources.

**Keywords**— Local Government, Federative Pact, Counties, Brazil.

## I. INTRODUCTION

The whole discussion of the Federative Pact that this work raises concerns in realizing the proposed problem, which is the symmetry syndrome, ie the equality that ignores the multiplicity of situations municipalities as

their economic, historical, geographical particularities and cultural. This leads us to reflect on their fragility, particularly in a country like Brazil universal complexity which requires caution when it comes to this federal crop. In this sense, the research we set out to accomplish aimed to investigate the existing problems in the relationship between city, State and Union (federal entity) through the Federative Pact, mainly for municipalities with population of less than 50,000 inhabitants.

Such problems of the Brazilian Federative Pact are consolidated in the distribution of taxes collected in Brazil. According to the Ministry of Finance of Brazil - National Treasury Accounting Data Collection System - SISTN 2011 of all taxes collected in Brazil, 66% goes to EU coffers, while 26.62% is allocated to the states and 7.32 % to 5,565 municipalities distributed throughout Brazil. This means that the Union is the one of the federal entities that have financial autonomy, that taking into account their ability to tax.

The funds for the participation of states and municipalities were important tools in an attempt to more fairness of tax revenues, but today clearly show insufficient for the federal units can meet the great demands on them populations, intensified by the progressive decentralization of many management public services. It is unanimous recognition of the concentration of these resources with the Union even after computed constitutional transfers to states and municipalities.

Finally, we present our final considerations, which do not constitute as finalists conceptions, but as provisional contributions, which will be the basis for the discussion of the existing problems, resulting from the reversal of responsibilities, powers and resources between federal, and their results will give rise to new research.

## II. THE AS LOCAL PACT UNDERSTANDING OF BASE FEDERATIONS

The individual is an indivisible. In living in society it is the smallest cell, then comes the family, community, neighborhood, church, school children, associations, political parties and, finally, the state. In a strong society, the state is the last to be fired, because both the market and the state, by itself, have not been able to implement a process of sustainable and socially just development; inversely, when the state is strong, citizens and civil society are weak. For Santos [1] "respect for the individual is the consecration of citizenship, in which a list of general and abstract principles is imposed as a concrete individual rights body"

Civil society was created by our needs and in the words of Bobbio [2] "is where emerge and develop economic, social, ideological, religious conflicts, that state

institutions have a duty to resolve or through mediation or through repression."

Civil society is made up of several components, civic, social institutions and organizations that form the foundations of a society running. The presence of an active civil society, participatory, strong is essential to ensure democracy, peace, security and local sustainability. It represents every kind of social organization that seeks and fight for their rights and demand solutions of social conflicts, always defending the interests of the majority of the community. It is made up of individuals and individuals, these in turn are permeated by different interests of a material nature, immaterial, moral, political, among others. In this composition scenario it is necessary to add private organizations such as businesses and public institutions represented by the state. There is no relationship between the constituent elements prerequisite. The state and civil society coincide and merge into such a degree that is hard to tell when one ends and the other begins. In this perspective, it is important to understand the mutually reinforcing relationship between the two. Max Weber addresses this social relationship: "By 'social relationship' should be understood behavior of many - that reciprocally as its significant content and gearing up for this reciprocity. [3]

The state was born with the purpose of organizing life in society. He of course exercises sovereign power over the individual and society itself, which grant them that power. It is a reciprocal relationship as one powers the other.

The concept of the modern state for Marx Weber best suited their considerations:

[...] the modern state is an institutional domination of association, within a territory intended successfully monopolize the legitimate physical coercion as a means of domination and gathered for this purpose, in the hands of its leaders, the organization of material resources, after evicting all autonomous state officials employees who had before in their own right, these means and to put himself in their place, represented by its supreme leaders [3].

The state arose from the need for order sought by social life. In the course of history the social differences were entreated by a policy line that systemising established disorder. Following what was inferred the state has a set of rules, administered and enforced by it laws. The it is allowed to control the lives of everyone. This control has limits of legal and territorial nature of certain people.

Individual concepts of the, civil society and state are important, however, an understanding is necessary, *a priori*, on the concept of power. Weber [3] power "means

all probability to impose their will in a social relationship, even against resistance, whatever the foundation of that probability."

In the words of Raffestin [4] is very enlightening:

The power seeks to control and domination over men and things through. You can reexamine the tripartite division in use in political geography: population, territory and resources. Considering what has been said about the nature of power, it is easy to understand why we put the people first. Simply because it is the source of all power. In it reside virtual processing capacity it is the dynamic element where does the action. [...]. The territory is no less essential since it is the scene of power and the place of all relationships, but without the people, it comes down to only a potentiality, a given static organize and integrate strategically. Resources, finally, determine the possible horizons of action. Resources determine the scope of action. [4]

Also for Raffestin [4] "the territory is a particular asset, resource and obstacle, continent and content, all at the same time."

When considering the concept of the state is tied to this concept of "power." The state authority is represented by the power it has on society, this power is considered a collective power.

To Raffestin [4] "every relationship is the point of emergence of power, and it bases its multidimensionality. The intentionality reveals the importance of the purposes and the resistance expresses the asymmetrical character that often characterizes relations "and every social relationship is producing spatiality / spatial. Produces (dis) continuities, by nature (dis) territorializadora power. And the power is noticeable fact alone, as Raffestin suggests, on the occasion of a relational process.

In this sense, the power can only be understood as a social relation, since everything that exists in society also is; what matters is to know what kind of specific social relationship it is.

Therefore, to rule a location, a territory of skill is necessary to understand the power relations brought that territory. You need to know the origin and nature of the kinds of powers that circulate among citizens. This allows to know the interests involved in the relationship of power, and the consequences of this type of relationship and the impacts they cause in society. Similarly, know the main power mechanisms involved in the site, in the territory, enables the involvement and participation of society in planning the city. The participation of the local community, and reduce social differences, provides the

local government to develop skills required to solve major problems. In the words of Raffestin "the territory is the political space par excellence, the field of action" [4].

When there is no civil society participation in local government this happens to be enjoyed and practiced by a very small representative group that territory. Right here come several questions: first - who are the subjects most involved with the power? Second - that interests circulating in power relations? And finally - In what segment of society power is presented as more latent? To answer these questions it is necessary to make the following considerations: there are types of power and types of subjects, who practice power. Bobbio [2] points out that there are three forms of basic power: economic power (the ownership of certain assets), the ideological power (the possession of certain forms of knowledge and doctrines) and political power (power whose specific medium is the power).

In our analysis the political power is our benchmark, but leaving for a simpler classification, in the foreground what you get are called formal power and informal power. The formal power is tied to the idea of institutionalization, represented by institutions of local, state and federal nature.

The informal power comes from the demonstrations spearheaded by civil society organizations. They are easily visible from group events, movements, associations, trade unions, among others. In the words of Bobbio [2] "negatively, by" civil society "means the sphere of social relations not regulated by the state."

The informal power targets to address to the formal power, represented by municipal, state and federal sectors, in order to assert the interests of their class representative.

The fact that the informal power need to address the formal power to get to legitimize the interests of this or that social category, does not mean that formal and informal relationship is one - sided. The demonstrations not only occur towards the formal to the informal. The interaction also exists starting from the formal to informal, establishing this way a *feedback* between the two types of power. The dialectical relationship of the two powers, the interference of a relative to each other, is what gives the body the development and form of land use.

The power is a social relation of domination, which implies the existence of dominant and dominated, ie, a group of human beings over others. In short, domination and exploitation are born together and can only continue to exist together, which means that the reason for the rule is exploitation, there is an indissoluble link between the two.



Although it is agreed that the power relationship includes an exploration of relationship, when we include in the discussion of state power does not consider that this necessarily will explore society. It is naive to say that the power exercised by the state over society includes an operating ratio since the state action is a result of compliance with society. What determines the state imposes, plans, executes, among other actions, makes the granting of the people who set up so that it did. However, as with everything, the structure of the relationship: State x Power Company, there are elements that are beyond the established rules and by establishing the aforementioned relationship of exploitation. This is the case of unlawful acts, the fees, the amounts of deviations, etc. But this kind of operation does not shake the foundation that led to the creation of the state, its structure, its laws, its rules; all fully set out in a document called the Brazilian Constitution, the Constitution of a country, the State Constitution of a State and the Organic Law of the municipality, among other common and complementary laws.

It is necessary to include this point the fact that between the state and the power exercised by it there is a "policy" that sets the so - called "political power", intrinsically related to state power. Contrary to the idea of exploratory domination, political power entitles the State to intervene, legislate, sanction and decide on the life of society under its jurisdiction. Political power is accepted as a public act, legal and necessary to society. Geographer Silva [5] says:

In addition to production conceived as legal body, the state is a form of social organization and does not dissociate from society and the underlying social relations. The approach undertaken is the state this social dimension, as a law of society, living there one of the justifications for their study in geography and the other sciences that deal not only social relationships, but your organization, including space [5].

Of all the types of political power exercised by a government that has the Federal Republic as a form of state, local government, the city appears as the federal entity most disadvantaged in resource fencing and obligations with the public services provided benefits the society. The federal republic divides the amount of taxes collected among his three federal agencies, namely: the Federal Government, the Federal District, the states and municipalities. The latter carries the so - called *local government* and all is the least has the resources and structure to work with quality to meet the needs of their society. At this point it is necessary to make a reflection: a "national society" as well as "state company" live in the cities, are therefore municipal corporations and not

"national" and "state". Thus enjoy the public services offered in their communities. Thus, the only federal entity before the federal pact that exists in fact as a territory is the municipality.

The city, in its totality of social representations, consists of business groups, religious, student, military representations, cultural, economic and many others that could be listed, which form the local authority of a municipality.

The long tradition of the period in which Empire, oligarchic and centralizing Brazil were or are governed by an elitist petty bourgeoisie, has made traditional forms of governing still exist. Of these forms the elite characteristic in the division of financial resources is one of them. According to the Ministry of Finance of Brazil - National Treasury System of collection of accounting data - SISTN 2011, of all taxes collected in Brazil: 66% go to the coffers of the Union while 26.62% are allocated to the States and 7.32% go to the 5,565 municipalities distributed throughout Brazil. This means that the Union is the only one of the entities of the federation that has financial autonomy, this is clear taking into account its ability to tax. After the constitutional and legal transfers of the Federal Government, passed on to the States, the Federal District and the Municipalities, the revenue apportionment slightly alleviates the regional and local inequalities of each R \$ 100.00 (one hundred reais) collected in Brazil, the Union is still with 55.50%, the States with 25.80% and the Municipalities with 18.70% of the total apportionment of the country. It is natural to ask, what are the consequences of this financial centralization in the Federal Government? A chaos in the Brazilian social welfare state and consequently establish in the municipalities of that country a public service provided to the population of poor quality. And the most penalized federal entity is the municipality and the biggest and most of the criticism comes and falls on the local managers, who is the political agent closest to the citizen, the taxpayer. The latter does not care to know from which sphere of public power responsibilities lie; to the citizen, who pays and is a taxpayer, is only interested in receiving quality and only public services.

As federal and state offices are institutionalized by presidential seat of government, its ministries, their departments and agencies with ministry *status*, the federal Senate, the chamber of deputies; likewise appears still institutionally representing the state level: the seat of state government, the legislative assemblies and state departments. Both institutionalization, federal and state, have representative spaces that follow a quantitative hierarchy in which the first offers of greater discretion or indicators than the second. Continuing this decreasing order, are the municipalities as those with less power of

decision in the institutionalized political spaces. This causes them not to have greater access in the democratization of decision making, execution and participation in the State's actions as a whole. Dowbor [6] confirms this thought:

"For years, the same interests that created our imbalances organized centralization of decisions, reinforced the concentration of wealth, created the state large aimed at providing the private sector goods at a price lower than the cost, and now preach privatization, as if participation or not the State was the crux of the problem, not the deformation that the elites have introduced it. The gist of the problem is the democratization of decisions so that they can meet the population's needs, and this implies a profound decentralization "[6].

Who actually enjoys the different nuances of power? Who uses so-called ruling elites, who are called lobbyists that lay on the other? Who is this network of relationships involved with the power? Who really governs, who actually has the power to decide? Who has control through the power?

There is a tradition of command and outrage towards the power of arrest, once-enjoyed by the federal power. It was common and still is, to assign to the Federal Government (national) the legitimacy of higher power enjoy them as well as to accumulate much more than other counties. However, today one can already witness a trend in order to realize these functions, hitherto only legacy to national power. Today this privilege is seen as also being the competence of the municipal (local) governments. Even better saying, to be more efficiently carried out by the local authority, the Municipality. Try to feel that it is the local level that gives the priority field of political action. Local government arouses patriotism, citizenship and consequently the ability and the ability to meet more effectively the interest of the population, with obligations by traditional national governments. But the technocrats or bureaucrats to support the argument that the local government does not have the "technical capability" to manage their interests.

Historically among federal agencies especially the municipality, ie also as clipping located and locatable is very tied to the Colonels, patrimonialism and personalism in the exercise of political power. But in a democracy the Local Government must be viewed from another angle, from decentralization notions of citizen participation in political power.

Consider that the local authority is rooted in an outdated historical period and that these customs need replacement by current practices of power, impose the need to establish differentiated analyzes of the local government,

now guided by the participation of the local community and the correlation of this with the political society. This table is presented as a new model of governance, the democratic rule of law. It local power is experienced in order to empower local excluded groups, provides the exercise of political power and the exercise of citizenship in order to break the boundaries that separate the citizen of the state. In this new model the city regains power over the territory in which they live and rebuilds the local area, from community, cooperative and democratic basis. Silva [5] contributes to this new vision:

Combine practices of participatory democracy to the traditional representation, where citizens, acting jointly with the government, will become responsible for their fate and the fate of the whole society [5].

Note that this view completely reverses the dynamics with which analyzes the category Local Government, now guided by the civil society and social movements and their relationship to political society. In this sense, a Law Democratic State Local Government presents itself as a new paradigm of exercise of political power, based on the emancipation of a new citizenship, breaking the bureaucratic boundaries between the citizen of the state and recovering control of the citizen in his municipality by rebuilding a community and democratic public sphere. Therefore, the Local Government is effective in action to produce appropriate conditions for the optimal development of the Brazilian public administration, capable of agreeing on participatory democracy and dismiss the failure of representative democracy at this stage.

For Magalhães [7] on the conceptual issues first actors reflect a little more about what is democracy:

Democracy is not a place where you arrive. It's not something you can achieve and after settling for it is the way and not arrival. It is process rather than outcome. Thus democracy exists in permanent tension with forces that wish to keep interests, the most diverse, maintain or reach the power to conquer interests of specific groups, and often these forces get out of balance, especially with the accommodation of dialogic popular participation, essence democracy we advocate, and the lack of interest to participate in the process of representative democracy, the perception of lack of representation and by the disenchantment with the results presented [7].

The big challenge is how to democratize democracy, Magalhães [7] insists that:

is democracy that is built of free dialogue, free thinking within a society where the construction of spaces of communication possible, which

depends on the construction of citizenship as an idea of dignity, freedom from misery and human respect. There is no freedom without effective means to exercise it, and these means are the rights to release the human misery and ignorance. [7]

Already making a conceptual distinction of participatory democracy of representative democracy. Representative democracy is considered an indirect democracy in which the people are not self-governing, but elected representatives, ie elected to govern. Representative democracy is the representation of an elected group, usually by vote, to represent the people, the population of a country, with an obligation to represent, act, speak and decide on behalf of voters.

Sartori [8] warning that the representative democracy the power exercised without legitimate participation of the people is a weapon against him:

The exercise of power is done by delegation (representation) and, if this delegation is not controlled and monitored by it delegates the power is exercised "on the people" and "not the people." It is, as mentioned, autocracy rather than democracy. The representation, unsupervised and without control by the citizens, is the *Achilles heel* of democracy. [8]

Sartori [8] "explains that the crisis is linked to the mass society that consists of the" mass man "isolated, vulnerable and available, with behavior ranging from intense activism and apathy." The "mass man" is part of an easily exposed to mobilization and manipulation society. Habermas [9] states that the ideology of mass culture is summed up in the phrase "makes you what you are", which means "duplication and legitimization of the *status quo* "By removing the" circulation all transcendence and all criticism. "In this sense, the DR could be seen as an institutional arrangement that would be part of a theory of mass society, whose aim would be to reach political and administrative decisions, excluding the participation [10]. Low participation would be a balance of the signal between democracy and capitalism (mass society) in Western societies explain that representative systems based on the contradiction between the formal democratic participation and civic passivity. [11] The democratic citizen must be active and passive; involved in politics, but not much; must be influential and obedient. [12]

Participatory democracy, participatory democracy the word at first sight, seems to be redundant, because there is no democracy without participation, without people, without civil society. Participatory democracy is a rule establishing the way you live where it is intended that there are effective mechanisms of control exercised by

civil society on public administration, not limited only to the right to vote, universal suffrage, but also extending democracy to social sphere. The participation of society with the collective, diffuse causes is considered a model or ideal for the exercise of political power, based on public debate between free citizens and equal conditions of participation.

Silva [13] lists the advantages of participatory democracy, deliberative democracy:

It involves discussions that bring benefits to the community; has educational character because it provides, each participant gains more knowledge through discussions; requires revisibility of opinions; encourages tolerance of divergent views; It improves individual justification capacity of preferences; filters arguments are not generalizable to the extent that only accepted the views that can be shared by all participants; increases confidence in the democratic process because the opinion of each is taken into account; It increases the confidence and the skills to be able to become a political actor; increases the legitimacy of political decisions that are justified to affected; contributes to making the most common positions;

For us Brazilians who live a missing social state, unable to secure the existing constitutional rights, the way the words of Magalhães [7] for a participatory democracy:

inclusion and active participation of our people as citizens is the coordinated fragmentation of power, the radical decentralization of powers to strengthen the states and especially the municipalities, as well as become permeable power, with the creation of popular permanent participation channels such as municipal councils, participatory budgeting and other mechanisms of participation, as well as the permanent incentive the organization of civil society and the strengthening of alternative media such as radio, newspapers and community televisions. We can, and so we are doing, build a social and participatory democracy from the local government. [7]

To understand this process we need to heed the words of geographer Silva [5]: "the location, the city first, is scale and arena construction of trans-scalar strategies and able political actors to opt in coordination with coalitions and alliances at multiple scales." The most usual and simple meaning, scale is the numerical representation of measure (reducing or enlarging) the real. This mathematical simplicity hides the enormous complexity of the term when it comes to crop the spatial reality. This cut

supposes, consciously or unconsciously, a concept that tells a perception of total space and "fragment" chosen. Bringing the question of the scope of the scale for the discussion of the local government, it should be considered that any trimming to be done to analyze its political phenomenon, this will have an intrinsic characteristic global territorial levels, national, regional and local mix. There is no way to consider the phenomenon of "local power" without considering the regional relations, national and global inherent to it. Anyway, to be able to analyze political phenomena involved around the discussion of the local government, we need to make this visible phenomenon and analysis of liabilities. This is possible through the limits imposed by the cut that is made of political reality, or even the scales considered around the same.

Within the territorial local government level are involved subjects who establish among themselves different types of relationship. reporting relationships, relationships of power, of authority, of outrage, obedience, submission, or to impose, in addition to numerous others not cited here. These subjects in turn, belong to social classes, and these classes are merged into the local society, or local government. Yes, the local government is not formed only by the group that represents the state. Local government covers the subject of the public and private sector, covers who is in charge and commanded.

The existence of domination and exploitation of one class over another is not without struggle and resistance of the classes and exploited and dominated groups, so the formation of a strong civil society is necessary, able to prevent the perpetuation of the exploited and not leave this task only in state hands, the result of a representative democracy. The order of domination is only possible through the effective participation of organized civil society and local.

Building citizenship is to build new relationships and consciousness, and this task is something you learn with living in the local, social and public community. It is in the living, day-to-day through these relationships established with others, citizenship in all its fullness.

Santos [14, 15], it states that "citizenship undoubtedly be learned. This is how it becomes a state of mind, rooted in culture. It is perhaps in this sense, that they say that freedom is not a gift but an achievement, an achievement to maintain."

The participation and mobilization of organized civil society, such as neighborhood associations, commercial, industrial, rural, trade unions, churches, etc., have the power to transform and build good public policies for society in general. Otherwise, the lack of participation in decisions about life in society triggers a series of

conditions that do not meet the main social needs of individuals.

Dowbor [16] contributes to this understanding, stating that:

When decisions are taken far from the citizen, they correspond very little to your needs. Thus, the dramatic centralization of political and economic power that characterizes our form of organization as a society, leads ultimately to a deep split between our needs and the content of decisions on economic and social development [16].

Citizen participation in the preparation of so-called public policies, generally held in public hearings, represents the interests of society as a whole.

Are results of so-called public hearings, not only the causes of fragmented society divided into social classes, unions, associations, in particular social groups such as the Indians, blacks, homosexuals, the handicapped, as well as , policies for society in general. The interests are consistent with the needs and causes the groups to which they belong.

Contributing to this debate a good performance of a democratic government is in its ability to take on the social demands generated by the social environment to which is attached and meeting effectively to these demands with the limited resources available and Putnam [17] contributes to say:

"A good democratic government not only considers the demands of its citizens (ie is sensitive) but also acts effectively in relation to such claims (ie, it is effective)." The good performance of a democratic institution would depend on what called social capital, expressed in horizontal systems for civic participation of a community. Thus, "the more civic region, the more effective his government" [17].

Costa [18] points out that comes to matters of local interest:

those where there is a predominance of the interests of the inhabitants of a particular area in the municipality, as a public entity, has better conditions to solve and implement than other federal entities. It's immense range of activities assigned to public officials of the municipality, with them set skills administrative but also political, where caveat their *autonomy*, subject to the criteria of convenience and opportunity, which not even the judiciary may violate [18].

The lessons of Meirelles [19]:

[...] local interest is not exclusive interest of the City, is not private interest of the locality, is not only interest of the citizens [...]. There are

municipal interest than reflexively Union and of the Member State, as there are no regional or national interest that does not resonate in the municipalities, as integral parts of the Brazilian federation. What sets and features local interest, enrolled as a constitutional dogma is the preponderance of the Municipality of interest on the State or the Union. [19]

Anyway, local interests can only take shape and concreteness as the local population if you listen, as their participation is real in discussions about planning and decision making on the local society. In contrast, the municipality makes its own administration because of their autonomy in matters of local interest, local management comprises the management of local public services, ie those in which the municipal interest is higher than the federal or state. It should be noted, however, that the municipality is located within the country, so that there is no opposition between the two interests.

For Putnam [17] "of civic engagement are an essential form of social capital: the more developed these systems are in a community, the greater the likelihood that its citizens are able to cooperate for mutual benefit."

The civic State is a stronger determinant that economic development of a country. So civic participation is important for the strengthening of institutions and is the main factor explaining the good performance of a government. Now what are ways for the consecration of this civility? Strengthening popular participation through the creation of mechanisms that provide permeability to state power. Creating ways of increasing participation, such as the democratization of public budgets, the participation of organized society in the municipal councils, first with the right to participate independently, then with deliberation of powers and regulation, democratizing access to information on the procedures of public money. This desired participation, resulting in decision more democracy and effective social control will occur effectively and efficiently, precisely in local government. Only then, we can expect a more decentralized country and the strengthening of integrated local power in a federation

### III. INTEREST AND LOCAL MUNICIPALITY IN BRAZIL

The participation of society in the public interest, namely the common good, the so-called third sector, is still the best way to build citizenship.

The local social mobilization is crucial for local development, for the community, despite existing internal differences, there is a common denominator, a consensus on what should be done. Local communities should seek the most appropriate practical ways to meet their

needs. Use of resources, for example, can get which resources are available and how they can be used.

With for example, public policies in the preparation of local education should suit the medium and basic education to environmental dynamics, economic and social in Geography of disciplines, Sociology and History from targeted content for the development of the city, seeking in this way, identify the natural, historical, tourism, human potential, among other locality. In this regard, Dowbor [16] defends the smallest administrative unit:

Defend the interests of the municipality is to promote balanced development, with a diverse economic base, a more just social situation. This is to promote a long-term vision, understanding that the city, the neighborhood, or a valley in a rural area, will be the place of life of children, their grandchildren, to whom we must make something better.

Congressman Ulysses Guimarães (Address televised House, 1989), emphasized throughout its legislative and political activity that the citizens do not live in federal entity called Union, much less in so-called states, the population resides in the city. With this statement, the parliamentarian, who chaired the National Congress during the drafting of the present Constitution, intended to emphasize the importance that have the municipalities, to people's lives, recognizing that these are federal entities, which become visible public administrations those who know the problems of their communities, faced with truly seeking their solutions, and therefore can produce results with public policies available in the direct service of society.

For local development can be effective, society needs leaders and organized communities to defend their cause is greater than the "common good", that is, the interest of all citizens. In this sense, the corporative interests, social groups, associations and trade unions should be prioritized in the second instance.

It takes participation in support of local society, questioning and mobilizing in the fight against unequal distribution of tax revenues between the entities of the federation. Study geographer and economist François Bremaeker, the Brazilian Institute of Municipal Administration (IBAM), and also very close to the central bank data on page 20, shows the flaws in the federal pact in Brazil, because when performed transfers and mandatory funds transfers, the Union is with 54.2%; States, with 28% and 17.8% with the Municipalities.

This reality is dichotomous, compared to developed countries, where municipalities control about half of



public resources. Dowbor [16] reinforces this situation by stating that:

While the countries developed increasingly citizen solve the issues in the city itself, in poor countries the municipality responsible adopt the pilgrimage system, traveling to the capital for each authorization of funding, with all the distortions in resource use that means. [...] Municipalities are stuck in legal frameworks that make its management a nightmare. On the pretext that there are less technical locally, it is thought that the resources will not be well spent if your transfer is not surrounded by a jungle of laws and regulations. The truth is that the more centralized the decision, there are more technical but less is control by the population. [...] The local administration is seen thus crushed between the explosive needs that arise in the municipality,

Besides Dowbor, you can also list a number of actions for the municipality, ie to the local interest, such as: Paulo Vannuchi, Marcio Pochman, Silvio Cacciabava, Peter Paul Martone White and Juarez de Paula, in a document entitled "National Support Local Development Policy - Note to the 2008 edition." In short, the main topics discussed in this document are presented below synthesized:

Motivating the national network of universities to produce completion of course work (TCC), research and other academic work focused on studies of the municipality or the region in which is located the municipality, the have a view to a database on these locations easily accessible to all of society;

In the same vein structuring of other key organs such as the Brazilian Institute of Geography and Statistics (IBGE) and Municipal Information System of the Federal Savings Bank (SIM), as well as taking advantage of its subsystems already developed to formalize the creation of a database basilar that contains integrated information about the city, to be mandatorily installed in each municipality;

All the themes presented above can contribute directly and indirectly to the development at the local level.

Social campaigns at the national level as "Child Hope," "Christmas Solidarity", among others, is important, but the contributions made by citizens do not have the proportionate return soon, these campaigns should be in their own locality, providing assistance to needs children from each municipality, according to the social problems of children and citizens being contemplated in the same town, so the children of the States and the Union does not

exist, that is, without running the risk of being "parochial" or having narrow view .

The degree of social and economic development of a city, or your municipality is the accurate portrayal of their community and its social heritage, in its actions to mobilization and collective participation, along with the government. Dowbor [16] elaborates on this theme:

Local government as organized system of civil society consensus on a limited space, therefore implies changes in the organization of information system, strengthening administrative capacity, and ample work training both in the community and in their own administrative apparatus. It is, therefore, an effort of the municipality about yourself. [...] First of all, it must be said that there is no model for the organization of community participation. This will vary according to the municipality is predominantly urban or rural, industrial or agricultural, relatively isolated or located near a large center. Also will be different according to local political balances and the level of awareness already achieved by the population. [...] For years, the same interests that created our imbalances organized centralization of decisions, reinforced the concentration of wealth, created the state large aimed at providing the private sector goods at a price lower than the cost, and now preach privatization, as the participation or not the State was the essence of the problem, not the distortions that elites it introduced. The essential problem is the democratization of decisions so that they can meet the population's needs, and this implies a profound decentralization.

From this generalized problem, which features holistic features, you can find a reverse path: the location, specific, particular, peculiar. Local government is the instrument that contains the customized media and representative of problem situations of each municipality in each location.

The city is considered by historians as the most primitive form of political organization of man, having arisen as a result of the need to solve the problems arising from community life, mediating and establishing rules for conflict resolution and acting on issues of common interest.

After all as context in scale as the smallest federal entity? According to Meirelles [19] states that:

[...] the Brazilian municipality is a legal entity of public law (CC, art. 41, III), and as such, endowed with full legal capacity to exercise rights and contract obligations in its own name,

accounting for all acts of its agents (CF, art. 37, § 6).

Meirelles also [19]

The "Brazilian municipality is political and administrative entity of the third degree, in descending order of our Federation: Union - United - Municipalities".

Art. 1. The Federative Republic of Brazil, formed by the indissoluble union of the states and municipalities and the Federal District, constitutes a democratic state [...].

Art. 18. The administrative political organization of the Federative Republic of Brazil comprises the Union, the states, the Federal District and the municipalities, all self-employed [...]. (BRAZIL).

The municipality, before being a political and legal institution is the social, and even natural, because it results from the grouping of several families in one place, united by common interests. As family and property, it is a social phenomenon that preceded it, the sociological point of view, the advent of the State [20].

However, not all doctrine is based on the recognition of the municipality as a federal entity. Silva [21] Castro and [22] support, in turn, that there is no federation of municipalities because the municipalities do not have representation in the Senate can not propose amendments to the Constitution, have no legal power or have territory.

There are different names attributed to the city by other countries in the same way, have the uneven nature of Brazil, their political moves differ from political moves practiced in Brazilian soil. It is possible that the institution "city," as it is conceived in the country, is unique worldwide. Elsewhere in the world, municipalities, even to a lesser extent, enjoy a political autonomy never practiced by the Brazilian, administer local people, usually belonging to the city and other urban centers.

The Brazilian municipal system is quite different compared to other countries like the United States of America (USA), Mexico, Argentina, Italy, Germany, United Britain. Considering only the United States as an example, it is necessary to point out that the cradle of federalism country (United States of America) did not include the "municipality" in its Federal Constitution, dated 1786, which, roughly speaking, has a limited text it's short; however, he stressed the importance and autonomy that member states have to deal with issues relevant to their internal organizations.

The above facts arise according to the customs and practices of the American people greatly influence the political traditions of that country. This directly affected the dealings with the issue of the municipality or

municipal approach, for which there is not even a distinct discrimination about what is, or what is "municipality" as notes Meirelles [19]:

[...] in certain regions dominates the *county* (equivalent to the Brazilian municipality) - as occurs, for example, in New York State. In others, the prevailing *city* (urban areas, lower in extension to the *county*, but not necessarily subject to this), while certain regions, such as New England, still adopt the *township* (entity whose definition varies considerably, if confusing sometimes with the *county*).

In Brazil, through the Federal Constitution of 1988, it increased the city to the rank of third level of government. This allowed the municipalities, at least in the constitutional text, the expansion of its autonomy: political, administrative and financial, as can be seen when considering the number of articles 29 to 31, articles 156, 158 and 159 of the Federal Constitution.

However, the legislation did not guarantee to the Brazilian nation that its municipalities would enjoy the full autonomy right advocated by the Federal Constitution. The municipalities in Brazil are totally dependent on scarce state and federal resources that are passed on too slowly, insufficiently and even unequally.

The 1988 Constitution established institutional decentralization conditions that have changed the organization of territorial authorities in Brazil through the reorganization of the federal structure. The modification allowed the supreme authority of the federal levels subordinate to the central state. It created a new economic articulation which can be called geographic democracy in view of the reorganization of institutional political spaces, territorialized representation of different interests, such as the interests of the municipalities.

The different interests present in the Brazilian continent as a whole clash with ideas and thoughts that no unilateral portray the Brazilian reality, ie a tangle of diverse political positions, thoughts and ways of acting, the most varied possible. However, this multi-society lives in cities, and it is precisely in the city that embodies their plans, their desires and their idealizations. When the inhabitants of the municipality put into action their interests, make the place a political space par excellence. In this environment of achievement of change and resistance to the new, the traditional coexist, the old and the modification, the new.

The Federal Constitution of 1988 [23] to incorporate the city as one of its federal entities increased their rights and duties, changed their empowerment and instrumentalized so that he could act more in the organization of the Brazilian territory. Despite the municipalities possess

numerous differences in relation to its geographical extent, population, human development index, economy, productivity, etc., the Constitution leveled municipalities alike and established the same empowerment for all.

Public policies of the federal government aimed at the country's municipalities should be asymmetric, because of the great cultural, linguistic, geographic and demographic among Brazilian cities, because Brazil has 5,565

municipalities. A city like Anhangüera - GO has 1,020 inhabitants and at the other end, a city like São Paulo - SP has 11,253,503 million. Of course the federal government can not create certain symmetry between the municipalities, placing them within the same group. But classifying the country's municipalities into four groups, demographically, one can get some better results, such as:

*Table.1: Amount of cities by population - Brazil*

Ranges population of cities	Number of cities	%	Total population	%
Up to 50,000	4,957	89,08	64.004.918	33,55
Of 50,001 to 100,000	325	5,84	22.314.204	11,70
From 100,001 to 500,000	245	4,40	48.565.171	25,46
Over 500,000	38	0,68	55.871.506	29,29
<b>Grand total</b>	<b>5.565</b>	<b>100,00</b>	<b>190.755.799</b>	<b>100,00</b>

Source: Data from the IBGE, 2010. Tabulation of authors

Bringing this classification for the state of Rondônia:

*Table.2: Amount of cities by population – Rondônia*

Ranges population of cities	Number of cities	%	Total population	%
Up to 50,000	45	86,54	669.499	42,90
Of 50,001 to 100,000	5	9,62	347.857	22,29
From 100,001 to 500,000	2	3,84	543.145	34,81
Over 500,000	-	0,00	-	0,00
<b>Grand total</b>	<b>52</b>	<b>100,00</b>	<b>1.560.501</b>	<b>100,00</b>

Source: Data from the IBGE, 2010. Tabulation of authors

In addition to the demographic issues, there are other factors that determine some differences between the Brazilian cities, for example, geographic location, it is on the inside, on the coast, in a metropolitan area; the degree of ruralization or urbanization; economic dominance if it is linked to industry, agriculture, agriculture, and trade and services.

What can we reflect, it is that concrete 89.08% of the municipalities of Brazil and 86.54% of the municipalities of the State of Rondônia are small, naturally the difficulties of running a small municipality are higher than those faced by mayors of cities of medium and large. After all, there is a greater population pressure on politicians - councilors and mayor, due to the access and contact with them are more facies, to collect directly meet the needs. Given this situation, the small towns, need special attention or contextualized the federal government and regulatory agencies.

Small and micro-municipalities have a reduced technical-administrative and financial capacity of course does not have a sufficient framework for the provision of public services with quality and depend on transfers from other federal entities to its sustainability.

Santos [24] states:

"It is in this light that the question should be seen in the federation and the nation's governance: the extent that the nation's government sympathizes with the designs of external forces, rising crucial problems for states and municipalities."

Regarding regulatory agencies, municipalities are monitored by the State Audit Court and the Federal, the District Attorney, Federal, the General Union CGU Comptroller and the Attorney General of the Union, this of course, in relation to federal funding that receive. Municipal managers are treated by such bodies as the police treat bandits, that is, they are seen as guilty until proven otherwise. The small municipalities have available technicians, prepared in the areas of accounting, administrative and legal, for fundraising and accountability, but they are all treated as if it were the city of Belo Horizonte-MG, Manaus AM or are Paulo-SP.

Castro [25] on the issue in question and the particular case of Geography, although the IBGE has given increasing attention to this cut in the basic information survey of municipalities, which has mapped and updated

profile of Brazilian cities, few issues facing the territory they have been raised and few analyzes.

In Brazil experienced a syndrome of equality, this symmetry of course ignores the multiplicity of realities in the municipalities, their historical, economic, cultural and geographical peculiarities, this requires a little more caution when it comes to this federal crop. After all, the city is much more than a part of the country, it is a loaded crop value and content, the fruit of their territoriality that can not be ignored. In this sense, the local authority, the municipality, may be one more resource to increase knowledge and understanding of other federal agencies and organs of control and supervision of this country.

#### IV. CONSIDERATIONS

In the course of this research, it is clear the importance of articulate local and married to a participatory and civic community vision for success of the Brazilian nation. As well as the Brazilian federal pact should be reviewed, debated and revised continuously to improve the state in social and economic whole nation.

Also because each individual naturally tends to care more about their interests than with the collective interests and those farther away, so there is the sum of the knowledge of individuals to an entire whole. Thus, to balance the risk of criticism, due to the concentration of power, with the natural particularity of men, and with the separation of knowledge in society, the Union State is still the best form of government today.

The system of cooperation and subsidiarity which is the essence of federalism should be put into practice in all its wholes, not only in political and administrative autonomy, but also in the financial. Therefore, the federal government should assume only the national political nature. Local government knows best of their main problems and demands and the results are more visible when the target is restricted.

When the individual is triggered to participate in public affairs in the community, we know that this is much more important than the act of voting from over 141 million voters to elect mayors, governors and the president of the republic. The greater the participation of the individual, of course better for the citizens and consumers of public services.

What we need is to invert the pyramid of importance among local, state and federal governments. We have a municipal government entirely dependent on the goodwill of other federal agencies.

Take, away and separate from the center, namely the decentralization of the federal state as an alternative to democracy is a trend of the contemporary world in an attempt to further community involvement. Thus, the municipality is the prime Community element in the

decentralization process, it is output to the modernization of public administrations and as the initial and favorable solution in citizen engagement.

It remains to implement participatory policy as an element of inclusion of citizenship as consolidation of democracy fiscal, political and administrative. Nowadays there is no more just the delegate or representative democracy. There is need for a dynamic, efficient and flexible administration, the simple representation is no longer the best way. The solution is new articulation, not only of representative democracy, but also participatory democracy, directly, for the practice of full citizenship implies participate in decisions in the public sphere.

Before all the data reported and presented in this study can understand that the Brazilian federal pact is distorted, backward and unbalanced, because the municipality is the federal entity with more public responsibilities to the citizens of this country and paradoxically gets the smallest share in the distribution of funds raised in the country. These distortions are the result of the manipulations that the Union and the states make the distribution of taxes to municipalities and consequently with the Brazilian people.

Unfortunately the federal pact is little debated, discussed, much less questioned by society in general, it only strengthens the lack of a legal and institutional framework for coordination and cooperation among federal entities in the country, the result is public policy fragmented in territory and without direction, hence causes the waste of public resources.

After eight Constitutions in Brazil, the 1988 Constitution brought a novelty, the elevation of the municipality member of the Brazilian Federation. Was assured to him also, administrative, political and financial. But progress soon conspired against the city with the ideology of "relative incapacity" as if it were a minor, a teenager, with this view, autonomy should be safeguarded. Therefore, he withdrew revenues was limited to the form of emancipation and labeled to corrupt all mayors and ignorant and unable local legislators, councilors. The other federal entities in the three powers began to torment the lives of local politicians without taking the trouble to look at the mirror itself.

As he said Tocquville [26], the municipal politics is the main school civics and democracy. Punish the municipalities is to encourage centralism, authoritarianism of the periods of the Colony, the Empire, the Old Republic, the New State and the military regime in 1964. Since guarantee municipal autonomy is the consolidation of the rule of law in Brazil.

In any case, discuss this territorial issue, even living the spatial dynamism of Brazil, was not and is not necessarily easy and allowing simplifications task because there are

many variables to be considered, which can lead to analysis and discordant results yourself that is not produced much effort for this to occur.

Finally, the challenge is not only on problem analysis, but continued thinking the Federative Pact in Brazil. Not least because the Brazilians live on an avenue or street and live with neighbors and friends in a municipality. This is the real and tangible world, the unreal, fiction is in the Union and the States. Until then, the Brazilians, the powers that be will attend the ills of the current Brazilian federative pact. Since the defense of Municipalities is the guarantee of political, economic and social, to Brazil.

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# Analysis of Volume Relationship, Traffic Speed and Density in the Tulukabessy Street with the Greenberg and Underwood Methods

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**Abstract**— The city of Ambon, a city that is often called the city of music or often dubbed the "Ambon manise" also does not escape the problem of congestion. There are several areas which are the points of congestion in the city of Ambon, namely, the area of Jalan Slamet Riyadi, precisely in front of Makodim 1504 Ambon, to Tulukabessy. The congestion that occurred on Tulukabessy road was partly because there was a shopping center (Citra) and several offices on the road, there was also a road body that was used as a garage. To overcome the congestion that occurs in some of the regions mentioned above, a good traffic management is needed. Traffic parameters that need to be known, namely traffic flow or volume, speed and density. The performance of a road can be measured from these three parameters or often referred to as traffic characteristics. For this reason, the volume, speed and density of traffic will be analyzed using the Greenberg method and the Underwood method.

This research is quantitative and data collection is done by means of surveys, namely speed surveys and traffic flow surveys. Volume and speed data are then processed to obtain density. Furthermore, the three traffic parameters were analyzed by the Greenberg and Underwood methods, resulting in a relationship between the three traffic parameters.

The most suitable method used for the Tulukabessy road is the Underwood method with a coefficient of determination ( $R^2$ ) = 0.960 with a maximum Density value ( $DM$ ) = 200 smp / hour maximum volume ( $VM$ ) is  $VM = 2481.84626$  junior / hour. The relationship between the parameters of the Tulukabessy road traffic with the Underwood method, as follows: Relationship Speed-Density  $\ln S = 3.7394 - 0.005 D$ ; Volume - Density Relationship  $V = 42,073 D e^{-0,005 D}$ ; Relationship Volume - Speed  $V = 747.88 S - 200 S \ln S$ . The

most suitable method used for the Tulukabessy road is the Underwood method with a coefficient of determination ( $R^2$ ) = 0.960 with a maximum volume value ( $VM$ ) is  $VM = 2481.84626$  junior high school / hour.

**Keywords**— Traffic Parameters, Underwood, Greenberg.

## I. INTRODUCTION

Congestion is a classic problem faced by cities in the world, including in Indonesia. The problem of congestion is a daily problem that must be faced by urban communities, including the city of Ambon.

Tulukabessy Road which is one of the points of congestion in Ambon city is a secondary road which is a road network system with the role of the distribution of goods and services for the community in urban areas or in simple language is a road network in urban areas. The congestion that occurred on Tulukabessy road was partly because there was a shopping center (Citra) and several offices on the road, there was also a road body that was used as a garage. Besides that, on the Tulukabessy road there are several crossroads which are also one of the causes of congestion, namely from the PHB intersection, PU Bridge intersection, Citra intersection and Hotel Josiba intersection. Besides this, the burden of vehicles on the Tulukabessy-Mardika road to the Batu Merah area is quite high, because drivers prefer the road to the Mardika coastal road to Ongkoliong (<https://www.tribun-maluku.com>). To overcome the congestion that occurs, a good traffic management is needed. Traffic management certainly requires information about the parameters of traffic on the road that is the point of congestion. Traffic parameters that need to be known, namely traffic flow or volume, speed and density.

## II. STUDY OF LITERATURE

### 1. Road

Definition of Road According to Law No. 38 of 2004 is land transportation infrastructure that covers all parts of the road, including complementary buildings and equipment intended for traffic, which are on the surface of the land, above the surface of the land, below the surface of the land and / or water, and above the surface of the water, except railroads, lorry roads and cable roads.

In accordance with the designation the road consists of public roads and special roads. Public roads are grouped according to system, function, status and class, while special roads are not intended for general traffic in the context of the distribution of goods and services needed.

Road characteristics will affect road capacity and performance if it is burdened with traffic. Road characteristics consist of:

#### a. Geometry

1) Road type: various types of roads will show different performance in loading certain traffic, for example a divided and undivided road; one way street.

The types of urban roads are as follows:

a) two-way two-lane road (2/2 UD)

b) Two-way four-lane road

- undivided (i.e. without median) (4/2 UD)

- divided (i.e. by median) (4/2 UD)

c) Split two-lane six-lane road (6/2 D)

d) One-way roads (1-3 / 1)

2) Traffic lane width: Free flow velocity and capacity increase with increasing traffic lane.

3) Kereb: kereb as the boundary between traffic lanes and sidewalks affects the impact of side obstacles on capacity and speed. The capacity of the road with kereb is smaller than the road with the shoulder. Furthermore the capacity decreases if there is a barrier that remains near the edge of the traffic lane, depending on whether the road has a kereb or shoulder.

4) Shoulders: urban roads without kereb generally have shoulders on both sides of the traffic lane. The width and condition of the surface affects the use of the shoulder in the form of additional capacity and speed at certain currents, due to increased shoulder width, mainly due to the reduction of side barriers caused by road side events such as stop public transport vehicles, pedestrians and so on.

5) Median: the median is the area that separates the direction of traffic in the road segment. Well-planned median increases capacity.

6) Road alignment: horizontal curves with small fingers reduce free flow velocity. Steep incline also reduces free

flow speed. Because in general the speed of free flow in urban areas is low, this influence is ignored.

#### b. Flow Composition and Separation of Directions

1) Separation of traffic direction: the capacity of the two-way road is highest at 50-50 separation, ie if the currents in both directions are the same for the time period analyzed (generally one hour).

2) Traffic composition: traffic composition affects the velocity-flow relationship if the current and capacity are expressed in vehicle / hour, that is, depending on the ratio of motorbikes or heavy vehicles in traffic flows. If the current and capacity are expressed in passenger car units (pcu), the light vehicle speed and capacity (pcu / hour) are not affected by the composition of the traffic.

#### c. Traffic control

Speed limits are rarely applied in urban areas in Indonesia and therefore have little effect on the free flow velocity. Other traffic rules that affect traffic performance are: parking restrictions and stops along the side of the road, restrictions on access to certain types of vehicles, restrictions on access from side roads and so on.

#### d. Side Road Activity (Side Obstacles)

Many roadside activities in Indonesia often cause conflict, sometimes having a large effect on traffic flow. The most influential side constraints on urban road capacity and performance are:

1) Pedestrians

2) Public transportation

3) Slow vehicles (egpedicabs, horse carriages)

4) Vehicles enter from the land beside the road.

#### e. Driver Behavior and Vehicle Population

The size of Indonesia and the diversity and level of development of urban areas show that the behavior of the driver and vehicle population (age, power and condition of the vehicle, the composition of the vehicle) are diverse. Smaller cities show less agile driver behavior and less modern vehicles, causing lower capacity and speed at certain currents, compared to larger cities.

### 2. Characteristics of Traffic Flow

To be able to represent the characteristics of traffic flow well, there are 3 (three) main parameters that must be known where the three parameters are mathematically related to each other, namely (Wohl and Martin, 1967; Pignataro, 1973; Hobbs, 1979; Tamin, 1992e in Tamin, 2000):

#### a. Traffic flow or volume

Traffic flow is the number of vehicles that pass a certain point in a certain road segment in one unit of time.

General formula:

$$V = \frac{n}{T} \dots\dots\dots(2.1)$$

with:

V = Traffic flow (vehicle / hour, junior / hour)

n = Number of vehicles (vehicles, junior high)

T = Observation time interval (hours)

b. Average space speed

The average velocity of space is the speed value along the observed road segment which is the result of a comparison between the distance traveled with the average time to take the road.

General formula :

$$S = \frac{d}{t} \dots\dots\dots(2.2)$$

with:

S = Average space speed (m/ sec, km / h)

d = Length of the observed road (m, km)

t = Average travel time along d (seconds, hours)

c. Density

Density is the number of vehicles in one unit of a certain road length. Difficult density is measured directly but can be calculated from speed and volume.

The formula:

$$D = \frac{V}{S} \dots\dots\dots(2.3)$$

with:

D = Vehicle density (vehicle / km, pcu / km)

V = Vehicle current / volume (Smp / hour, vehicle / hour)

S = Vehicle speed (km / h)

Analysis of the characteristics of traffic flow for a road segment can be done by studying the mathematical relationship between speed, flow and traffic density that occurs on the road section. The mathematical relationship can be expressed by the equation:

$$V = D.S \dots\dots\dots(2.4)$$

The mathematical relationship between these parameters can be explained using Figure 2.1. which shows the general form of mathematical relations between speed-density (S-D), current-density (V-D) and current-speed (V-S).

The mathematical relationship between speed-density is monotonically downward which states that if the traffic flow density increases, the speed will decrease. Traffic flow will be 0 (zero) if the density is very high so it does not allow the vehicle to move again. This condition is known as total traffic jam ( $D = D_j$ ). in conditions of density 0 (zero) ( $D = 0$ ), there are no vehicles on the road so that the traffic flow is also 0 (zero). If the density increases from zero, then the speed will decrease while the flow of traffic will increase. If the density continues to increase, conditions will be

achieved where an increase in density will not increase the flow of traffic, on the contrary it decreases the flow of traffic (figure 2.1). The maximum point of the traffic flow is expressed as current capacity.

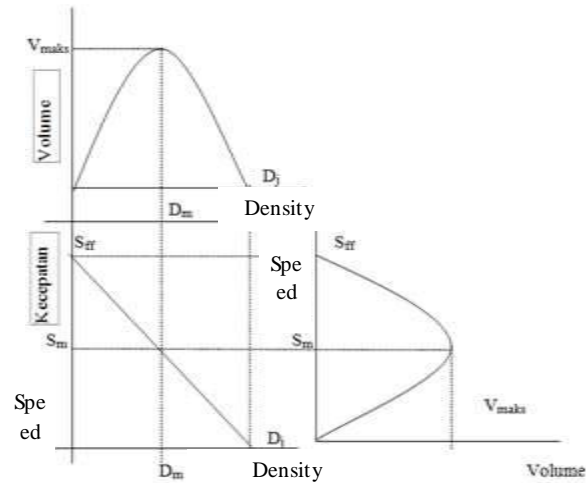


Fig.2.1.Mathematical relationship between speed, current and density

Figure 2.1 also shows some other important parameters of traffic flow which can be defined as follows (Wohl and Martin, 1967; Pignataro 1973; Salter, 1978; Hobbs, 1979; Tamin et al, 1992b; and Country, 1994, and Tamin, 1996 in Tamin 2000):

$V_m$  = Maximum capacity or current (vehicle / hour)

$S_m$  = Speed at maximum traffic flow conditions (km / h)

$D_m$  = Density in maximum traffic flow conditions (vehicle / km)

$D_j$  = Density in total traffic jam conditions (vehicles / km)

$S_{ff}$  = The speed of traffic conditions is very low or at conditions close to zero or free flow velocity (km / h)

Free flow velocity ( $S_{ff}$ ) cannot be observed in the field because the condition occurs when there is no vehicle ( $D = 0$ ). Free flow velocity values can be obtained mathematically derived from the mathematical relationship between current-velocity that occurs in the field. Data that can be collected in the field by conducting surveys is the flow and speed of traffic. Traffic passes through various types so the traffic flow data must be stated in passenger car units (pcu). The number of vehicles observed is based on the type and will be equivalent to passenger cars. Emp value (passenger car equivalence) for each type of vehicle can be seen in Table 2.1.

Table.2.1: The equivalent value of passenger cars with divided and one-way road types

Road type: one-way road and divided road	Traffic flow per track (vehicle / hour)	Emp	
		HV	MC
Two lanes one direction (2/1) and Four divided lanes (4 / 2D)	< 1050	1,3	0,4
	≥ 1050	1,2	0,25
Three lanes one direction (1/3) and Six divided lanes (6 / 2D)	< 1100	1,3	0,4
	≥ 1100	1,2	0,25

Source: Indonesian Road Manual Capacity 1997

### III. METHODOLOGY

In this study the method used for data collection is by survey in the field.

#### 1. Survey volume

The way is by direct observation in the field (counting every vehicle that passes per 15 minutes). The survey of traffic flow or survey of the number of vehicles in this study was carried out manually, namely recording the number of vehicles passing one observation point for one unit of time. The number of vehicles observed is based on the type and will be equivalent to passenger cars. The observation point for volume surveys is the front of the KDP building.

#### 2. Speed survey

You do this by measuring the travel time of the vehicle through the observation point by using a stopwatch aid. In this study the average speed of the traffic flow space is determined by the speed of the point (spot speed) that is the observer recording the travel time of a vehicle with a certain distance. The assumption of using point speed is that the speed along the road is fixed. The spot used for speed surveys is the front segment of the PPK Building to the front of the Taspen office (+ 50 meters).

#### A. Analysis Method

Survey data in the form of volume data and velocity data are then processed to produce density. After that, these three parameters are analyzed further using the Greenberg method and the Underwood method, which can be described as follows:

##### 1. The Greenberg Method

Greenberg (Wohl and Martin, 1967; Pignataro, 1973; Salter, 1978; and Hobbs, 1979 in Tamin 2000) assume that the mathematical relationship between speed-density is a

logarithmic function. The basic equation of the Greenberg method can be expressed through equation (3.1).

$$D = C \cdot e^{bS} \dots\dots\dots (3.1)$$

Where C and b are constants

The mathematical relationship between speed-density can then be expressed in equation (3.3).

$$S = \frac{\ln D}{b} - \frac{\ln C}{b} \dots\dots\dots (3.2)$$

Next is the mathematical relationship between current-speed:

$$V = \frac{D \cdot \ln D}{b} - \frac{D \cdot \ln C}{b} \dots\dots\dots (3.3)$$

The mathematical relationship between current-density can be seen in the equation. The maximum current condition (VM) can be obtained when the current  $D = DM$ . The  $D = DM$  value can be obtained through the equation:

$$D_M = e^{\ln C - 1} \dots\dots\dots (3.4)$$

Next is the mathematical relationship between current and speed:

$$V = S \cdot C e^{bS} \dots\dots\dots (3.5)$$

The maximum current condition (VM) can be obtained when the current is  $S = SM$ . The value of  $S = SM$  can be obtained through the equation:

$$S_M = -\frac{1}{b} \dots\dots\dots (3.6)$$

#### 2. Underwood method

Underwood (Wohl and Martin, 1967; Pignataro, 1973; Salter, 1978; and Hobbs, 1979 in Tamin 2000) assumes that the mathematical relationship between speed-density is an exponential function. The basic equation of the Underwood method can be expressed by the equation:

$$S = S_{ff} \cdot e^{-\frac{D}{D_M}} \dots\dots\dots (3.7)$$

where:  $S_{ff}$  = free flow velocity

$D_M$  = Speed at maximum current (capacity)

The mathematical relationship between speed-density can then also be expressed in equation (2.36).

$$\ln S = \ln S_{ff} - \frac{D}{D_M} \dots\dots\dots (3.8)$$

mathematical relationship between current-density as follows:

$$V = D \cdot S_{ff} \cdot e^{-\frac{D}{D_M}} \dots\dots\dots (3.9)$$

The maximum current condition (VM) can be obtained when the current  $D = DM$ . While the mathematical relationship between current-velocity is as follows:

$$V = S \cdot D_M \cdot (\ln S_{ff} - \ln S) \dots \dots \dots (3.10)$$

The maximum current condition (VM) can be obtained when the current is  $S = S_M$ . The value of  $S = S_M$  can be obtained through the following equation (3.11):

$$S_M = e^{\ln S_{ff} - 1} \dots \dots \dots (3.11)$$

#### IV. RESULTS AND DISCUSSION

##### A. Overview of Research Sites

Tulukabessy Street is an urban road located in Mardika village, Sirimau sub-district, Ambon City. The width of the Tulukabessy road is 10.3 meters with a one-way traffic system, the cross section of the Tulukabessy road can be seen in Figure 4.1. Tulukabessy Road has a fairly heavy traffic flow, especially during peak hours. This is because mainly because JalanTulukabessy has a shopping center, motorcycle taxi, directions to the mardika terminal, offices, and places of business / trade on both sides of the road.

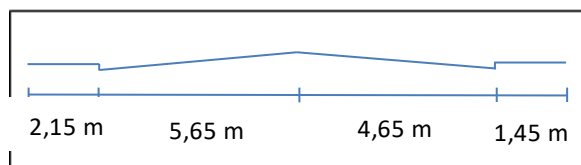


Fig.4.1: Cross Section of the Tulukabessy Road

##### B. Description of Research Variables

##### 1. Calculation of Traffic Flow / Volume

Data on traffic flow obtained from the survey results in the form of vehicle data every 15 minutes. This data is multiplied by the Equivalence factor of Passenger Cars (EMP) for each type of vehicle then summed so that the traffic volume is obtained for each hour.

Equivalent Value of Passenger Cars (EMP) for each type of vehicle according to MKJI 1997 for urban roads are:

- a) Heavy vehicles (HV) = 1.3
- b) Light Vehicle (LV) = 1.0
- c) Motorcycle (MC) = 0.4

The current / volume survey is conducted for three days, namely on the 24th, 26th and 29th of September 2018 starting at 6:00 a.m. until 19:00 a.m. every day. The processed data is then presented in graphical form which shows the relationship between traffic volume (pcu / hour) and time interval (hour), the graph can be seen in figure 4.2 to figure 4.4. From the graph can be described the condition of the traffic flow at the highest and when the lowest current.

Charts The Volume Of Traffic  
(September ,24,2018)

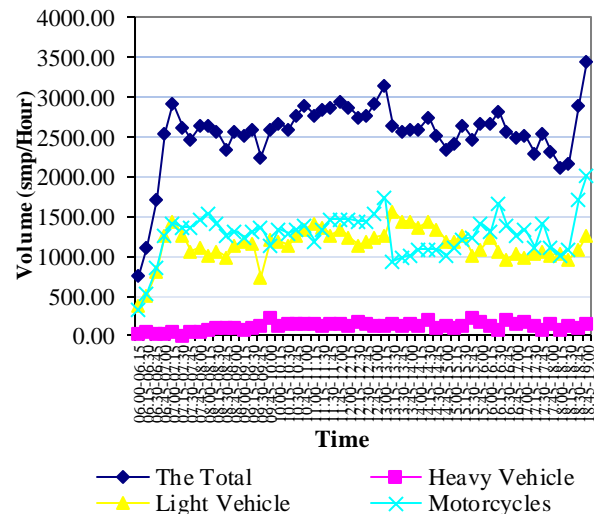


Fig.4.2: Charts the volume of traffic (September 24, 2018)

From graph 4.2 above, it can be seen that the highest traffic volume on September 24, 2018, which is equal to 3468.40 pcu / hour occurs in the afternoon at 18.45-19.00 Wit. For the morning the traffic volume is high at 7:00 a.m. to 7:15 a.m. that is equal to 2922 pcu / hour and during the day at 1:00 a.m. to 13:15 wit at 3144.80 pcu / hour.

Charts The Volume Of Traffic (September 26,  
2018)

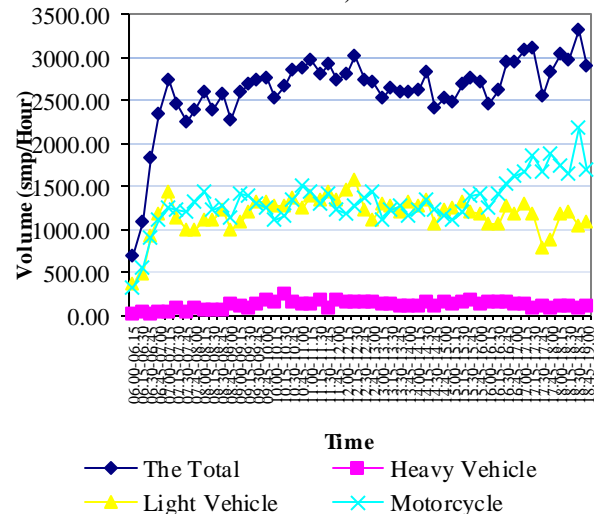


Fig.4.3: Charts the volume of traffic (September 26, 2018)

From graph 4.3 above, it can be seen that the highest traffic volume on September 26, 2018 which is equal to 3324.40 pcu / hour occurs in the afternoon at 18.30-18.45 Wit. For the morning the traffic volume is high at 07.00 a.m. 07.15 Wit which is equal to 2738.40 pcu / hour and during the day at 12.15-12.30 Wit at 3008.40 pcu / hour.



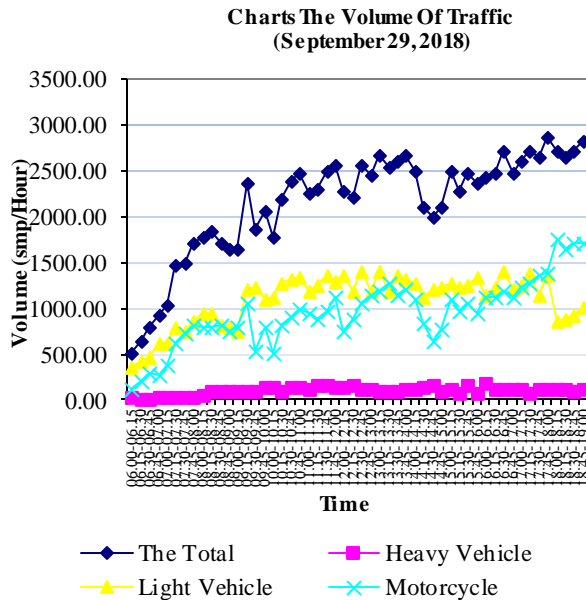


Fig.4.4: Charts the volume of traffic (September 29, 2018)

From figure 4.4, it can be seen that the highest traffic volume on Saturday, September 29, 2018, which is equal to 2871.60 pcu / hour occurs in the afternoon, namely at 17.45-18.00 Wit. For the morning the traffic volume is high at 10:45 a.m. to 11:00 a.m. that is equal to 2475.60 pcu / hour and during the day at 1:00 a.m. to 13:15 wit at 2677,20pcu / hour.

## 2. Calculation of Vehicle Speed

From the results of the speed survey, the data obtained in the form of travel time from 5 samples for the type of light vehicle every 15 minutes of observation. Travel time data from 20 samples of the vehicle is then calculated on the average travel time of the vehicle at each observation hour (in seconds). The distance taken for the survey is 50 meters long, then to get the vehicle speed data, the distance is divided by the travel time. The speed obtained is still in m / sec so it needs to be converted to units of Km / Hour.

The processed data is presented in graphical form as follows:

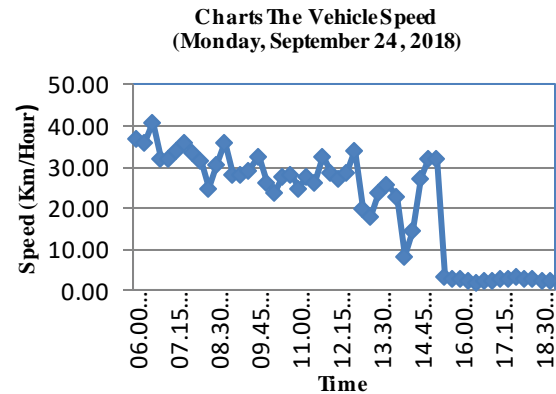


Fig.4.5: Charts the vehicle speed (mondayoctober 24, 2018)  
From Figure 4.5 it can be seen at the highest vehicle speed in the morning at 06.30-06.45 Wit at 40.78 Km / Hour while at 16.30-16.45 Wit is the vehicle's lowest speed which is only 1.94 Km / Hour.

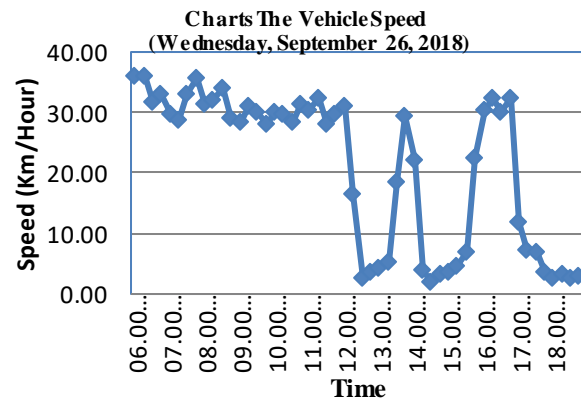


Fig.4.6: Charts the vehicle speed (wednesdayoctober 26, 2018)

From Figure 4.6 it can be seen at the highest vehicle speed in the morning at 06.00-07.00 Wit at 35.94 Km / Hour while at 14.30-14.45 Wit is the lowest speed of the vehicle which is only 1.84 Km / Hour.

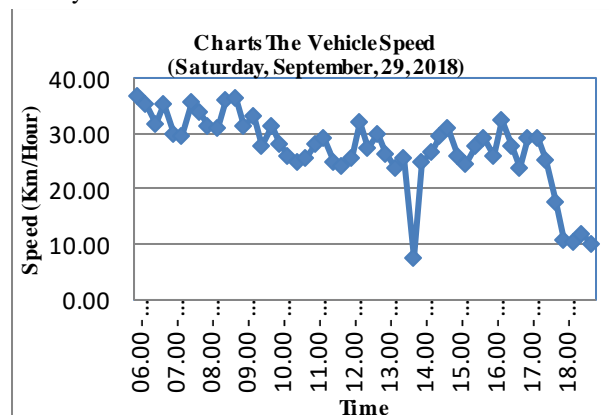


Fig.4.7: Charts the vehicle speed (saturdayoctober 29, 2018)

From Figure 4.7 above it can be seen at the highest vehicle speed in the morning at 06.00-07.00 Wit at 36.95 Km / Hour while at 13.45-14.00 Wit is the lowest speed of the vehicle which is only 7.63 Km / Hour.

#### C. Data Testing and Analysis

Daily volume (V) data in junior high / hour and daily average (S) speed data (Km / Hour) are then processed using formula 2.4 to obtain Density (D) data. Then the three variables are processed using the Least Square method in this case the Logarithmic equation (Greenberg Method) and exponential equation (Underwood Method) with the help of SPSS 16 software, to obtain the best method that can represent the traffic parameter relationships on the Tulukabessy road. For traffic parameter data on the three observation days, namely Monday, September 24 2018, Wednesday September 26 2018 and Saturday, September 29, 2018 can be seen the relationship of traffic parameters in this case density and speed based on observations, Logarithmic (Greenberg) method and Exponential method (Underwood) can be seen in figures 4.8, 4.9 and 4.10

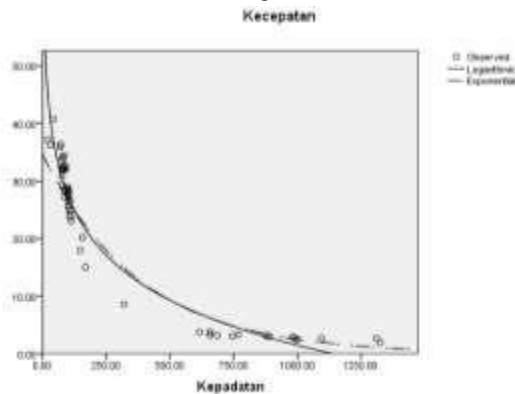


Fig.4.8: Relationship of Traffic Parameters on Monday, September 24, 2018

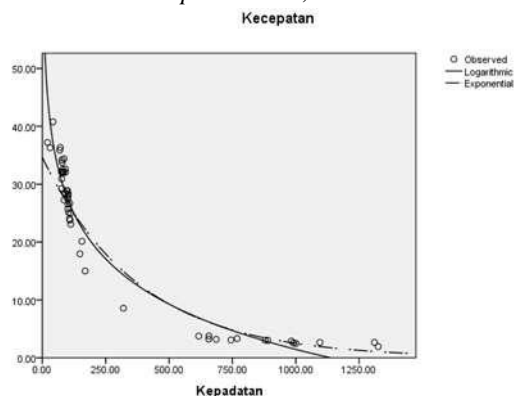


Fig.4.9: Relationship of Traffic Parameters on Wednesday, September 26, 2018

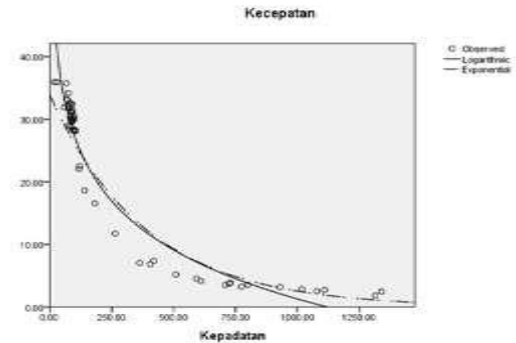


Fig.4.10: Relationship of Traffic Parameters on Saturday, September 29, 2018

#### D. Discussion

From the results of data analysis with the help of SPSS, the value of the Correlation Coefficient (R) and Determination Coefficient (R<sup>2</sup>) is obtained for each method on each observation day. Correlation coefficient values range  $-1 < R < 1$ , which shows the relationship between dependent and independent variables. While the Determination coefficient is the determinant coefficient, which shows the closeness of the relationship between the research variables. If R<sup>2</sup> is equal to 1, then the number indicates the regression line matches the data perfectly. To determine the best method and the most suitable for the Tulukabessy road, it can be seen from the results of analysis with SPSS for the value of each coefficient of determination for each observation day at SPSS output, attachment 9. Determination coefficient value obtained by each method for 3 days of observation can be seen in table 4.1.

Table.4.1: Value Coefficient Determination of each method for 3 days of observation

Observation Day	Method	
	Greenberg (Logarithmic)	Underwood (Exponential)
Monday, September 24, 2018	0,942	0,927
Wednesday, September 26, 2018	0,941	0,919
Saturday, September 29, 2018	0,791	0,960

Source: Analysis Results

From table 4.1 above, the best method and the most suitable for the Tulukabessy road is the Underwood (exponential method) method for observing Saturday, September 29, 2018, with the coefficient of determination closest to 1, which is 0.960. For the Greenberg method, the

determination coefficient value that is closest to 1 is obtained on Monday, September 24, 2018.

#### 1. The Greenberg Method (Logarithmic)

From the equation  $Y = A + BX$ , it is assumed that  $S = Y$  and  $\ln D = X$  so that through processing data with SPSS, the following results are obtained:

$$A = 79,793$$

$$B = -11,283$$

From parameters A and B, the following values can be calculated: so and the value of 1178,463

By using the values b and C, a mathematical relationship can be determined between the following parameters:

Speed-density relationship

$$S = 79,793 - 11,283 \ln D \dots\dots\dots (4.1)$$

Volume-density relationship

$$V = 79,793D - 11,283 D \ln D \dots\dots\dots (4.2)$$

Volume-Speed Relationship

$$V = 1178,463 S e^{-0,0886 S} \dots\dots\dots (4.3)$$

#### 2. Underwood Model (Exponential Method)

Through data processing with SPSS, for observations Saturday, September 29, 2018, the Underwood method assumes that the mathematical relationship between speed-density is an exponential function. From the equation  $Y = A + BX$ , it is assumed that  $\ln S = Y$  and  $\ln D = X$ , obtained the following results:

$$A = \ln 42,073 = 3.7394$$

$$B = -0.005$$

From the above data,  $S_f = 42.073$  km / h, and the maximum density value (DM) can be obtained:

$$D_M = -\frac{1}{B} = -\frac{1}{-0,005} = 200 \text{ pcu / km}$$

By using the value of  $S_f = 42.073$  km / h and  $DM = 200$  smp / hour, then the mathematical relationship can be determined between the following parameters:

$$\text{Relationship Speed-Density } \ln S = 3.7394 - 0.005 D \dots\dots\dots (4.4)$$

$$\text{Relationship Volume - Density } V = 42,073 D e^{-0,005 D} \dots\dots\dots (4.5)$$

$$\text{Relationship Volume - Speed } V = 747.88 S - 200 S \ln S \dots\dots\dots (4.6)$$

From the results of the previous analysis, the underwood method is the most suitable method used for the tulukabessy road, so that the maximum volume calculation can be continued by entering the DM value into equation (4.5) or SM into equation (4.6) then  $VM = 2481,84626$  junior / hour.

## V. CONCLUSIONS AND SUGGESTIONS

### A. Conclusion

The results of this study can be summarized as follows:

1. Relationship between the parameters of the Tulukabessy road traffic and the Greenberg method, as follows:

Relationship of Speed-Density  $S = 79,793 - 11,283 \ln D$

Density Volume  $V = 79,793D - 11,283 D \ln D$

Volume-Speed Relationship  $V = 1178,463 S e^{-0,0886 S}$

2. The relationship between the parameters of the Tulukabessy road section and the Underwood method, as follows:

The Speed-Density Relationship  $\ln S = 3.7394 - 0.005 D$

Volume - Density Relationship  $V = 42,073 D e^{-0,005 D}$

Volume - Speed Relationship  $V = 747.88 S - 200 S \ln S$

3. The most suitable method used for the Tulukabessy road is the Underwood method with a coefficient of determination ( $R^2$ ) = 0.960 with a maximum Density value (DM) = 200 smp / hour maximum volume (VM) is  $VM = 2481.84626$  pcu / hour.

### B. Suggestions

This research is input so it needs to be followed up by the parties related to improving the Tulukabessy road facilities such as adding traffic signs, removing side barriers and widening the road to break down the congestion on the Tulukabessy road.

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# Import Cost Analysis: A Case Study on an Oil & Gas Company in Brazil

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**Abstract**— The present work aims to analyze the financial impacts incurred in a Norwegian company based in Macaé in the oil and gas industry. In this manner it is intended, at first, to enter in foreign trade facing its history in the world as well as in Brazil, the taxes, laws, NCMs and Incoterms to which the case study of the company is based on for its critical analysis. Then, it presents the company and the flowchart of tasks prior to embark the goods and as a result it analyzes the numbers incurred of the processes, the transport more used at the most and employment of its resources concerning the processes of importation. Finally, it is submitted to the analysis of the costs generated by the choice of air freight shipments and using special customs regime Repetro. The methodology used in this study consisted of an exploratory research, explanatory and descriptive made via books, scientific articles, papers, essays and Internet sites. Secondary data were also raised along with the company studied. Thus, when analyzing the theoretical and practical aspects, it has been highlighted the importance of the employment of inputs in an optimized way with the aim of generating increasingly less cost to the company. Among the analyzes and results obtained, it was realized that there is

no planning in acquisition of inputs resulting in exacerbated use of the air freight shipment, as well as the little use of special customs regime Repetro.

**Keywords** — Logistics, Import Fees, Offshore Industry.

## I. INTRODUCTION

Import, export have been and always will be important in the deficit / surplus trade balance of any country in Brazil is no different. the purpose of this article is import costs analysis: seeing process into Macaé, to serve the oil and gas industry.

It was through its autonomy in the negotiations that Brazil entered foreign trade and despite having large-scale export products such as coffee, for example, with its still unfavorable scenario, that is, Brazil imported more than it exported, thus making its balance of trade not reach the positive balance. By virtue of this fact, Brazil intervenes in order to optimize the national industry, which was achieved through high customs duties following the Trade Agreement with England. Such a measure makes the scenario in Brazil have optimistic horizons through which the trade balance reaches the positive balance for the first time in history. (MDIC, 2013).



In the midst of the great development of the world economy, Brazil is gaining notoriety in this scenario of foreign trade, it also increases its national productivity and since then the trade balance oscillating when reaching highs and lows, but with its economy in constant rise. And in the last decades, it has already reached the position among the three countries that import and export the most in the world (FILHO, 2007).

It is well known that the Brazilian oil and gas market is constantly on the rise and the domestic industry in turn does not follow its technological growth, resulting in a local industry that can not meet the demand for equipment for the oil and gas sector, in this way companies are forced to import large quantities of parts and assets to meet production. Brazil is one of the most important countries in the world and the import process has become an increasingly recurring activity in companies. This fact makes the volume of merchandise imports in the country is high and as a consequence the costs of the company also increase. The challenge is to reduce costs in a scenario where logistical expenses and customs duties are high. Having said this, the present work will present an analysis of the import process in light of its costs incurred. Nevertheless, the import process is costly, complex and presents risks and the lack of management of the resources employed can lead to an unsatisfactory result for the company (OLIVEIRA, 2013).

The research was carried out for the purposes, the research will be exploratory, explanatory, and descriptive. Exploratory because, despite the Import Costs theme being well developed in several other countries, in Brazil there is still much to explore in view of our too much bureaucracy in the import process. Explanatory, as it aims to clarify facts that contribute to the knowledge of the import process in Brazil. It is descriptive because it exposes a certain phenomenon, that is, the import process, as well as applied since the analysis of the research will show the means to optimize the costs incurred in the process, thus solving the problem of high costs.

As for the means of investigation, the research will be a case study of an import process of an oil and gas company, followed by an experiment in which the modal of the applied import process will be compared to another modal, leading to the analysis of the costs of each mode experienced.

In the context of the case study, data collection was performed using numbers from the ones selected for the case study. Research is conducted from August 2012 to August 2013. The research instrument chosen is the compilation of all the import processes included in these 13 months.

We will briefly analyze the foreign trade, the customs legislation of the oil sector, the analysis of the import process of a company from Macaé.

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## II. FOREIGN TRADE

Foreign trade is one of the earliest ways of exchanging its production surpluses and interacting with other peoples, say by means of the Romans and Greeks who crossed the seas in search of merchandise in other lands or even the discovery of the Americas by the Spaniards and Portuguese people who carried in their ships what was found to be valuable to them. However,

Through the high technology of the countries today, foreign trade can interact and communicate in order to streamline logistics processes. This affirmation ratifies that foreign trade in Brazil could be somewhat more effective if there were logistical planning that would sustain the country's growth and development (FILHO, 2007).

### 2.1 IMPORT AND EXPORT INTO BRAZIL

Currently, Brazil has major presence the world scenario to foreign trade, it has already reached a relevant position, which benefits transactions. This position was reached due to the country's economic growth in the middle, and despite crises around the world. Soon after joining the international negotiations and negotiations, Brazil instituted a 24% tax rate on imported products of any nationality (SILVA, 2013).

After entering international protectionist measures were implemented with the purpose of controlling the flow of goods in the country as well as promoting the domestic industry, however the countries interested in the Brazilian market were manifested and agreements had to be made, the Decree of June 11, 1808, whereby goods coming from Portugal would have cheaper tariffs in comparison with other countries, thus favoring ties with the Portuguese economy (MDCI, 2013).

Some time after, Brazil sees the need to expand its international business and makes agreements with other countries. In this way the measures and rates applied to Portugal are also valid for items coming from England. Such agreement makes England the main exporter for the Brazilian lands. In effect in the Brazilian economy, the tariff agreement until then valid only for Portugal and England, becomes valid for any country with an interest in doing business with Brazil (SILVA, 2013).

There was a change in the years that followed regarding protectionist measures. Liberals interested in developing international trade reduced the rights and privileges of certain industries and it was through these liberal measures that Brazil, for the first time since its autonomy, achieved a positive balance of trade.

Despite reaching the positive balance of trade, Brazil is in crisis and uses a customs tariff as an economic measure, and since then it has become an instrument of financial policy and foreign trade, around it were taken important decisions of the Government in the economic sphere, in view of crises and swings of change.

Figure 1 reflects the scenario in which Brazil was in a phase and that justified interventionist measures of the government regarding customs tariffs. One can see the decline from 1928 onwards, in which Brazil invoices in exports around 500 million dollars and subsequently

fluctuates between 100 and 400 million dollars. Progress, in turn, arises from 1941 to almost 700 million in 1945. This phase was amidst crises and world wars.

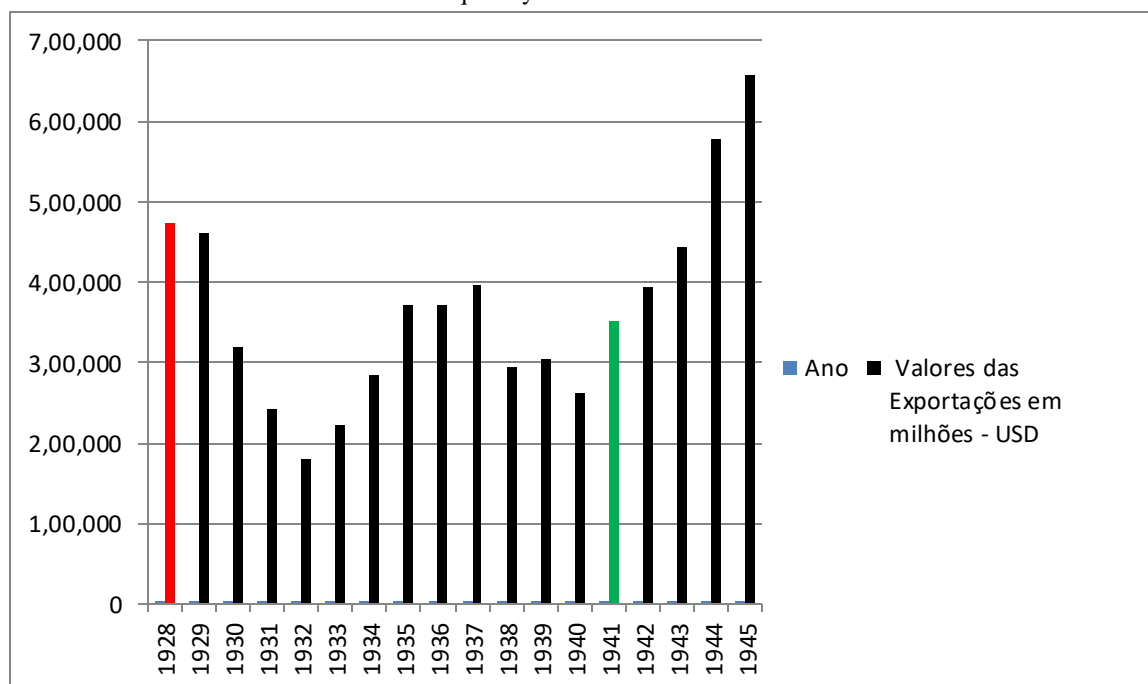


Fig. 1: Values Exports Million Dollars Source: Comex Data, 2013

Brazil understood that there should be changes in order to boost its economy, that is, through products that add more value and not only the basic product like coffee, it would open more doors to international trade with the aim of leveraging and saving profit for the public safes. These aggregate products were high value and more sophisticated goods such as cars and parts and electronics, whose values were up in the international market and for this the government stimulated foreign investment as well as a more incentive exchange rate policy. This is then an example of how the Brazilian economy made use of foreign trade as a financial and economic policy platform. (GAMA, 2012).

## 2.2 CUSTOMS TAXES AND NCM - COMMON MERCOSUR NOMENCLATURE

The taxes incurred by the companies carrying import or export transaction. When there is incidence, it occurs on the assets of the companies. The taxes are the import tax (II), tax on industrialized products linked to import (IPI), contribution to social integration programs and training of public servant assets (PIS / PASEP - Import), social contribution to financing of social security (COFINS - import), all of which are within the competence of the Union. States may, according to their legislation, change the rates on goods and services of interstate and inter-

municipal transportation and communication services (ICMS). (Silva, 2007).

The aforementioned taxes have their rates based on NCMs - Mercosur Common Nomenclature. Then clarified about the NCM and its origin.

Since always the classification of merchandise is interest of the most varied nations that aim the tributes regarding the procedures of foreign trade. The first lists with the classified goods appeared alphabetically, but there was a need to expand by virtue of the different words within the same territory, even when the subject was treated at an international level (BIZELLI, 2003).

The Harmonized Commodity Description and Coding System is a method of classifying commodities which aims to promote international trade in order to make statistical measurements feasible, facilitate negotiations, facilitate the preparation of freight rates, among others. The system is composed of 6 (six) digits, which delimit for example, the origin and raw material of a given piece. This system is the basis of NCM through which tax rates are established (MDCI, 2013).

Since January 1995, Brazil, Argentina, Paraguay and Uruguay have used the Mercosur Common Nomenclature, which, as previously mentioned, is based on the Harmonized System. Therefore, NCM is composed of the digits of the Harmonized System followed by two (2) digits that are specific and attributed to MERCOSUR,

as shown in figure 2, where one can see the formation structure of an NCM. It is by means of the classification of the goods that defines the percentage of the tax rates

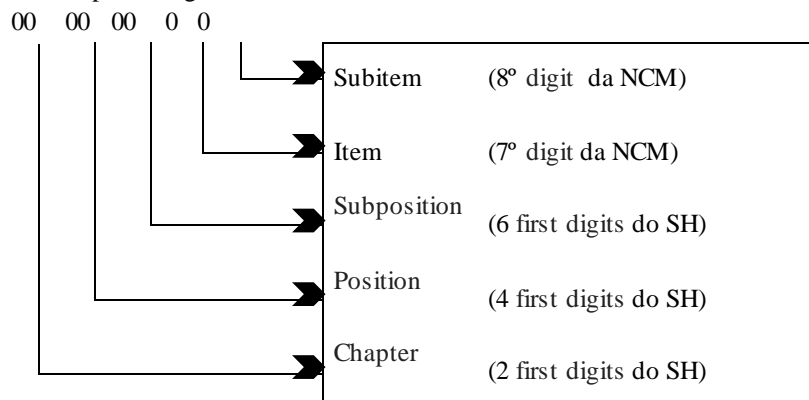


Fig. 2: Formation of NCM. Source: Ministry of Commerce and Industry Development, 2013.

### 2.3 INCOTERMS – INTERNATIONAL COMMERCIAL TERMS

Araújo (2009) affirms that it is not of today that the society is governed by contracts. Be it the Brazilian society only or even internationally. In international contracts there are rules that dictate the rights, obligations and duties of the parties involved, that is, the importer and the exporter. In other words, in the absence of specific legislation risk transfer is clearly exposed through Incoterms (GLITZ, 2013).

These rules are called Incoterms (International Commercial Terms) and an operation based on them has its reduced uncertainties making the process run with less possibility of errors and litigations (ARAÚJO, 2009).

Incoterms were created by the ICC (International Chamber of Commerce) in 1936 with only seven rules and in 1953 two more rules were added to its list. Another five revisions occurred in 1967, 1976, 1980, 1990 and 2000 respectively, the year in which Incoterms were included, excluded and replaced in order to meet the market and current demand. This last revision of 2000 was in force until 2010, when one more revision was published, going into effect on January 1, 2011 to the present day (SOUZA, 2003).

The Incoterms serve to facilitate negotiation and clarify it, as well as define the responsibility of those who pay what part of the process, where the risk is transferred from the exporter to the importer, who contracts and pays for the insurance of the cargo, who hires and pays the transportation of the cargo, who produces the necessary documentation among other factors that are decided in the negotiation of purchase and sale (SOUZA, 2003; RACHED and CORTES, 2010).

Thus, Incoterms are divided into categories according to modal, or simply through the "E", "C", "D" and "F"

incident and which body is competent to authorize the importation of the product.

groups, as will be explained in more detail below (SOUZA, 2003).

In group "E" is Incoterm EXW (Ex Works), in which the importer or buyer is responsible for the collection of the cargo with the exporter or seller, in this way the risk and all contracting freight and insurance are the responsibility importer. When making use of this Incoterm the exporter has the minimum of obligation and risks. (BERTAN, 2010).

In Group "C" are Incoterms CPT (Carriage Paid To), CIP (Carriage and Insurance Paid To); CFR (Cost and Freight) and CIF (Cost Insurance and Freight) (SOUZA, 2003).

The Incoterms "D" group is represented by the Delivered at Terminal (DAT), DAP (Delivered at Place or Delivered Duty Paid) and DDP (Delivered Duty Paid) and can be used in any modal (RACHED, CÔRTEZ, 2010).

Finally, there is the group "F" of Incoterms, which consists of the terms FCA (Free Carrier), FAS (Free Alongside Ship) and FOB (Free on Board).

### 2.4 CUSTOMS LEGISLATION FOR THE PETROLEUM SECTOR - REPETRO

Since 1970, after international financial crises, Brazil has seen the economic need to produce oil and gas through which its self-sufficiency would be achieved. It was supported by IN 136/87 that Brazil imported inputs into temporary admission to serve the gas oil industry at this time. However, the law was not exclusive to the sector and, in view of the need for economic growth, new laws were introduced, thus revoking the previous ones in order to structure the regime according to the table above (SANTOS, 2011).

Table 1: Current and Revoked Laws. Source: Repetro Special Customs Regime - Jus Navigandi Magazine - Doctrine and Parts. Ferreira, 2013.

YEAR	LAW	IMPORTANT OBSERVATION
1997	IN 136/97	Temporary admission covering oil and gas imports.
1998	Added IN 162/98	It fixed the terms, depreciation and useful life of the imported goods in the regime.
	Added IN 163/98	He talked about the application of NCMs.
	Added IN 164/98	It disciplined the action of the regime.
1999	IN 122/99	Repeals IN 163/98.
	IN 150/99	Repeals IN 164/98.
2000	Added IN 87/00	Requires computerized system for control of goods in real time.
2001	IN 04/01	Support REPETRO and repeal IN 136/97
2008	IN 844/08	More rigidity regarding the applicability of the goods, as well as obtaining the authorization of the regime.

Novas políticas de incentivo do setor foram adotadas a partir da década de 1990. A primeira mudança deu-se na constituição Federal em 1995, emenda nº9 que buscou a flexibilização do setor no tange o monopólio de exploração e produção por parte da Petrobras S.A. A Lei do Petróleo nº 9.478/1997 foi então editada permitindo a participação de empresas estrangeiras nas licitações dos poços de exploração e produção de petróleo (SILVA, 2007).

In order to encourage the participation of foreign companies and their investments, Brazil created at the end of 1990, rules that reduce the tax contribution of companies when they import or export their assets. The tax reduction occurs when the oil assets and according to the legislation described in the 2002 Customs Regulation, Decree No. 4543/02, pass through the Brazilian Customs. The assets that fit under this special customs regime then have their taxes suspended (SILVA, 2007).

The main special customs regime used is called REPETRO (special regime of import and export of goods destined for research and mining of oil and gas).

Before an analysis to benefit from the REPETRO benefit, companies must pay attention to the requirements of the government, among which is the presentation of a computerized system for real-time monitoring, through which federal revenue has access to any and all movement of items in this customs regime (SILVA, 2007; SANTOS, 2011).

Currently, REPETRO is supported by IN 844/2008, an instruction that defines the goods that are covered by the law, that is, it stipulates and guides the importer as to what good it may bring, thus making it a tax suspension benefit. These items should have their applicability directly linked to the research and mining activities of the oil and natural gas fields as well as their production. (SANTOS, 2011).

### III. THE COMPANY

In the middle of the nineteenth century, three brothers became ship commanders in the town of Hvitsten, a village in Norway at a very young age. Shortly thereafter, and by accumulating all the expertise in the segment as commanders, the brothers began to buy boats and became owners of a fleet of 43 ships, the growth of their company made that a complex to receive all that fleet was created in the city by Hvitsten.

In 1848 the company of the brothers, identified here as Parent Company, appeared in the navigation segment. Years passed, and the family saw the opportunity to diversify their businesses around the world.

The entry into the oil segment and its exploration only occurred in the following century. As early as 1960 the parent company group entered a company with 45% of the shares of two companies that ended up having a considerable success in oil exploration, refining oil and oil sales. In 1974, Company X emerged, in the oil and gas division in Houston, United States and later in Stavanger, Norway and Aberdeen, Scotland.

Atualmente a Empresa X tem uma frota de 11 (onze) sondas ao redor do mundo operando na África, no mar do Norte, no Golf do México e na América Latina.

Of these eleven platforms, two operate in Brazil. With an operational base located in the city of Macaé, a study can be carried out on the import processes in Company X.

#### 3.1 THE DEPARTMENT OF EXPORT AND IMPORTATION

The Import Sector in Brazil is composed of two employees, one analyst and one coordinator. The coordinator is responsible for the subpoenas received from various government agencies and other legal matters, while the analyst is responsible for daily import and export activities, performance measurements of cargo

agents and customs brokers, and indicators for top management.

The indicators brought by the analyst will be the basis of all the study presented here.

#### IV. AN ANALYSIS OF THE IMPORTATION PROCESS OF A MACAÉ COMPANY

The shipments come mostly from Aberdeen and from the origin the shipment coordinator organizes the shipment according to the requests of Brazil, in order to comply with the Brazilian customs legislation. Below you can see the flowchart of the tasks before the load is sent.

The purpose of this flowchart is precisely to avoid that the work of adaptation to the legislation had to be redone. The flowchart marks the beginning of the material report preparation process, issued by the warehouse supervisor

in Aberdeen. Subsequently, the shipment coordinator, also based in Aberdeen, sends the report to the analyst, who, together with the customs broker, translates and classifies the NCMs of each item in the report.

When classifying and translating, the analyst consults with the stockist of the platform to consult the requestor of an item about the raw material, urgency and other questions so that the classification can be accurate. After the translated and classified report, the analyst asks the platform manager that air shipments, when the volume of processes is increased, are approved. Once approved the report, the analyst sends the final version to the shipment coordinator so that the shipment coordinator can issue the documentation according to the instructions of the report and Brazilian legislation, as shown in figure 3.

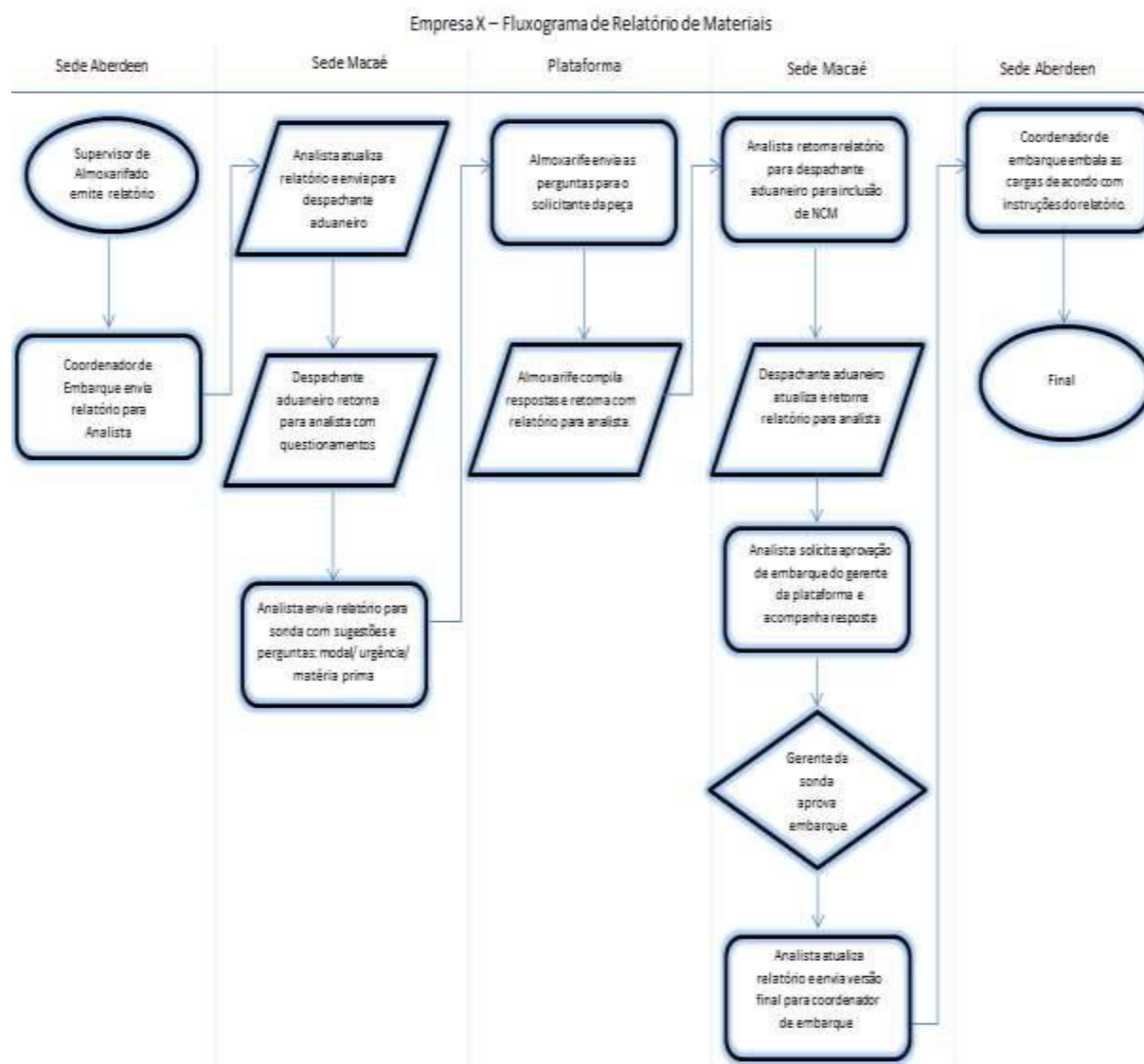


Fig. 3: Material Report Flowchart

Next, facts and conclusions based on the numbers provided and analyzed of the company studied are

elucidated. All the graphs cover the period from August 2012 to August 2013 and through them you can see more



clearly where the company's resources were used, where the failures in the import process as well as other were analyzes for information.

Depending on the modalities used in the shipment there are some steps that precede the registration of the DI - Import Declaration - and from the measurement on how long this step of the process is can observe the speed and

efficiency of the customs agent, which is the executing this task in the import process. The effectiveness of DI recording directly impacts the storage of the load, so the longer it takes to register an DI, the higher the storage cost, as shown in Figure 4.

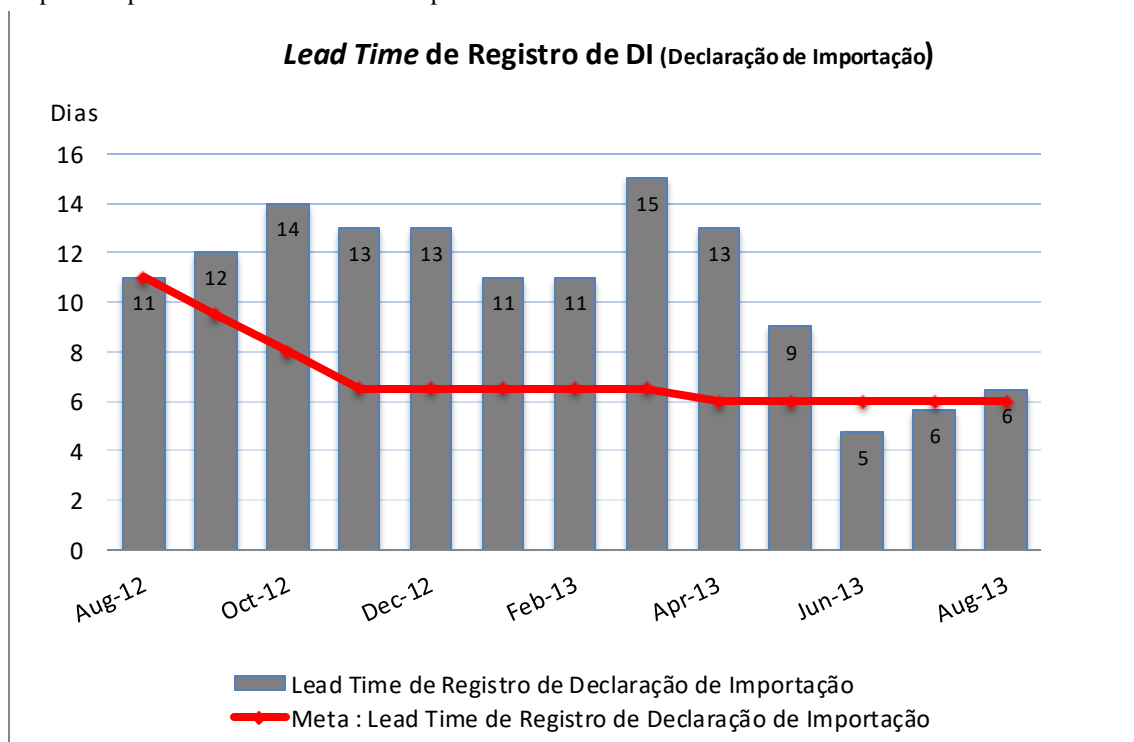


Fig.4: DI Log Lead Time - Average - in Days

The present figure 4 shows the number of days that the analyzed company took, in average, to the registry of its DIs from the arrival of the load in the airport or port. It is

noted that there was an improvement in the performance of this stage of the process, Figure 5 analyzes the percentage of air and sea shipments.

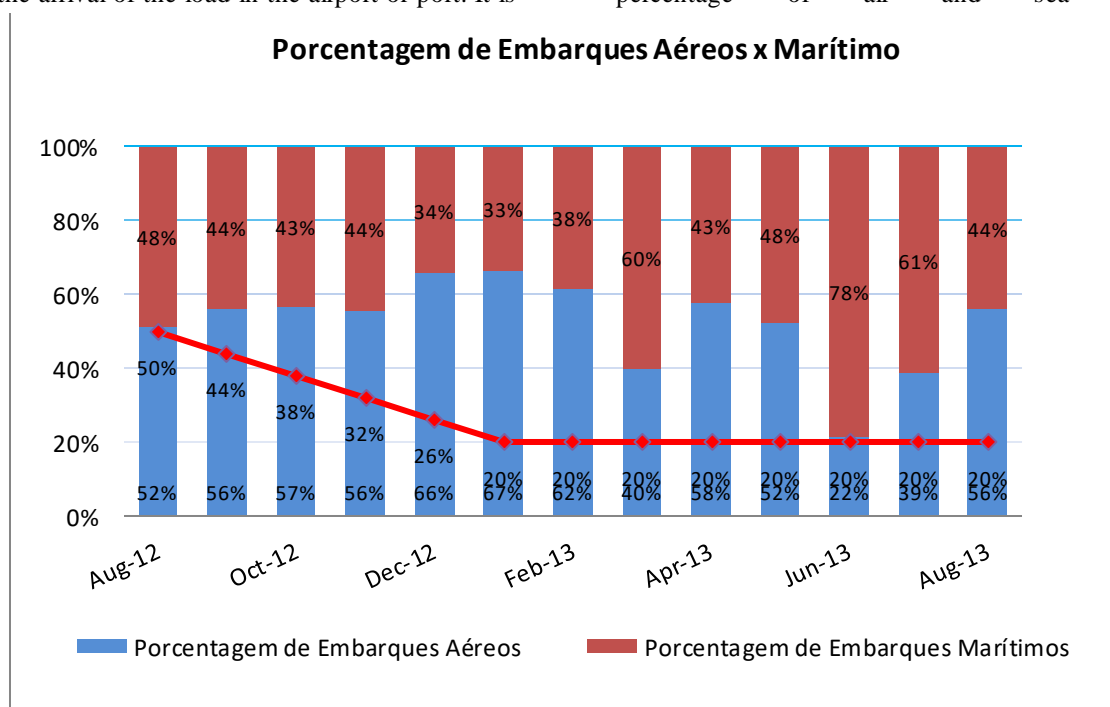


Fig. 5: Percentage of Shipping Mode and Stipulated Target

Figure 5 shows the modal air and modal modal relation of the shipments, as well as the comparison of the air modal in relation to the total of the shipments. During these 13 months of analysis it can be concluded that the number of shipments with air freight was higher than the number of shipments with maritime freight. It is also noted that the

goal of air shipments to be achieved, stipulated by the company at 20%, was not successful leading to consider a lack of inventory planning and spare parts, which in turn leads to the urgency at the time of export, figure 6 analyzes the quality of import processes.

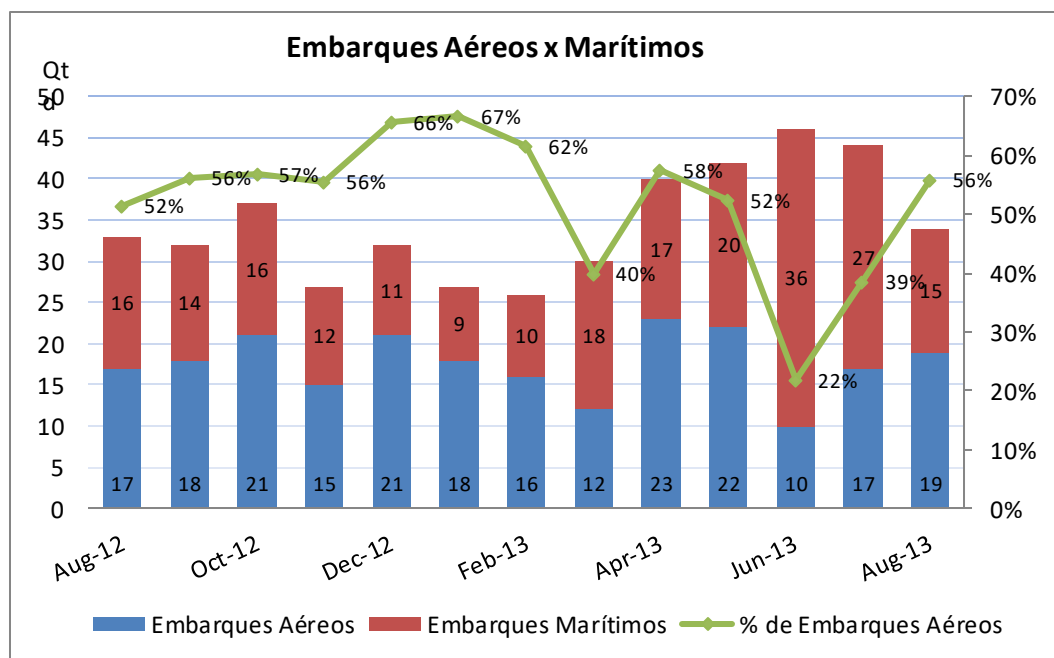


Fig. 6: Quantity of Import Processes x Modal

Figure 6 illustrates the number of import processes in relation to the modal chosen. In it we can observe that the percentage of air shipments to an average of 52%, was above the goal stipulated in 20%.

Both graphs lead to the conclusion that the lack of

planning of the stock of spare parts and spare parts leads to an urgent demand for the cargo making it impossible to board the ship. Such a failure leads to the impossibility of reducing costs as we shall see later.

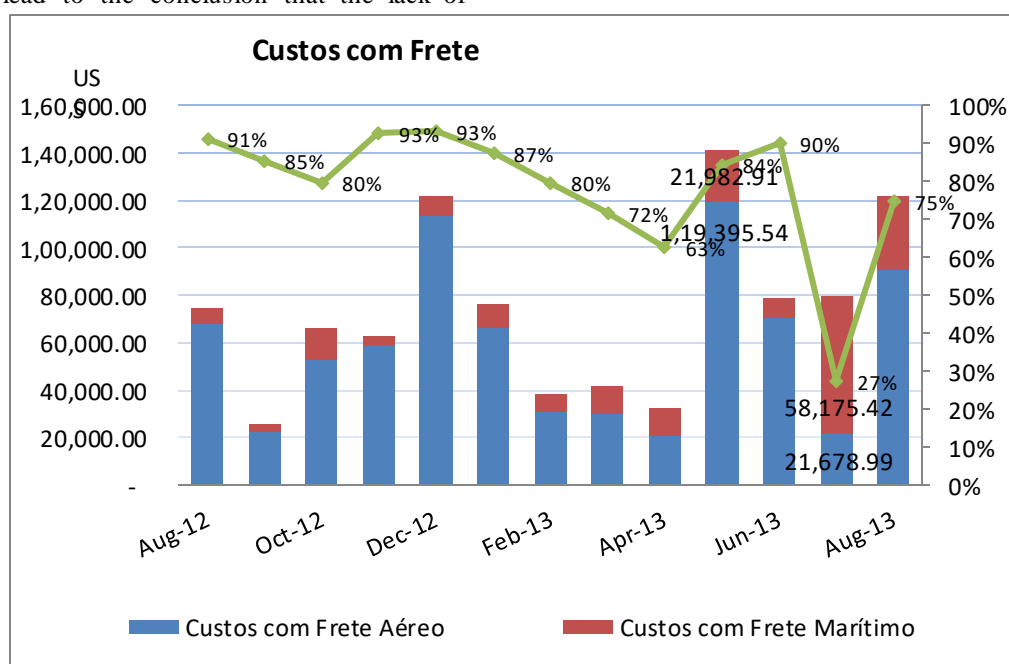


Fig. 7: Percentage of Shipping Mode and Stipulated Costs Target

Costs incurred with freight during the analyzed period are shown in figure 7. By means of numbers, it can be concluded that air freight is much costlier than sea freight. The months of May and July 2013 stand out, and in a comparison with figure 16 one has the conclusion of the freight more onerous.

In May, 42 cases were imported, and in July, 44 cases, as illustrated in figure 6, but despite importing less, the month of May was more expensive than the month of July and the modal chosen was the explanation. In figure 7, it can be seen that around 140 thousand dollars was the

freight cost in May, while in July it was spent only around 80 thousand dollars. Therefore, it should be concluded that in making use of more air freight, in detriment of the maritime, the company incurs more costs, as shown in figure 16, in which 52% of the 42 processes were airborne in May, and in July only 39% were aerial. Another alarming figure shown in figure 7 is that 84% of freight costs in May came from the airlift mode, while in July the cost of the airlift dropped to 27%.

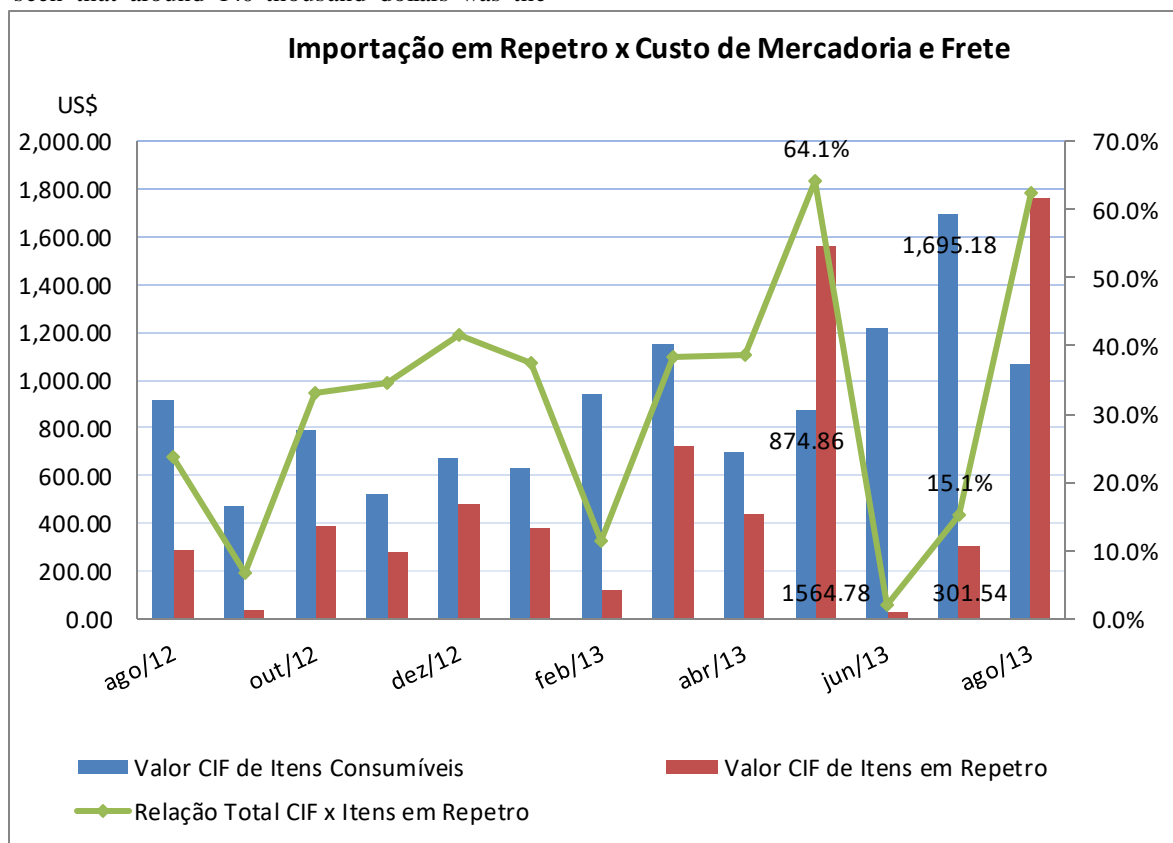


Fig. 8: List of CIF Values x Items in Repeat in Thousands of Dollars

Figure 8 shows the CIF values (Cost, Insurance, Freight or Cost, Insurance and Freight on which taxes are levied) of consumable items and items admitted in temporary admission, as well as the representation of how much in Repetro in relation to total. We will do the comparison again between May and July.

In May, imports of items in Repetro were significantly higher than imports of consumable items in relation to the CIF cost (Cost, Insurance, Freight or Cost, Insurance and Freight) of the merchandise.

## V. FINAL CONSIDERATIONS

Despite constant changes in Brazilian customs legislation, logistical and geographical limitations, the Brazilian tax burden and even the lack of knowledge of the legislation by oil companies, they import a considerable amount of

inputs to service their operations.

As it was verified that the cost with the air freight was higher than the cost with the maritime freight, it is suggested to the studied company a reorganization of the department in the supply chain so that there is the inventory control making use of the tool of maximum and minimum stock, for example, so that your stock is always spinning in as few pieces as possible. In this way there would be more resources deposited in the planning of purchase of the parts thus avoiding the waste of merchandise, the stock stopped or missing, which consequently accelerates the urgent imports.

Shipment planning becomes positive as urgent imports become costlier because of rapidity as an added value to it. In making the exacerbated use of air freight the company incurs costs, which with the right tool and

planning, could be avoided.

It can be seen then that the lack of planning costs the import costs, the lack of customs and logistic knowledge on the part of the taxpayer company also lead to a more expensive and expensive import process.

It is concluded that the company studied makes too much use of the most expensive modal, air freight, as well as does not make planning in obtaining its inputs.

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# Time distribution of intense rainfalls at Campinas, Brazil

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**Abstract**— the temporal variation of intense rainfalls is of great importance in hydrological analyses and prediction, which is required for dimensioning engineering projects. Therefore, this study has as objective to determine the temporal distribution of intense rainfalls with durations of 1, 2 and 4 h in Campinas, state of Sao Paulo, Brazil, for the period from 1997 to 2016. The rainfalls with duration of 1 h were subdivided in three intervals of 20 min. Rainfalls with duration of 2 and 4 h were subdivided in four intervals each, respectively of 1 h for the latter and of 30 min for the former. For rainfalls of 1, 2 and 4 h, the early rain distribution prevailed, i.e., the rainfall is more intense in the first period of time, regardless the total and duration of the event. Statistically, the intensive rainfall data adjusted to the Lognormal and Truncated Negative Binomial probability distributions.

**Keywords**— heavy rainfalls, hyetograph, probability distribution, temporal distribution.

## I. INTRODUCTION

The study of extreme climatic events is a topic of great interest in meteorology, because they are responsible for numerous social and economic impacts throughout the world (Vörösmarty et al., 2013; Swaminathan & Rengalakshmi, 2016). The analysis of these events provides important information on the behavior of watersheds from the point of view of floods (Beskow et al., 2015). Such skills are fundamental to the design of hydraulic structures and flood control (Cheng & AghaKouchak, 2014) and to the elaboration of strategies for soil conservation, since high-intensity rains have active participation in erosion processes (Vallebona et al., 2015; Martínez-Casanovas et al., 2002; Carvalho et al., 2009).

Severity and potential damages of storms depend on variables such as quantity of precipitation, intensity and duration, given that such information is crucial for practical and scientific purposes (Gaál et al., 2014). Another characteristic to be considered in the analysis of these events is their temporal distribution, factor that can significantly influence the shape and the peak of the

hydrograph. The knowledge of temporal distribution, besides being of great importance in the sizing of hydraulic structures, helps to understand the rainfall potential for causing flood and eroding the soil (Huff, 1967). In this context, engineers often need to establish flood control techniques and estimate the maximum discharge or design hydrographs for hydraulic structures scaling (Terranova & Iaquina, 2011; Ghassabi et al., 2016; Dolšák et al., 2016; Back, 2011; Beskow, 2015).

Since this temporal distribution, which can vary in both space and time and also in relation to the type of precipitation, is unknown a priori, it is common to adopt empirical distributions that seek to represent the most critical conditions possible of temporal disaggregation of rainfall and thus define an equally critical hydrograph (Abreu et al., 2017). It is in the disaggregation of precipitation for determination of the design hyetographs that the hydrologist's main problem lies, since each temporal distribution of rainfall has different hydrographs (Canhali, 2005).

According to the Manual of Rainwater Drainage and Management of the State of São Paulo (Manual de Drenagem e Manejo de Águas Pluviais de São Paulo – São Paulo, 2012), the kind and duration of temporal distribution of design rainfalls are subjected to several methodological guidelines, implying in results of maximum loads and flood volumes that can be quite discrepant.

Therefore, knowing the temporal distribution model of intense rainfalls of a locality makes the hydrological forecast in engineering projects in rural and urban areas more realistic, allowing the quantification of the effect of a hydrological event, which can be conducted by applying methods of hydrographs analysis (Sentelhas et al., 1998; Ahmed et al., 2012; Bonta, 2004).

Another important factor in intense rainfall analysis is to find the probability density function that best adjusts to the data, given that it is used for probability determination of stochastic variables, such as the prevision and estimate of precipitation (Mandal & Choudhury, 2015). Several probability distribution functions can be used for analysis of extreme events.



According to Aksoy (2000), the most common distributions in hydrology are the normal, log-normal, gamma, Gumbel and Weibull.

Due to the importance of finding the probability distribution that best adjusts to the precipitation data, several studies for different localities are conducted aiming the best probability distribution (Amin et al., 2015; Li et al., 2014; Haddad & Rahman, 2011; Mamoon & Rahman, 2017; Zin et al., 2009; Sharma & Singh, 2010; Olumide et al., 2013).

Despite the literature being vast and diverse regarding rainfalls and its intensity, studies that report how the intense rainfall is distributed throughout its occurrence, i.e., its temporal distribution, are rare (Li et al., 2017; Syafrina et al., 2015; Forestieri et al., 2018; Douka & Karacostas, 2017). Thus, the objective of this study is to analyze data from hyetographs of the climatological station in Campinas, SP, Brazil, from 1997 to 2016, to determine the temporal distribution of intense rainfalls with duration of 1, 2 and 4 h. We also verified whether the analyzed data fit to a probability distribution.

## II. METHODOLOGY

We used data from intense rainfalls with durations of 1, 2 and 4 h obtained from the climatological station, located in Campinas/SP, state of São Paulo, Brazil (22°49'07"S, 47°03'43"W and altitude of 635m). The climatological station, regarding the locality and equipment installation, is in accordance with the guidelines of the World Meteorological Organization (WMO). The pluviograph consists of a bascule model and records the precipitation every 10 minutes. The bascule to measure precipitation has a sensitivity of 0.5 mm.

We analyze isolated extremes events in the period between 1997 and 2016, from October to March, characterizing the rainy season, period of intense rainfalls, when approximately 80% of the total annual rainfalls occurs. The events, subdivided into intervals according to duration of rainfalls, were arranged in histograms.

After definition of rainfall duration, another issue addressed in this study was which value to adopt when considering a rainfall as intense. In practice, it is difficult to establish a value considering a rainfall as intense, as the impact can be different, depending on the characteristics of the local (Pinto, 1999). For example, in the urban area the problem is associated to the accelerated superficial runoff and low infiltration, causing floods and inundations, very common in major Brazilian cities that grow in a disorderly manner (Canholi, 2005). In rural areas, intense rainfalls can cause the erosive process in the soil (Kaufmann et al., 2012). For this study, the criterion adopted was based on basic infiltration rate in soils of the region, which according to Reichardt (1987),

is equal to 15 mm/h. Thus, we selected events with potential for runoff generation following the same criteria by Cruciani et al., (2002) and Sentelhas et al., (1998), which were:

- a) for intense rainfalls with duration of 1 h:
  - Divided into 3 time intervals of 20 min each and precipitation equal to or higher than 12 mm.
- b) for intense rainfalls with duration of 2 h:
  - Divided into 4 time intervals of 30 min each;
  - Precipitation equal to or higher than 15 mm in the first hour and total precipitation equal to or higher than 20 mm.
- c) for intense rainfalls with duration of 4 h:
  - Divided into 4 time intervals of 1 hour each;
  - Precipitation equal to or higher than 15 mm in the first hour and total precipitation equal to or higher than 20 mm.

The events, subdivided into intervals, were arranged in histograms, and the most frequent cases of temporal distribution were selected for analysis. Within the intense rainfall records obtained from precipitation data, we divided the cases from 1 to n, representing the intensity of precipitation in each time interval. Rainfalls in which the highest rainfall event depth occurred in the first interval, we named as case 1; if the highest rainfall event depth occurred in the second interval, the rainfall was named as case 2, and so on.

After selection of events according to the criteria, precipitation data were analyzed considering the observed values, ordered so that the frequency distribution analysis and the search for a theoretical probability distribution that best adjust the sampling distribution were allowed. There are numerous probability models applied to continuous random variables, such as the annual maximum daily precipitation. In Brazil, the most used theoretical probability models are the Lognormal distribution of 2 and 3 parameters, and the Extreme Value Distribution Type I, also known as Gumbel (Mello & Viola, 2013; Caldeira et al., 2015). The probability distribution used in this study was the lognormal distribution with two parameters, widely used in hydrology and easily transformable into normal distribution (Mello et. al, 1994). The probability density function is given by:

$$f(x) = \frac{1}{\sigma \cdot x \cdot \sqrt{2\pi}} \cdot e^{-0.5 \frac{(\ln x - \mu)^2}{\sigma^2}} \quad \text{for } 0 < x < \infty \quad (1)$$

It's distribution function is given by:

$$F(x) = \int_0^{\infty} f(x) \cdot d(x) \quad (2)$$

being:

$$E(x) = e^{\mu + \frac{\sigma^2}{2}} \text{ and } \text{Var}(x) = \mu^2(e^{\sigma^2} - 1) \quad (3)$$

in which:  $\sigma$  is the standard deviation of the distribution, referring to the intense rainfalls;  $\mu$  is the average intense rainfalls;  $x$  is the daily intense rainfall to be considered;  $E(x)$  the expected value and  $\text{Var}(x)$  the theoretical variance.

The truncated negative binomial distribution is given by:

$$p(x+1) = f(x) \left( \frac{K+x}{x+1} \right) (1-W) \quad (4)$$

being:

$$W = \frac{\bar{x}}{S^2} \left( 1 - f \frac{1}{N} \right) \text{ and } K = \frac{W \bar{x} - f \frac{1}{N}}{1-W} \quad (5)$$

in which:  $x$  is the daily intense rainfalls to be considered;  $\bar{x}$  is the average of the data grouped by class;  $S^2$  is the sample variance;  $N$  is the sum of rainfall frequencies;  $W$  and  $K$  are parameters of the equation.

And the Gumbel distribution:

$$f(X) = \frac{1}{\beta} e^{-\frac{X-\alpha}{\beta}} e^{-e^{-\frac{X-\alpha}{\beta}}} \quad (6)$$

in which:  $x$  is the daily rainfall to be considered;  $\alpha$  and  $\beta$  are parameters of the equation. The cumulative probability function is:

$$F(X) = e^{-e^{-\frac{X-\alpha}{\beta}}} \quad (7)$$

The double signal in the second exponent refers to the maximum (negative sign) and minimum (positive sign) values.

The adjustment of precipitation data for each of the distributions was evaluated through the  $\chi^2$  and Kolmogorov-Smirnov (KS) tests at a significance level of 0.01 (Assis et al., 1996).

### III. RESULTS AND DISCUSSION

#### 3.1 Temporal distribution of rainfalls

Table 1 shows a statistical description of the events of rainfalls with duration of 1, 2 and 4 h. The data indicate a distribution with strong asymmetry for the precipitation events. The mean is higher than the median and mode, and the coefficient of variation (CV) is high, 51.23%, 55.55% and 42%, for the rainfalls with duration of 1, 2 and 4 h, respectively.

We identified 201 events of intense rainfalls with duration of 1 h, according to the distribution shown in Table 2. In this way, three histograms were prepared for the rainfalls with duration of 1 h (Fig. 1). One can see that

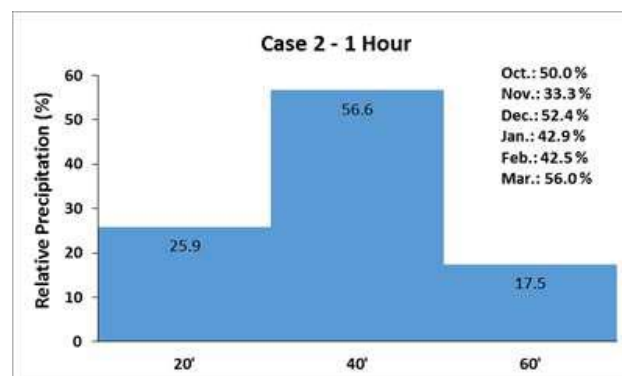
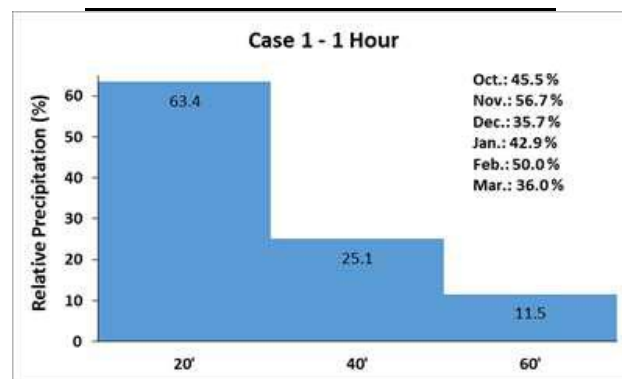
the most frequent distribution model for the intense rainfalls with duration of 1 h was the type 2 model. Cruciani et al. (2002), analyzing precipitation data from Piracicaba, 65 km from Campinas, in the period from 1966 to 2000, found type 1 more frequently, in 85.7% of the events in the analyzed period.

Table 1. Statistical description of the events of intense rainfalls with 1, 2 and 4 h duration, in Campinas/SP, in the period from 1997 to 2016.

	Rainfall (mm) 1 h	Rainfall (mm) 2 h	Rainfall (mm) 4 h
N	201	82	18
MEAN	21.7	37.8	49.9
STDEV	11.1	21.0	20.9
MAXIMUM	68.3	119.2	94.2
MINIMUM	11.2	17.8	25.8
MODE	12.7	23.3	-
MEDIAN	17.80	31.24	42.42
CV (%)	51.23	55.55	42.00

Table 2. Distribution of intense rainfalls with 1 h duration

Type	Frequency	Distribution (%)
Type 1	89	44.3
Type 2	92	45.8
Type 3	20	9.9
Total	201	100



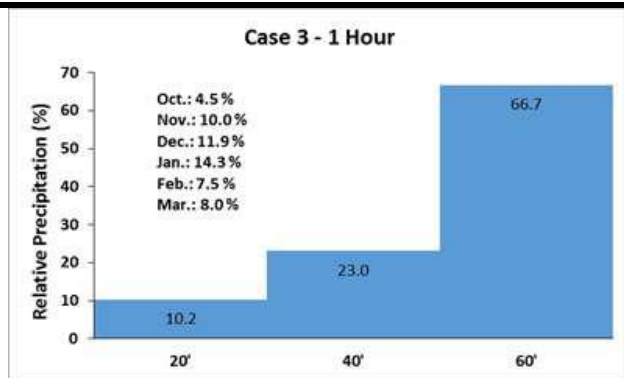


Fig. 1 – Distribution histograms of intense rainfalls with 1 h duration, in the period from October to March, for the city of Campinas/SP, from 1997 to 2016.

Distribution models of intense rainfalls with duration of 1 h for each month are shown in Fig. 2, in percentage. March was the month that showed the highest average precipitation, with 25.1 mm. A result similar to that achieved by Mello et al. (1994), in which March represents a critical state regarding the intensity of rainfall with duration of 60 min.

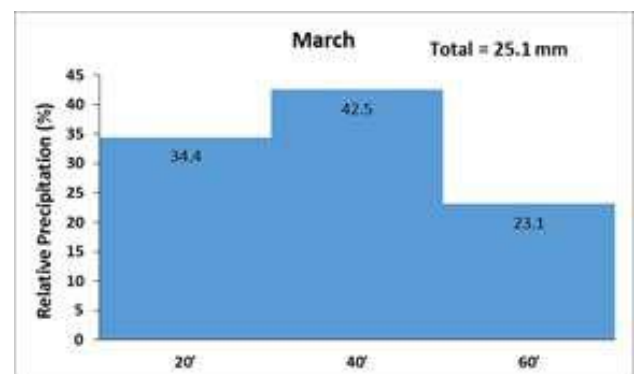
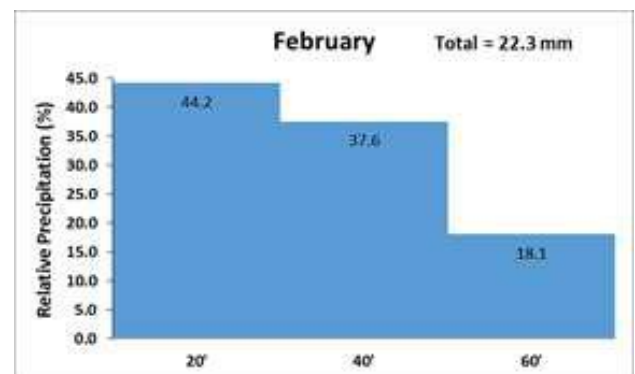
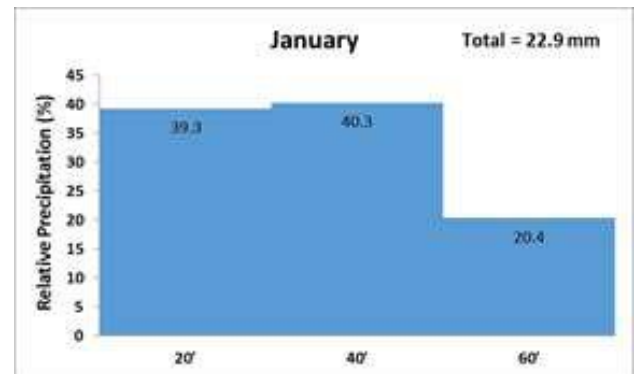
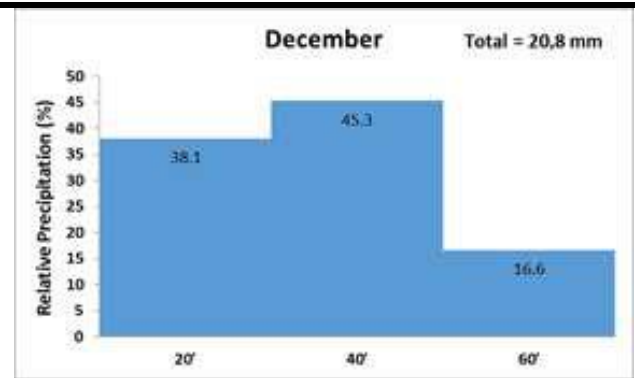
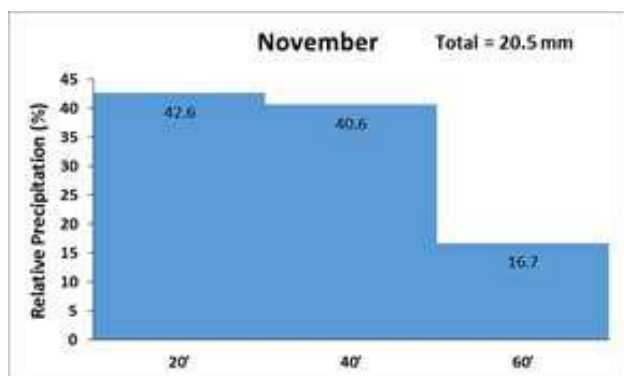
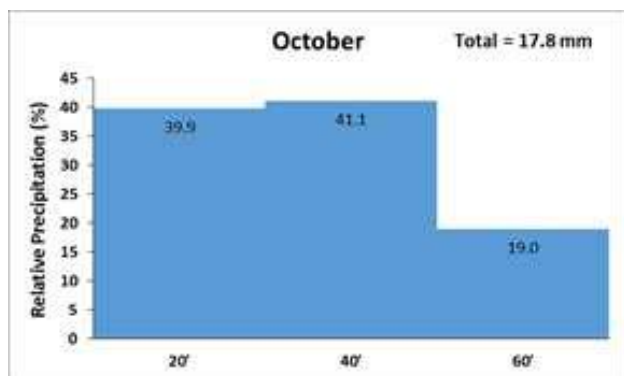


Fig. 2. Temporal distribution of intense rainfalls with 1 h duration, from 1997 to 2016, for the city of Campinas/SP, in the period from October to March.

The predominant distribution model of intense rainfalls with duration of 1 h showed an average of 21.7 mm (Fig. 3), with the following relative distribution:

39.8% in the first-time interval, 41.1% in the second interval and 18.9% in the third interval.

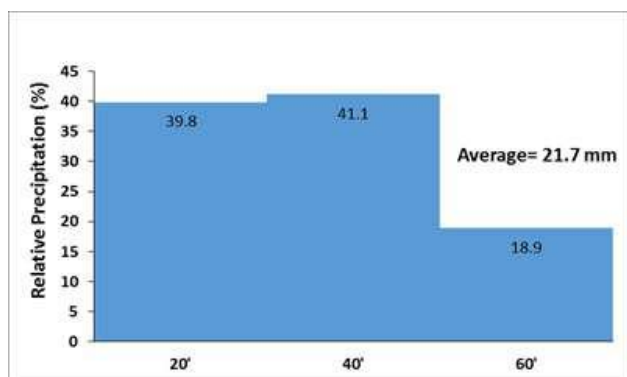


Fig. 3 – Distribution histograms of intense rainfalls with 1 h duration, from 1997 to 2016, for the city of Campinas/SP, in the period from October to March.

In the data analysis of the intense rainfalls with duration of 2 h, we found 82 events of intense rainfalls distributed according to Table 3. Thus, we observe that the most frequent distribution model was type 1. Fig. 4 shows the histograms generated for intense rainfalls with duration of 2 h for each case.

Table 3. Distribution of intense rainfalls with 2 h duration

Type	Frequency	Distribution (%)
Type 1	48	58.5
Type 2	26	31.7
Type 3	8	9.8
Total	82	100.0

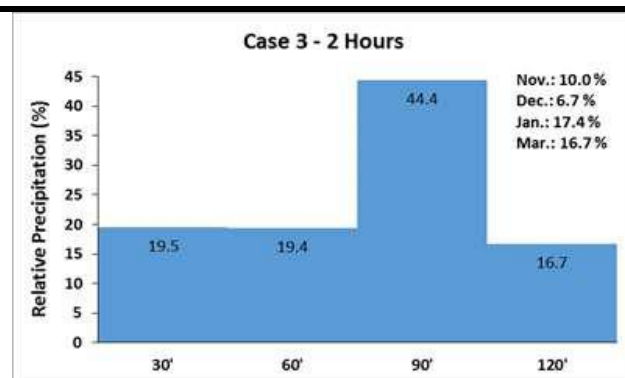
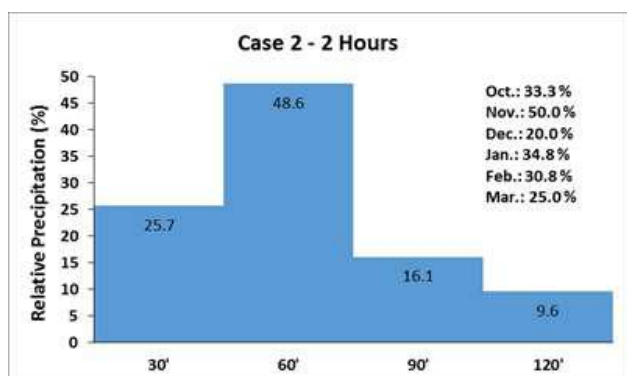
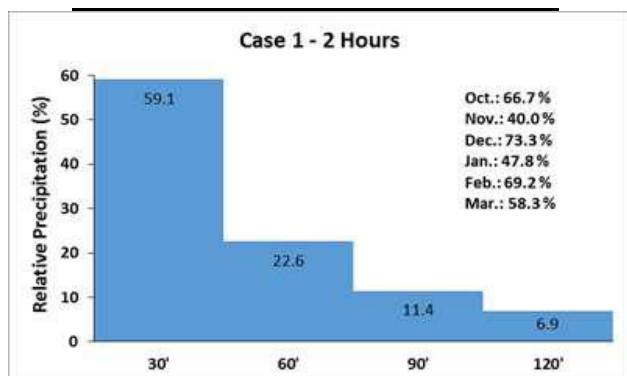
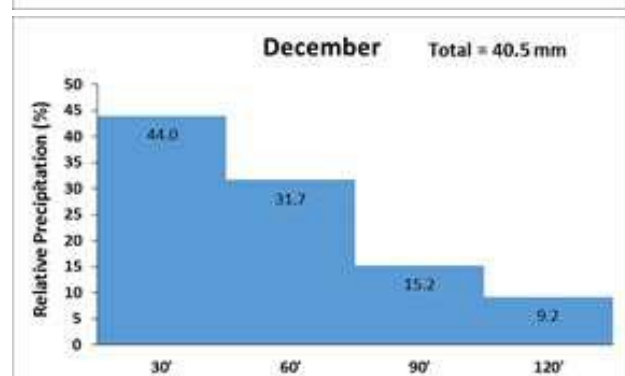
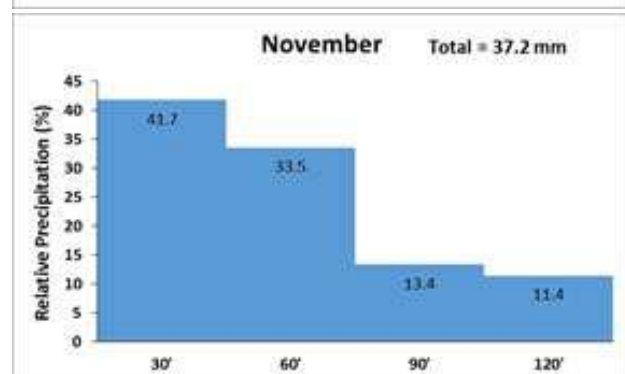
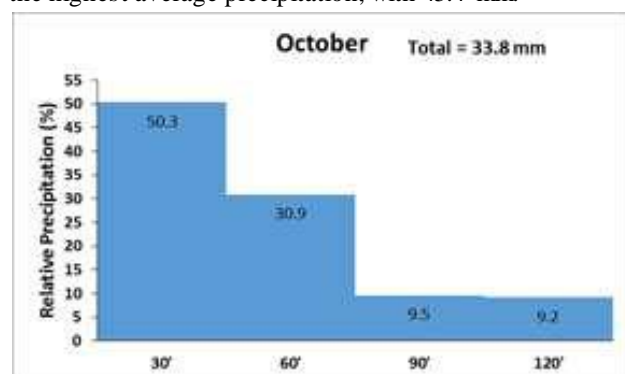


Fig. 4 – Distribution histograms of intense rainfalls with 2 h duration, in the period from October to March, for the city of Campinas/SP, from 1997 to 2016.

Distribution models of intense rainfalls for each month in the period studied are shown in Fig. 5, in percentage. The month with the highest rainfall levels in the first 30 min of precipitation was October, with 17 mm (50.3%). However, February was the month that showed the highest average precipitation, with 45.4 mm.



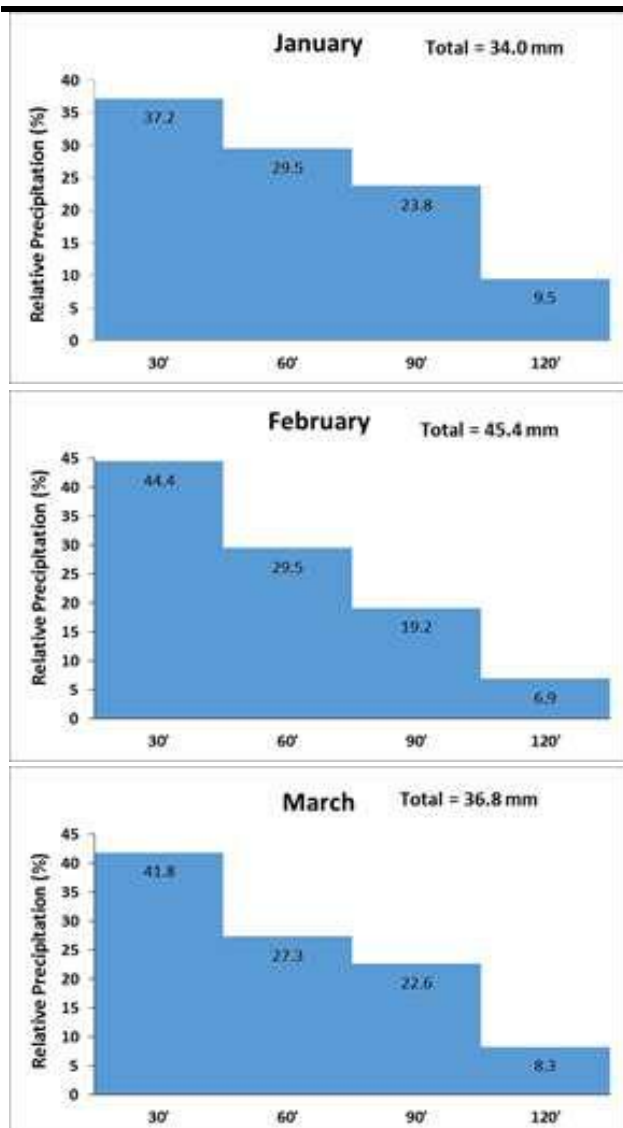


Fig. 5 – Temporal distribution of intense rainfalls with 2 h duration, from 1997 to 2016, for the city of Campinas/SP, in the period from October to March.

The representative model of intense rainfalls with duration of 2 h showed an average of 37.8 mm (Fig. 6), with the following temporal distribution: 42.3% in the first time interval, 30.2% in the second interval, 18.4% in the third interval and 9.0% in the fourth interval. This pattern is characteristic of convective rainfall, which predominate in the region during the period under examination.

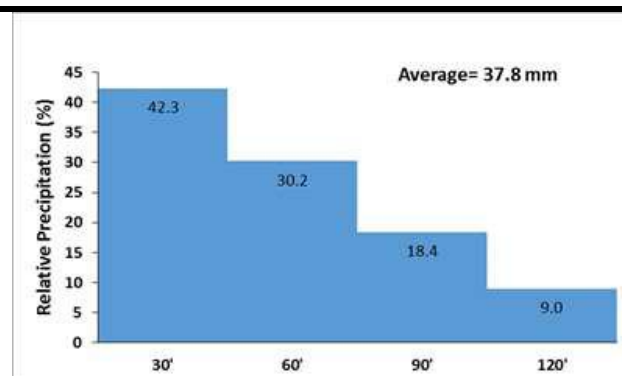


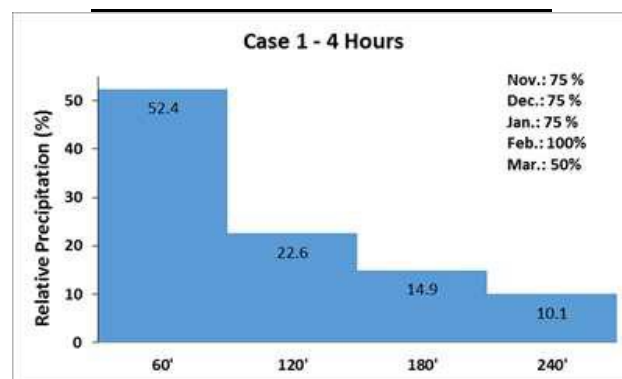
Fig. 6 – Representative model of distribution of intense rainfalls with 2 h duration, from 1997 to 2016, for the city of Campinas/SP, in the period from October to March.

For intense rainfalls with duration of 4 h, 18 events were found within the analyzed period, of which 72.2% were classified as type 1 (Table 4). With these data, the histograms for the intense rainfalls with duration of 4 h were generated (Fig. 7).

Distribution models of intense rainfalls with duration of 4 h for each month are shown in Fig. 8, in percentage. December was the month with the highest rainfall levels within the first hour, 52.4% (29.4 mm). However, the highest rainfall levels took place in March, with an average of 62 mm. For October, no events of intense rainfall with duration of 4 h were found.

Table 4. Distribution of intense rainfalls with 4 h duration

Type	Frequency	Distribution (%)
Type 1	13	72.2
Type 2	3	16.7
Type 3	2	11.1
Total	18	100.0





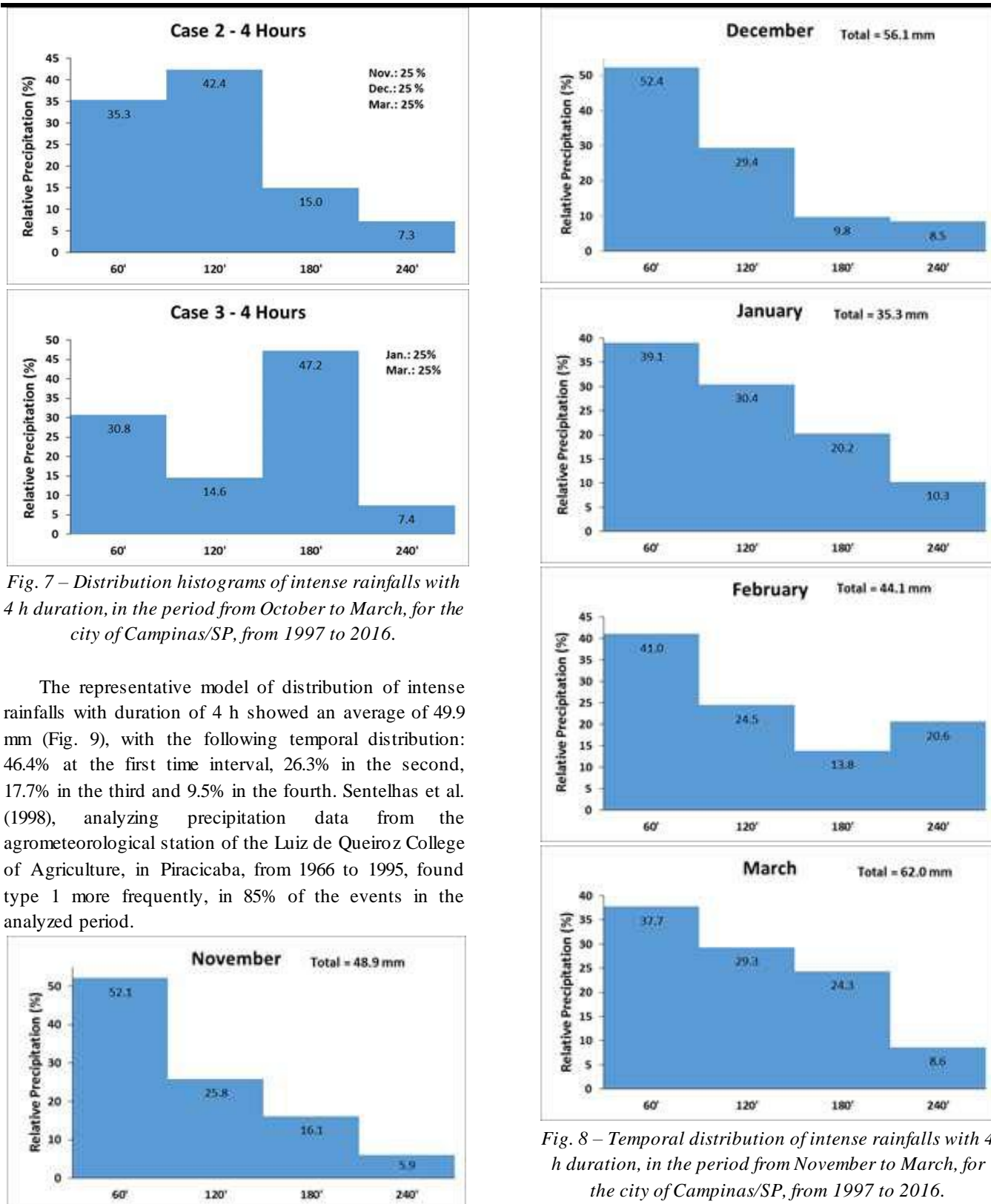


Fig. 7 – Distribution histograms of intense rainfalls with 4 h duration, in the period from October to March, for the city of Campinas/SP, from 1997 to 2016.

The representative model of distribution of intense rainfalls with duration of 4 h showed an average of 49.9 mm (Fig. 9), with the following temporal distribution: 46.4% at the first time interval, 26.3% in the second, 17.7% in the third and 9.5% in the fourth. Sentelhas et al. (1998), analyzing precipitation data from the agrometeorological station of the Luiz de Queiroz College of Agriculture, in Piracicaba, from 1966 to 1995, found type 1 more frequently, in 85% of the events in the analyzed period.

Fig. 8 – Temporal distribution of intense rainfalls with 4 h duration, in the period from November to March, for the city of Campinas/SP, from 1997 to 2016.

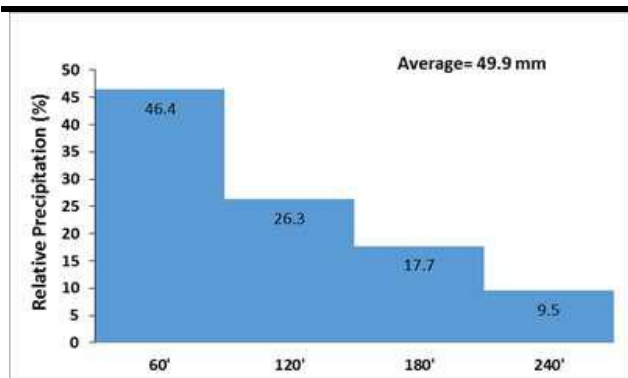


Fig. 9 – Representative model of distribution of intense rainfalls with 4 h duration, in the period from October to March, for the city of Campinas/SP, from 1997 to 2016.

The results found are typical of convective rainfall, also characterized as advanced, which predominates in the region during the study period. The convective events in Brazil suffer great influences of the South Atlantic convergence zone, but they can also, in some cases, occur because of the interaction of cold fronts with hot air masses (Vicente & Nunes, 2004). The predominance of this rainfall pattern can be found in other regions of the country, such as in the cities of Lajes (Cardoso et al., 2014) and Urussanga (Back, 2011), both located in the state of Santa Catarina, Southern Brazil.

In other countries, the prevalence of convective rainfall was found by Oñate-Valdivieso et al. (2018) in an Andean region in Southern Ecuador, where it's predominates during the rainy season and also by Syafrina et al. (2015), who found great contribution of convective rainfall in events that reach the west region of Peninsular Malaysia.

The type of precipitation is strongly related to soil erosion. In the study by Carvalho et al., (2009) the rains with greater intensity at the end of their duration were responsible for the greatest soil loss (58.3%), while the advanced and intermediate ones showed a loss of 35.1% and 6.6%, respectively. According to Sao Paulo (2012), rains with higher intensity at the end of their duration, cause greater floods.

### 3.2 Probability distribution

To view the data behavior of rainfalls with duration of 1, 2 and 4 h, we arranged them in histograms represented graphically (Fig. 10) together with the Lognormal probability (LogN), Truncated Negative Binomial (NTBin) and Gumbel distributions.

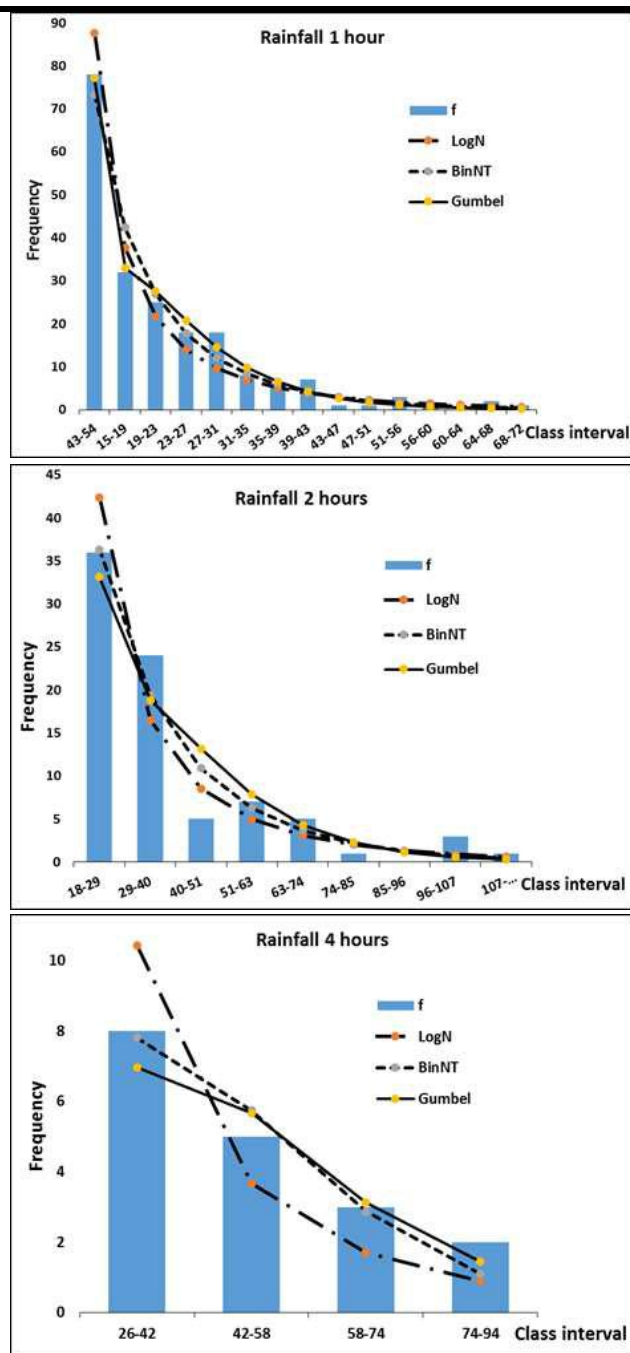


Fig. 10 – Empirical and theoretical probability (%) of maximum rainfall values greater than or equal to the given value, using the LogNormal (LogN), Truncated Negative Binomial (NTBin) and Gumbel distributions, for rainfalls with 1, 2 and 4 h duration.

The distributions were fit to data related to hourly intense rainfalls. To corroborate with the graphical analysis,  $\chi^2$  and Kolmogorov-Smirnov (KS) statistical tests were conducted to verify if the precipitation data follow any of the distributions. The tests have the following hypotheses:

$$\begin{cases} H_0 = \text{Belongs to the tested distribution} \\ H_1 = \text{Does not belong to the tested distribution} \end{cases}$$

According to Table 5, both the lognormal distribution (LogN) and the Truncated Negative Binomial (NTBin) distribution were statistically adjusted to the sampling frequency distribution for the rainfalls with duration of 1, 2 and 4 h. The  $\chi^2$  calculated was lower than the one shown in the table. However, the BinNT distribution had a better adjustment. The same applies to the KS test. The Gumbel probability distribution was adjusted only for the rainfalls with duration of 4 h. However, despite the calculated  $\chi^2$  and KS being lower than those shown in the table for the LogN, BinNT and Gumbel probability distributions for the rainfalls with duration of 4 h in the analyzed period, it is not safe to affirm, with a non-representative sample number, the data adjustment to a sampling distribution for rainfalls with this duration.

*Table 5.  $\chi^2$  and Kolmogorov-Smirnov (KS) statistical tests at 1% significance level applied to probability distributions for intense rainfalls with 1, 2 and 4 h duration for Campinas/SP.*

Intense rainfalls	Distributions	$\chi^2_{\text{calc}}$	$\chi^2_{\text{tab}}$	KS <sub>calc</sub>	KS <sub>tab</sub>
1 h	LogN	19.249	21.666	-0.050	-0.115
	BinNT	16.491	20.09	-0.052	-0.115
	Gumbel	24.07	20.09	-0.996	-0.115
2 h	LogN	14.642	16.812	0.088	0.180
	BinNT	13.822	16.812	-0.073	0.180
	Gumbel	20.106	16.812	-0.985	0.180
4 h	LogN	3.362	6.635	-0.159	0.370
	BinNT	0.839	6.635	-0.056	0.370
	Gumbel	0.442	6.635	-0.852	0.370

#### IV. CONCLUSION

The temporal distribution model of heavy rainfalls with duration of 1, 2 and 4 h for the city of Campinas is very similar to the model of distribution of heavy rainfalls for Piracicaba. Early distribution rainfalls prevail in the region, regardless of the total and the duration of precipitation. However, as the climate phenomena are random, to determine the representative distribution model of heavy rainfalls in a determined region, one should consider the fact that a single rainfall may have other combinations of intensity and distribution throughout its duration. Lognormal (LogN) and Truncated Negative Binomial (BinNT) distributions were the ones best adjusted to the data collected for rainfalls with duration of 1 and 2 h. However, despite the Gumbel probability distribution being better adjusted for the rainfalls with duration of 4 h, few rainfall events with this duration occurred in the analyzed period. This article showed that the analysis of temporal distribution of design rainfalls is crucial to the numerous issues of interest to engineering, especially the control of surface

runoff, in urban and rural areas.

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# Evaluation of PPP/GNSS obtained Coordinates Accuracy using a Decision Tree

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**Abstract**— Point positioning over the Earth's surface has become simpler after the advent of positioning systems using artificial satellites. Nowadays, the satellites constellations of GNSS are GPS and GLONASS, the most structured systems, however, other systems were built to integrate the GNSS in last years. There are different methods to perform precise positioning using the data transmitted by GNSS satellites and the PPP method is one of these. Similarly to others, the PPP uses the observables to produce the coordinates and precise them. As we know, precision is different from accuracy. While precision informs the data set quality, accuracy tells us how much the coordinate is close to its real position on the ground. Although the correlation between precision and accuracy correlation is implicit in the observables, the processing methods cannot achieve it. The purpose of this study was to identify this relationship using the data mining tool known as Decision Tree. The creation of a large set of coordinates with known precision and accuracy were necessary for the recursive training of the Decision Tree, which became able to predict the coordinates' accuracy using only its precision abstract should summarize the content of the paper. Try to keep the abstract below 250 words. Do not make references nor display equations in the abstract. The journal will be printed from the same-sized copy prepared by you. Your manuscript should be printed on A4 paper (21.0 cm x 29.7 cm). It is imperative that the margins and style described below be adhered to carefully. This will enable us to keep uniformity in the final printed copies of the Journal. Please keep in mind that the manuscript you prepare will be photographed and printed as it is received. Readability of copy is of paramount importance.

**Keywords**— GNSS, PPP, Decision Tree, Precision, Accuracy.

## I. INTRODUCTION

The evolution of global artificial satellite navigation systems that integrate the Global Navigation Satellite Systems, or simply GNSS, has been happening regularly and steadily over the past decade and leads us to understand that in a short time the world will reach a new stage in positioning of points using artificial satellites. Among these systems, the Global Positioning System (GPS) is in a more advanced stage, finalizing its modernization with the planned launch of Block III satellites and other investments in land infrastructure. The Russian Global Navigation Satellite System (GLONASS) is in the final stages of completing its constellation, while the European GALILEO system and the Chinese Compass Navigation Satellite Experimental System or Beidou-1 are in intermediate stages of deployment. In this context of novelties, with the consequent enlargement of horizons, some points still deserve to be researched, since they belong more to the fundamental technique applied in the positioning of points than to a particular positioning system. The relationship between precision and accuracy of a positioning is the subject addressed in this paper, investigated from data observed with dual frequency GNSS receivers.

The objective of this paper was to study the accuracy of coordinates obtained by the Precision Point Positioning (PPP) method and the feasibility of using them in engineering works that require good accuracy. To understand accuracy behavior, the PPP processing results obtained over a period of six months were analyzed taking into account the different sources of error that act on the propagated signal and cause deviations above the limits acceptable for engineering purposes.

In this project, the machine learning technique was applied. This technique uses a database populated with the known accuracies and precision of a set of previously measured point to, by computational training, induce a Decision Tree and make it capable of estimating the

accuracy of a new positioning in which only the precision is known.

Different methods of observation can be developed by using signal receivers transmitted by the satellites that make up the constellations that integrate the GNSS. These methods produce the geodesic coordinates of points, with different precisions, practically on the entire physical surface of the Earth. Among them, the absolute method known as Precision Point Positioning (PPP) allows precise positioning using only one receiver to record the carrier phase data transmitted by the satellites and then process them in combination with accurate ephemeris provided by the International GNSS Service (IGS). This is a very useful method for determining coordinates of points that are far from a terrestrial reference network.

Since it is an absolute method, PPP does not connect to the existing terrestrial geodesic networks in the studied region and, therefore, the coordinates determined with its use do not have the adjustment residuals of an existing terrestrial geodesic network. It can be said that, using PPP, each point determined is an independent point that has its own accuracy. However, jobs that will use the coordinates of that point will certainly make their connection to existing terrestrial geodesic networks, which can be a problem if their accuracy is not adequate. The Brazilian Institute of Geography and Statistics (IBGE) has a PPP Service available online (IBGE-PPP), which processes the GNSS data and provides the coordinates of a point measured using dual frequency receivers. These coordinates are linked to the Geocentric Reference System for the Americas (SIRGAS2000) and to the International Terrestrial Reference Frame (ITRF).

According to HOFMANN et al. (2007) [1], the technique used to determine the coordinates by the PPP method uses a mathematical adjustment by the criterion of least squares (MMQ) and provides statistical indicators on the precision of the solution found in the adjustment.

As it is known, accuracy is different from precision and for this reason there is some risk in assuming the coordinates that result from PPP processing based only on its precision. In many situations, the coordinates determined with very high precision do not have good accuracy and, therefore, do not represent the true point position on the Earth's physical surface. This happens initial data acquired by the receivers contain perturbations of some kind, such as the multipath influence, which according to MONICO (2008) [2], is a local interference capable of degrading the observables of the phases and of the codes and producing the coordinates from a point certainly far from their real position on the ground. Thus, the study presented here was developed to find a way to indirectly estimate how different are the precision and accuracy of a PPP-GNSS positioning solution.

This paper's main hypothesis is that once the correlation between accuracy and precision of a significant set of GNSS data is known, it becomes possible to predict the accuracy of a new measurement, based on its precision, using the computational technique of Machine Learning known as Decision Tree.

### 1.1 The Precise Point Positioning Technique (PPP)

PPP is a method in which the position coordinates of the receiver are calculated directly in function of the position coordinates of the satellites. This is an absolute positioning method and for this reason PPP is also known as a Precise Absolute Positioning method. The georeferenced coordinates obtained with this method are not associated to any planimetric network, or to any existing altimetric network on the Earth's surface, and for this reason, according to IBGE (2013) [3], the PPP coordinates can present significant differences regarding the vertices of these terrestrial networks. In other words, coordinates determined with the PPP may present unacceptable accuracy. PPP is a method similar to simple absolute positioning, but it is not the same, as there are some fundamental differences. One remarkable difference is that the coordinates of the receiver are calculated in the PPP from the precise ephemeris available in the IGS network or other similar institution. It is an expressive difference compared to the simple absolute positioning method that uses the broadcasted ephemeris transmitted by the satellites. In the PPP calculation, the movement of tectonic plates, the ground tides, the satellite clock errors, the receiver clock errors, the offsets of the antenna center of the satellite and the phase center of the receiver antenna are considered to get coordinates with good accuracy. Another important difference is that the PPP method also uses, in addition to C/A Code data, the L1 and L2 carrier phase data, which requires the user to use a dual frequency receiver. It is only with this type of receiver that the necessary data is obtained to model the ionosphere and to develop the model known as ionosphere-free, or ionofree, which according to XU (2016) [4], eliminates the effects of the ionosphere by the combination of the codes and carrier phases equations. It is a linear combination of data, extremely useful for eliminating the errors produced by the ionospheric refraction, when the signals cross the Earth's atmosphere heading to receiver. SILVA and SEGANTINE (2015) [5] estimate the precision of the PPP method in the order of 5 to 10 cm, although some tests show that it can reach 2 to 5 cm precision, especially when the collecting data time is more than two hours and there is a convergence of results. The PPP method began to be offered in Brazil by the Brazilian Institute of Geography and Statistics (IBGE)

around the year of 2000, through the link <http://www.ppp.ibge.gov.br/ppp.htm>.

Strictly speaking, the PPP method can also be applied to data collected with single frequency receivers, which can only acquire data from a single carrier. In this case, some mathematical resources are applied to model the ionosphere, since it is not possible to combine the carriers phases. We did not deal with this case in this study.

## 1.2 Decision Tree

Machine Learning is a characteristic of a computer system training using a large amount of data to learn how to execute a certain task and execute it at other times with better performance. WITTEN and FRANK (2005) [6] understand that the system modifies itself and automatically learns about a certain event, allowing a task from the same group of tasks to be more effectively performed the next time. It is a process that automatically or semiautomatically identifies the patterns implicit in large amounts of data.

Due to this capacity, Machine Learning techniques are increasingly used to deal with problems of great complexity and difficult to conceptualize in different areas, such as in Mathematics, Medicine, Biology, and Engineering. ZHAN-LI et al. (2015) [7] demonstrated that this process is able to identify and synthetically recover three-dimensional points lost during the capture of a sequence of video images, in a process conceptually very close to the classification of points determined by the PPP method. Among the current Machine Learning techniques are:

- 1) The Neural Network, or Multi Layer Perceptron network, indicated for multiple classification of events, in which the number of learning examples is typically large.
- 2) The algorithm of Support Vector Machines, extremely fast, but with the disadvantage of solving only binary problems, involving only two classes.
- 3) The Decision Tree, designed to work with an unlimited number of multivariate data that serve as test examples in the training stage. It also has the ability to interpret and understand the implicit rules in this data set, and then uses these rules in a prediction process able to create infinite classes that will be used to classify a new event by the similarity of its characteristics compared to the characteristics of the examples used in the training stage. The accuracy of the coordinates obtained using GNSS, especially using the PPP method, can be understood as a complex problem, since the PPP is dissociated from existing geodesic networks on the surface of the Earth. For this reason, the Decision Tree is an appropriate tool to clearly explain the implicit positioning accuracy in the

observed data. All measurements made by GNSS are made up of different variables that can be modeled, such as: observables, recording rate, collection time, ionospheric disturbance, and tropospheric disturbance all items that can be analyzed by a Decision Tree. According to LEVINE et al. (1988) [8], a Decision Tree is induced (created) from a reliable database, a data structure constituted recursively by: decision nodes which correspond to a test on a variable and leaf nodes, which correspond to the resulting classes, as shown in Figure 1.

To classify a measurement consisting of GNSS observables, the process begins at the root, following to each test node until the decision leaf is reached, at which point the classification takes place.

Each Decision Tree can be represented by a set of rules, in which each rule begins at the root of the tree and walks to one of its leaves. Like any other automated and repetitive procedure the Decision Tree presents advantages and disadvantages. Among the advantages some can be highlighted:

- 1) The Decision Tree is easily created and intelligible.
- 2) Does not require "a priori" definitions for any parameter of the data under analysis.
- 3) The number of examples used, the quality of the database, and the intensity of the training control in the decision tree generating algorithms are considered to be unstable and sensitive to variations in the training data. This minimizes weak results at the decision points of the tree (decision nodes) and prevents inference errors from spreading to all subsequent branches.
- 4) The Decision Tree allows for simultaneous classification of alpha data, numerical data and alphanumeric data, with the condition that the output attribute is always an alpha class.

After being recursively trained, a Decision Tree produces, as a result, the stratification of data in the form of classes. According to RICH & KNIGHT (1991) [9], classification is an important component for solving many problems, being in its simplest form considered as a direct task of recognition. From the point of view of machine learning, the act of classifying is the process of assigning to a given data the name and class to which it belongs. Previously to the classification some tasks had to be carried out for the Decision Tree induced in this study to classify the accuracy of the solutions of new positioning points. First, a set of coordinates with known precision and accuracy was organized and the Decision Tree was intensively trained based on this data until it established the intrinsic inference rules contained in them and in that way, the tree became able to perform the classification.

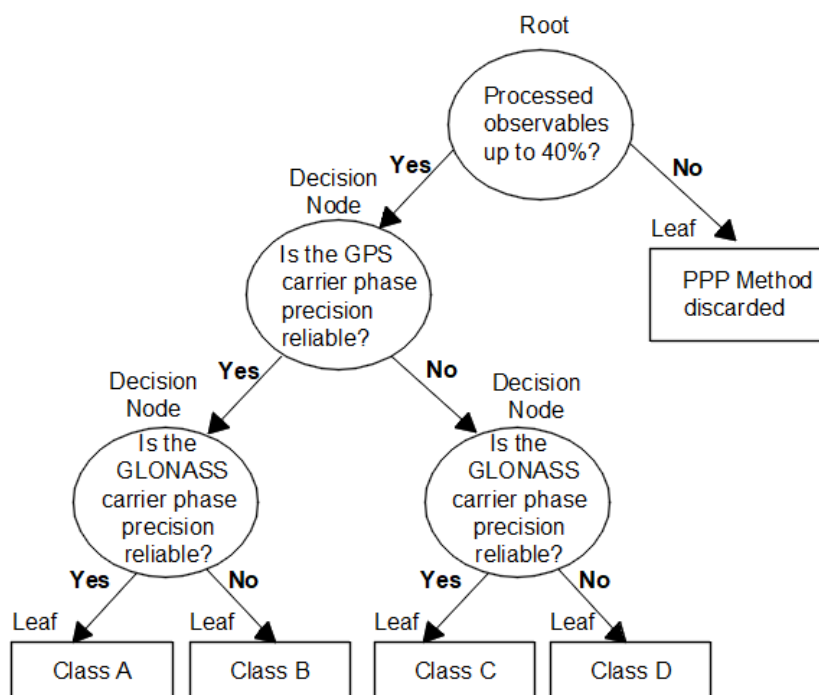


Fig.1: Decision Tree Conceptual Structure.

## II. MATERIALS: STUDY AREA AND DATA SET

In this paper, a reference database composed of a multivariate dataset was prepared. This dataset was used to create the Decision Tree and then make it able to make the predictions about the accuracy of results. The data of the reference bank were acquired from three geodesic stations, located in the state of São Paulo, according to Figure 2.



Fig.2: Geodesic stations used.

These stations belong to the Brazilian GNSS Systems Continuous Monitoring Network (RBMN), managed by the Brazilian Institute of Geography and Statistics (IBGE). More precisely the geodesic stations are detailed as follows:

-EESC station, code 99560, with official coordinates published by IBGE as being latitude ( $\square$ ):  $22^{\circ} 00' 17.8160''$  S, longitude ( $\square$ ):  $47^{\circ} 53' 57.0497''$  W, and geometric

height (h): 824,587 m, fixed in a metal tower on the ceiling of the School of Engineering of São Carlos, in the city of São Carlos (SP), Brazil, where a double frequency Leica GR10 GNSS receiver operates.

-SPBO station, code 99537, with official coordinates published by IBGE as being latitude ( $\square$ ):  $22^{\circ} 51' 08.8825''$  S, longitude ( $\square$ ):  $48^{\circ} 25' 56.282''$  W, and geometric height (h): 803.122 m, fixed in a cylindrical pillar on the slab next to the Didactic Laboratory of Topography and Remote Sensing of the Department of Rural Engineering of the Faculty of Agronomic Sciences of UNESP, in the city of Botucatu (SP), Brazil, where a double frequency GNSS receiver Leica GRX 1200 plus operates.

-Station SPC1, code 96181, with official coordinates published by IBGE as being latitude ( $\square$ ):  $22^{\circ} 48' 58.6305''$  S, longitude ( $\square$ ):  $47^{\circ} 03' 45.6958''$  W, and geometric height (h): 622.980 m, fixed in a concrete cylinder at the top of the building of the Department of Geotechnics and Transportation, Faculty of Civil Engineering of Unicamp, in the city of Campinas (SP), Brazil, where a double frequency GNSS Trimble NETR9 receiver operates.

At these stations, the GNSS data were acquired from January to May 2016, with intervals spaced every 15 days, which, after being processed by the PPP method were used to compose the reference database.

As all data observed at RBMC geodesic stations were stored in 24-hour continuous files and due to that, it was necessary to extract several files with 3 hours of data each day of the study. This was done because according to



IBGE (2013) [3], the result of a PPP positioning converges after two hours of stored data, and one of this study's objectives was to analyze one hour of data with the same convergence pattern.

Therefore, the first file of the day contains data from 4:00 a.m. to 7:00 a.m., the second file from 5:00 a.m. to 8:00 a.m., and the last file of the day contains data from 3 p.m. to 6 p.m. In this way, 12 files were prepared each day, covering the daytime period from 4:00 a.m. to 6:00 p.m., which is considered business time, when most of the companies that work with georeferencing activities acquire their data, which shall be used in engineering services.

This form of organization allowed for preparation of 132 observation sessions in each geodesic station, totaling 396 study sessions, which were used in the creation and training of the Decision Tree.

According to the instructions of the PPP-IBGE manual, each three-hour file was submitted online at <http://www.ibge.gov.br/home/geociencias/geodesia/ppp/default.shtm>, in which the data of the L1 and L2 carrier phases transmitted by the satellites of the GPS and GLONASS constellations were processed, with a mask of elevation higher than 10°, by the PPP method. Each processed file has produced several relevant information to the interpretation and analysis of the positioning results, among which are the coordinates of the point, its precision and other 17 variables, described below:

1. Precision of the PPP solution in latitude;
2. Precision of the PPP solution in longitude;
3. Precision of the PPP solution at geometric height;
4. Number of GPS's processed epochs;
5. Number of GPS's rejected epochs;
6. Residues of GPS Pseudodistances;
7. Residues of the GPS carriers phases;
8. Number of GLONASS's processed epochs;
9. Number of GLONASS's rejected epochs;
10. Residues of GLONASS Pseudodistances;
11. Residues of GLONASS carrier phases;
12. Percentage of GPS's rejected epochs;
13. Percentage of GLONASS's rejected epochs;
14. Accuracy of the solution according to latitude;
15. Accuracy of the solution according to longitude;
16. Accuracy of the solution according to geometric height; and,
17. Accuracy class.

Strictly speaking, PPP-IBGE processing provides the eleven first variables and the six final variables are obtained by crossing the data. The accuracy of the coordinates, for instance, was obtained by comparing the measured coordinates with the known coordinates of each geodesic station. This was done to highlight the important

points in the Decision Tree training, which were the percentage of rejected GNSS epochs, both GPS and GLONASS, whose proportion has a direct relationship with the precision of the positioning result.

### 2.1 Decision Tree Induction Software

To interpret the 17 variables produced in PPP processing and to identify how they are related, we used the open software developed by Professors Ian H. Witten and Eibe Frank of the University of Waikato, New Zealand, known as WEKA (Waikato Environment Knowledge Analysis), version 3.8.

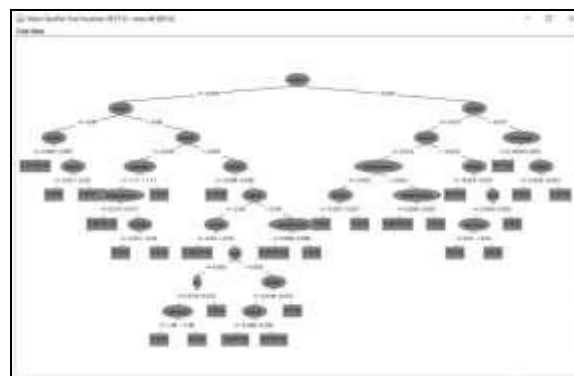


Fig.3: Example of a Decision Tree.

This software was chosen due to its capability of working with large volumes of data and for offering different Machine Learning techniques, including Decision Trees. The software facilitated the construction of several decision trees, such as the example above, created for this study until it reached the appropriate version to carry out the classification.

### 2.2 Accuracy Classes

During the computational training of a Decision Tree, the computational system creates the classification rules from the known situation to predict new events. For this reason the Decision Tree needs to be instructed about the interval of each class to be considered.

Working with geodesic stations that have known coordinates, it is always possible to identify the quality of the positioning of the PPP method. Making a comparison between the coordinates determined in the PPP and the known coordinates enables the establishment of the classes and their amplitudes which must be respected in the results predicting process. In this study, the following accuracy classes were defined for the training of the trees:

CLASS	ACCURACY
A	0.0 to 2.0 cm
B	2.1 to 4.0 cm
C	4.1 to 6.0 cm
D	6.1 to 8.0 cm
Z	> 8.0 cm.



The reference bank used to carry out the Decision Tree training used only the known information in the three geodesic stations, thus being the known reference in the process. It was populated by the 396 daily measurement sessions, each containing the 17 mentioned attributes. The accuracy class known in each case was classified by the researcher and became the 18th attribute in the database.

The following figure shows the implicit accuracy in the Decision Tree training data. This figure also shows that the user, when working only accurately, is not aware of the accuracy of the result, being exposed to the risk of adopting as reliable some sets of coordinates that are very distant from the real position of the point on the ground. The Decision Tree interprets what really matters in a positioning, which is the accuracy of the result.

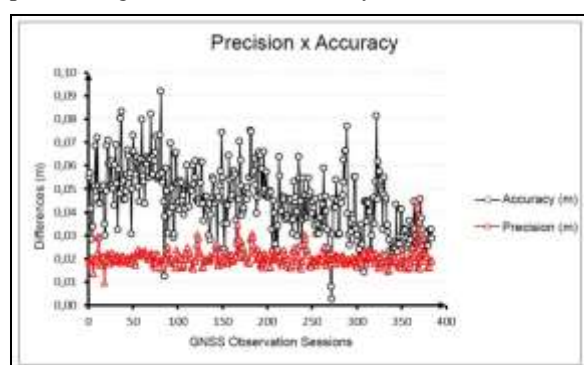


Fig.4: Precisions and Accuracies in GNSS data.

### III. VALIDATION TEST

Whenever the Decision Tree is triggered to classify the accuracy of a new PPP positioning solution from which it only knows the precision, it follows the rules implicit in the reference bank, identifies the links that may exist among the 17 variables of this new measurement, and makes the prediction about the 18th variable, which is the accuracy of the new solution, something still unknown, as of WITTEN and FRANK (2005) [6]. As it is an inferential method, there are always probabilities of errors directly associated with the quality of the reference bank. To verify the quality of the predictions made by the Decision Tree, a specific stage was developed to validate its predictions.

To carry out the validation test, a new set of GNSS data could be acquired at any randomly chosen new location inside the triangle in question, in a different location from the EESC, SPBO and SPC1 geodesic stations, which had already been used in the training stage. If the chosen location was a place without any control we would only have to accept the prediction made by the Decision Tree without means to verify the quality of its prediction, which is the object of the validation.

To know exactly how the Decision Tree classified the new data, we decided to use a fourth RBMC's geodesic station, located inside the territorial area formed by the three initial ones. The classification made by the Decision Tree over the collected data in this 4th station was used to validate the level of quality of the made predictions. The chosen station for the validation test was:

-SPPI station, code 99588, with official coordinates published by IBGE as being latitude ( $\square$ ): 22° 42' 10.9769 "S, longitude ( $\square$ ): 47° 37' 25.0333" W and geometric height (h): 561.88 m, fixed in a concrete cylinder built at the USP/ESALQ Meteorological Station, in the city of Piracicaba (SP), Brazil, where a double frequency GNSS Trimble NETR8 receiver operates.

The data acquired at this station was used to organize 33 observation sessions scattered from January to May 2016, but on different days from those used in the composition of the reference bank. The data files of each session were organized in the same way as the files used in the training, i.e., three hours each, a period sufficient for the convergence of data in PPP processing.

These 33 files were sent online for PPP processing on the IBGE website. The table below shows the differences found in latitude ( $\square$ ), longitude ( $\square$ ), and geometric height (m) values, comparing the calculated coordinates in each session with the known coordinates of the SPPI station, differences that inform the actual accuracy of each session. The last column on the right presents the accuracy prediction made by the Decision Tree, through alphabetic characters: A, B, C, D and Z, which represent the class estimated for each session, according to item 2.2.

Table.1: Accuracy Classification made by the Decision Tree in the Validation Test

Session	Differences			Accuracy		Session	Differences			Accuracy	
	Latitude $\Delta\phi(m)$	Longitude $\Delta\lambda(m)$	height $\Delta h(m)$	Real (m)	Predicted (Classe)		Latitude $\Delta\phi(m)$	Longitude $\Delta\lambda(m)$	Altura $\Delta h(m)$	Real (m)	Predicted (Classe)
1	-0.03	-0.01	-0.03	0.04	B	18	-0.01	0.00	-0.06	0.06	C
2	-0.02	0.01	-0.04	0.05	C	19	-0.02	0.02	-0.06	0.06	C
3	-0.02	0.02	-0.04	0.05	C	20	-0.02	0.01	-0.05	0.05	C
4	-0.01	0.03	-0.06	0.07	Z	21	-0.02	0.01	-0.04	0.04	B
5	-0.01	-0.01	-0.03	0.03	B	22	-0.01	0.01	-0.02	0.02	A
6	-0.01	0.00	-0.06	0.06	C	23	-0.01	0.02	-0.05	0.05	C
7	-0.02	0.01	-0.08	0.08	Z	24	-0.02	0.01	-0.01	0.02	A
8	-0.02	0.01	-0.05	0.05	C	25	-0.02	0.02	-0.05	0.06	C
9	-0.01	0.01	-0.09	0.09	Z	26	-0.02	0.02	-0.03	0.04	B
10	-0.03	0.00	-0.09	0.09	Z	27	-0.03	0.01	-0.03	0.04	B
11	-0.02	0.00	-0.04	0.04	B	28	-0.01	0.01	-0.04	0.04	B
12	-0.02	0.01	-0.06	0.06	C	29	-0.02	0.01	-0.03	0.04	B
13	-0.03	-0.01	0.01	0.04	B	30	-0.02	0.01	-0.05	0.05	C
14	-0.01	-0.01	-0.04	0.04	B	31	-0.02	0.00	-0.04	0.04	B
15	-0.01	-0.01	-0.06	0.06	C	32	-0.02	0.01	-0.04	0.05	C
16	-0.02	0.02	-0.05	0.06	C	33	-0.02	0.01	-0.04	0.05	C
17	-0.02	-0.02	-0.07	0.07	Z	-	-	-	-	-	-

At this point, it should be remembered that in the training stage, 17 attributes were used in each new measurement session, the latter being precisely the classification of the accuracy of the coordinates known in that stage. This point is emphasized because now, in the validation step, each instance representing a measurement session was organized with only 16 attributes, leaving the 17th attribute, concerning accuracy, for the Decision Tree to make its own prediction.

All new instances could be validated because the SPPI station has known coordinates. The validation test reached a result with 29 correct predictions in a universe of 33 predictions, which puts the degree of accuracy in this work at 88%, a little above the initial expectation, which gave the Decision Tree a confidence level of 86%.

#### IV. CONCLUSIONS

As predicted by WITTEN and FRANK, (2005) [6], the results obtained in the creation of the Decision Tree proved to be better as we introduced cross-data and not only the initial data. Variables number 12 and 13 were introduced to explain, respectively, the proportion of rejected GPS epochs and the proportion of rejected GLONASS epochs, in addition to making evident the degree of participation of each positioning system for the final result. In addition, these variables show the proportion of each system's data utilization individually, which helped the Decision Tree to be better conditioned for future interpretations.

It has been confirmed that, in fact, the precision of measurements made with GNSS is something very different from accuracy. Figure 4 presents this difference very clear. In addition, the figure shows that the

relationship between accuracy and precision is not deterministic and, therefore, each positioning result has to be monitored individually, otherwise a bad result may be accepted as good. The Decision Tree is a tool that allows the user to anticipate the correlation between both accuracy and precision.

The data processing by the PPP-GNSS method reached, in this study, an accuracy of decimetric order, as already estimated by SILVA and SEGANTINE (2015) [5]. This level of quality puts the method in equal conditions to other methods of precise positioning and in a much better condition than was initially assumed.

The obtained results are satisfactory and completely within the expected range, since they showed a behavior very similar to each other, both for the set of precisions and the set of accuracies. Only 4 values of accuracy did not follow the behavior of the tests group in the 396 measurement sessions, although they resulted in values better than 2 centimeters, which is not significant for the study, according to LINOFF and BERRY (2011) [10].

From the results in this study, which used six months period of data to show the accuracy of coordinates as a greater parameter of importance than precision, it can be concluded that:

It was clearly demonstrated that accuracy is something different from precision, which accompanies the coordinates calculated by any GNSS positioning method, including the PPP-GNSS method. It can be proven by the distance between them in Figure 2.

The 396 measurement sessions used to create and train the Decision Tree showed a correlation between precision and accuracy in the GNSS data, suggesting that there may

be one or more connection rules between them, which needs to be investigated.

As a support tool, the Decision Tree can be applied in the investigation of accuracy obtained with other GNSS positioning methods, since, regardless of the method applied to get the solution, the result of any GNSS measurement session are the coordinates of the measured point, always accompanied by the statistical indicator of precision, an element used as variable in this study.

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# Evaluation of the Physical Attributes of Soil under Different Uses and Management in the Territory of the Zona da Mata in Rondônia, Brazil

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**Abstract**— *The results of soil use is widely known mainly for the productivity and visual aspect of plant development. In order to characterize the results of the different soil management, this study was carried out on family farms in the Zona da Mata Territory in Rondônia. The samples were submitted to physical attributes analysis of density, total porosity, macroporosity, microporosity, aggregate stability and organic matter analysis. The soils under different uses were negatively influenced when compared to the forest, having in average decrease in total porosity, macroporosity, organic matter and increase in microporosity and density.*  
**Keywords**— *Attributes soil. Management soil. Rolim de Moura.*

## I. INTRODUCTION

The colonization of the state of Rondônia had a great increase in the 1970s and 1980s, with the overthrow of large areas of the forest for agricultural practices and most extensive cattle ranching. This occupation was mainly done by people with low technology and capital

investment, where the practice of cleaning the pastures for the use of fire predominated for many years and, in addition, the vast majority of the pastures never received any liming and correction fertilization or maintenance. The results of these modes of use of the Rondônia soils have brought many problems in chemical, physical and biological attributes (Dias Filho, 2003, Schlindwein et al., 2012, RUDNICK 2015, HENRIQUE, 2016 and PEREIRA 2017).

The exploitation of the soil in its various uses alter its properties. According to Cardoso et al. (2011), assessments of changes in soil properties resulting from impacts of anthropogenic intervention on natural ecosystems can be an important tool to assist in the monitoring of environmental conservation, since they allow characterizing the current situation, alert to risk situations and, sometimes, predict future situations, especially when used as reference to the original native vegetation (FREITAS L de, 2015).

Henrique (2016) found lower values of density for the use of the forest soil compared to different managements

evaluating the quality of the soil in areas altered by the uses in the central region of the state of Rondônia. According to Rudnick (2015) the anthropic action, from the soil management, increases the density, which affects the macroporosity, generally causing the reduction of the total porosity.

An important tool for study in cultivated soils is the stability of aggregates, since it allows to evaluate the resistance or fragility of the soil in relation to the factors that can influence in the formation and distribution of the same (FERREIRA, 2010 and RUDNICK 2015).

The physical attributes of the soil influence the decision making on how it can be better managed. The success of

agricultural projects are often dependent on these attributes. (GUIDOLINI, 2015).

Thus, the objective of this work was to compare the changes in physical attributes and organic matter of the soil under different uses: extensive grazing, rotational grazing and coffee crop comparing them with the forest.

## II. MATERIAL AND METHODS

The present work was carried out in the territory of Zona da Mata, located in the central-south region of the state of Rondônia (Picture 1), composed of 07 municipalities: Alta Floresta D'Oeste, Alto Alegre dos Parecis, Castanheiras, Nova Brasilândia D'Oeste, Nova União D'Oeste, Rolim de Moura and Santa Luzia D'Oeste.



Picture 1 - Territory of Zona da Mata - RO  
CGMA / STD / MDA adaptation, March 2015

The selected properties for the collection of the samples were based on the following uses and management of soils: permanent forest (MT) to serve as reference, extensive pasture of *Brachiaria* (*Brachiaria brizantha*) with more than 20 years of use and that never received liming and fertilization (PT), pasture of mombaça (*Panicum maximum*) rotary with three years of use, fertilized with urea and potassium chloride (PR) and coffee crop (LV), being three crops of clonal conilon coffee (*Coffea canefora*) with 4 years belonging to the municipalities of Alto Alegre dos Parecis, Rolim de Moura and Alta Floresta D'Oeste, a crop with 8 years of cultivation belonging to the municipality of Nova Brasilândia D'Oeste; two traditional conilon coffee farms,

one with 10 years belonging to the municipality of Novo Horizonte D'Oeste and another with 15 years of cultivation belonging to the municipality of Santa Luzia D'Oeste; the coffee plantations, with the exception of the cultivation of 15 years of cultivation, received liming and fertilization in the cultivation lines without any analysis or technical recommendation.

EMATER-RO has indicated its properties and the search has been performed with the agreement of the owners.

Each site selected for collection was divided into four homogeneous parts, from a visual point of view (quadrants), with an area of approximately 0.25 ha, serving as a repetition. All samples were randomly collected in zig-zag, in the 0-10 and 10-20 cm layers, and



for organic matter and stability of aggregates were collected in four subsamples to form a sample composed by quadrant, samples for density and porosity analyzes were collected with 100 cm<sup>3</sup> volumetric rings.

The physical analyzes were performed according to the methodology described by EMBRAPA (2011) and organic matter by the methodology of Tedesco et al, (1995). The results of the laboratory analyzes were submitted to analysis of variance for each site with Tukey test at 5% probability in a 4 x 2 factorial scheme, with 4 replications, 4 soil uses and 2 depths.

### III. RESULTS AND DISCUSSION

The forest soils had lower densities in the 0-10 cm layer for all sampling sites when compared to other types of soil use, already in the 10-20 cm layer and in the average of the two layers, most of the soils of the showed this tendency (Table 1).

For the depth factor the density means differed statistically to Alto Alegre from Parecis, Alta Floresta D'Oeste, Nova Brasilândia D'Oeste and Novo Horizonte D'Oeste. Henrique (2016) also verified increase in soil density in depth evaluating the soil quality in areas altered by the uses in the central region of the state of Rondônia. The Alto Alegre dos Parecis property in PT soil use presented the highest result for the total porosity (0.73 cm<sup>3</sup>.cm<sup>-3</sup>) and for microporosity 0.62 cm<sup>3</sup>.cm<sup>-3</sup>) at 0-10 cm depth ( Table 1). Although it presents a greater total porosity than the MT use, the animal load of PT soil use and the trampling effect may contribute to the reduction of macroporosity that was 50% lower than the MT soil use.

In the property of Nova Brasilândia D'Oeste, in the average of the results of the use of the use, the LV presented the lowest result 0.48 cm<sup>3</sup>.cm<sup>-3</sup> of total porosity, consequently lower results for macroporosity and higher results for microporosity. This reduction of total porosity and macroporosity can be attributed to the preparation of

The minimum densities found were 0.92 g cm<sup>-3</sup> in the depth of 0-10 cm and 1.10 g cm<sup>-3</sup> in the depth of 10-20 cm in the Alta Floresta D'Oeste property. These values can be attributed to the influence of MT litter where soil organic matter (SOM) can improve physical and chemical attributes. Similar values were also found by Rudnick, (2015); Henrique, (2016) and Pereira (2017). According to SILVA et al., (2012) MOS contributes to the improvement of physical attributes such as density and porosity, as well as its effect on soil aggregation.

Soils with the highest average soil density values for all sampling sites were 1.60 g cm<sup>-3</sup> at depth of 0-10 cm and 1.72 g cm<sup>-3</sup> at depth of 10 -20 cm in the Rolim de Moura property in LV use (Table 1). Similar values were also found by Rudnick, (2015) and Henrique, (2016). Lima et al. (2007) found that densities greater than 1.69 g cm<sup>-3</sup> may be restrictive to root growth.

the soil, which in the first moment increases macroporosity and total porosity, but after some rainfall the porosity is reduced as a function of the reorganization of the aggregates that are generally reduced due to the preparation of the soil and the decrease of organic matter. In Alta Floresta in the uses of the soil (PT and PR), Novo Horizonte D'Oeste (PT, LV and PR), Rolim de Moura (PT) and Santa Luzia D'Oeste (PT, LV and PR) had results below 0 , 10 cm<sup>3</sup> cm<sup>-3</sup> for macroporosity, which is considered restrictive for the growth of roots of plants, according to Carmo et al. (2011) and Cardoso et al. (2011).

In the Alto Alegre dos Parecis property, the PR soil use had a higher percentage of stable aggregates larger than 2 mm in the two depths, obtained by wet sieving (84.12 and 54.77%, respectively) (Table 2). Perusi and Carvalho (2007) and Henrique (2016) found greater stability of the aggregates in soils under pasture when compared to annual crops, they attributed the result to the grass root system.

Table.1: Density, total porosity, macro and microporosities in different soil uses and sampling sites in the state of Rondônia

	Densidade			Porosidade total			Macroporosidade			Microporosidade		
Uso do Solo	Profundidade (cm)											
	00-10	10-20	Média	00-10	10-20	Média	00-10	10-20	Média	00-10	10-20	Média
	g cm <sup>-3</sup>			cm <sup>3</sup> .cm <sup>-3</sup>			cm <sup>3</sup> .cm <sup>-3</sup>			cm <sup>3</sup> .cm <sup>-3</sup>		
-----Alto Alegre dos Parecis-----												
Mata (MT)	1,13bB	1,37aA	1,25b	0,60abA	0,53aA	0,56a	0,22aA	0,19aA	0,21a	0,37bA	0,34aA	0,36b
Pastagem (PT)	1,26abB	1,45aA	1,36ab	0,73aA	0,53aA	0,63a	0,11bA	0,09bA	0,1b	0,62aA	0,44aB	0,53s
Lavoura (LV)	1,47aA	1,45aA	1,46a	0,45bA	0,55aA	0,5a	0,16abA	0,09bA	0,12b	0,29bB	0,46aA	0,38b
Pasto Rotacionado (PR)	1,36aA	1,44aA	1,40ab	0,56abA	0,53aA	0,54a	0,12bA	0,15abA	0,13b	0,44abA	0,38aA	0,41ab
Média	1,31 B	1,43A	-	0,58A	0,54A	-	0,15A	0,13A	-	0,43A	0,40A	-
CV%		8,14			18,60			33,19			24,50	
-----Alta Floresta D'Oeste-----												
Mata (MT)	0,92cB	1,28aA	1,10b	0,69aA	0,61aB	0,65a	0,28aA	0,23aA	0,25a	0,41aA	0,38aA	0,40b
Pastagem (PT)	1,55aA	1,40aA	1,47a	0,53bA	0,47bB	0,50b	0,09bA	0,10bA	0,09b	0,44aA	0,37aB	0,41ab
Lavoura (LV)	1,21bB	1,46aA	1,33a	0,59bA	0,5bB	0,54b	0,12bA	0,10bA	0,11b	0,47aA	0,4aB	0,43ab
Pasto Rotacionado (PR)	0,4abA	1,37aA	1,39a	0,54bA	0,52bA	0,53b	0,08bA	0,08bA	0,08b	0,46aA	0,44aA	0,45a
Média	1,27B	1,38A	-	0,59A	0,52B	-	0,14A	0,13A	-	0,44A	0,40B	-
CV%		9,08			5,83			24,84			8,12	
-----Nova Brasilândia D'Oeste-----												
Mata (MT)	1,17bB	1,37bA	1,27b	0,61aA	0,60aA	0,61a	0,27aA	0,26aA	0,27a	0,34abA	0,34aA	0,34ab
Pastagem (PT)	1,35abB	1,55abA	1,45a	0,59abA	0,58aA	0,59a	0,23aA	0,23aA	0,23a	0,36aA	0,35aA	0,36ab
Lavoura (LV)	1,47aA	1,63aA	1,55a	0,48cA	0,48bA	0,48b	0,20abA	0,14bA	0,17b	0,28bB	0,34aA	0,31b
Pasto Rotacionado (PR)	1,45aA	1,62aA	1,53a	0,52bcA	0,48bA	0,50b	0,14bA	0,13bA	0,13b	0,38aA	0,36aA	0,37a
Média	1,36B	1,54A	-	0,55A	0,54A	-	0,21A	0,19A	-	0,34A	0,35A	-
CV%		8,54			7,96			19,89			10,59	
-----Novo Horizonte D'Oeste-----												
Mata (MT)	1,15bA	1,30bA	1,22b	0,58aA	0,58aA	0,58a	0,19aA	0,22aA	0,21a	0,38aA	0,36aA	0,37a
Pastagem (PT)	1,34abB	1,57aA	1,45a	0,58aA	0,46aB	0,52ab	0,05bA	0,06bA	0,05b	0,53aA	0,4aB	0,47a
Lavoura (LV)	1,45aA	1,51aA	1,48a	0,49aA	0,48aA	0,48b	0,07bA	0,09bA	0,08b	0,42aA	0,39aA	0,41a
Pasto Rotacionado (PR)	1,32abB	1,52aA	1,42a	0,48aA	0,49aA	0,49b	0,06bA	0,05bA	0,05b	0,43aA	0,44aA	0,44a
Média	1,31B	1,47A	-	0,53A	0,50A	-	0,09A	0,11A	-	0,44A	0,4A	-
CV%		7,71			12,14			34,99			18,98	
-----Rolim de Moura-----												
Mata (MT)	1,12bA	1,30bA	1,21b	0,66aA	0,59aA	0,63a	0,27aA	0,19aB	0,23a	0,39aA	0,40aA	0,4a
Pastagem (PT)	1,72aA	1,64abA	1,68a	0,46aA	0,57aA	0,52a	0,11cA	0,09bA	0,10c	0,36aA	0,49aA	0,42a
Lavoura (LV)	1,6aA	1,72aA	1,66a	0,56aA	0,49aA	0,52a	0,19bA	0,15abA	0,17b	0,37aA	0,34aA	0,35a
Pasto Rotacionado (PR)	1,40abA	1,49abA	1,45ab	0,61aA	0,51aA	0,56a	0,14bcA	0,14abA	0,14bc	0,47aA	0,37aA	0,42a
Média	1,46A	1,54A	-	0,57A	0,54A	-	0,18A	0,14B	-	0,40A	0,40A	-
CV%		11,86			19,06			25,53			27,72	
-----Santa Luzia D'Oeste-----												
Mata (MT)	1,14bB	1,37aA	1,25b	0,51bcA	0,53aA	0,52bc	0,16aA	0,16aA	0,16a	0,35cA	0,37aA	0,36b
Pastagem (PT)	1,52aA	1,47aA	1,49a	0,42cB	0,51aA	0,46c	0,09bA	0,12aA	0,10b	0,33cA	0,39aA	0,36b
Lavoura (LV)	1,30abA	1,41aA	1,35ab	0,68aA	0,55aB	0,61a	0,06bB	0,11aA	0,09b	0,61aA	0,44aB	0,53a
Pasto Rotacionado (PR)	1,46aA	1,49aA	1,48a	0,56bA	0,61aA	0,58ab	0,09bB	0,16aA	0,12ab	0,47bA	0,45aA	0,46a
Média	1,36A	1,43A	-	0,54A	0,55A	-	0,10B	0,14A	-	0,44A	0,41A	-
CV%		10,31			9,89			24,20			12,82	

**Note:** Averages followed by the same letter, lowercase in the columns and upper case in the rows, within the same sampling location, do not differ by Tukey test at the 5% probability level.

For the depth factor the density means differed statistically to Alto Alegre from Parecis, Alta Floresta D'Oeste, Nova Brasilândia D'Oeste and Novo Horizonte D'Oeste. Henrique (2016) also verified increase in soil density in depth evaluating the soil quality in areas altered by the uses in the central region of the state of Rondônia. The Alto Alegre dos Parecis property in PT soil use presented the highest result for the total porosity (0.73 cm<sup>3</sup>.cm<sup>-3</sup>) and for microporosity 0.62 cm<sup>3</sup>.cm<sup>-3</sup>) at 0-10 cm depth ( Table 1). Although it presents a greater total porosity than the MT use, the animal load of PT soil use and the trampling effect may contribute to the reduction

of macroporosity that was 50% lower than the MT soil use.

In the property of Nova Brasilândia D'Oeste, in the average of the results of the use of the use, the LV presented the lowest result 0.48 cm<sup>3</sup>.cm<sup>-3</sup> of total porosity, consequently lower results for macroporosity and higher results for microporosity. This reduction of total porosity and macroporosity can be attributed to the preparation of the soil, which in the first moment increases macroporosity and total porosity, but after some rainfall the porosity is reduced as a function of the reorganization

of the aggregates that are generally reduced due to the preparation of the soil and the decrease of organic matter. In Alta Floresta in the uses of the soil (PT and PR), Novo Horizonte D'Oeste (PT, LV and PR), Rolim de Moura (PT) and Santa Luzia D'Oeste (PT, LV and PR) had results below 0, 10 cm<sup>3</sup> cm<sup>3</sup> for macroporosity, which is considered restrictive for the growth of roots of plants, according to Carmo et al. (2011) and Cardoso et al. (2011).

In the Alto Alegre dos Parecis property, the PR soil use had a higher percentage of stable aggregates larger than 2 mm in the two depths, obtained by wet sieving (84.12 and 54.77%, respectively) (Table 2). Perusi and Carvalho (2007) and Henrique (2016) found greater stability of the aggregates in soils under pasture when compared to annual crops, they attributed the result to the grass root system.

Table.2: Distribution of the mass percentage of aggregates larger than 2mm obtained by wet sieving in different properties of the state of Rondônia.

USO DO SOLO	00-10	10-20	Média	00-10	10-20	Média
		%			%	
<b>-----Alto Alegre dos Parecis-----</b>						
Mata (MT)	59,93 bA	21,80 bB	40,87 bA	87,52 aA	67,75 aB	77,64 aA
Pastagem (PT)	73,38 aA	52,62 aB	63,00 aA	83,39 aA	76,01 aA	79,70 aA
Lavoura (LV)	47,60 bA	48,27 aA	47,93 bA	59,51 bA	40,02 bB	49,77 bA
so Rotacionado (PR)	84,12 aA	54,77 aB	69,44 aA	81,36 aA	67,43 aA	74,39 aA
Média	66,26 aA	44,36 aB	-	77,95 aA	62,80 aB	-
CV%		41,50			40,07	
<b>-----Alta Floresta D'Oeste-----</b>						
Mata (MT)	74,66 aA	59,18 aB	66,92 aA	80,30 aA	62,02 aB	71,16 aA
Pastagem (PT)	80,96 aA	48,55 bB	64,76 aA	79,84 aA	64,16 aA	72,00 aA
Lavoura (LV)	44,06 bA	22,87 cB	33,46 bA	47,42 bA	35,48 bA	41,45 bA
so Rotacionado (PR)	75,16 aA	62,90 aB	69,03 aA	82,18 aA	73,79 aA	77,99 aA
Média	68,71 aA	48,38 aB	-	72,43 aA	58,86 aB	-
CV%		30,67			40,36	
<b>-----Nova Brasilândia D'Oeste-----</b>						
Mata (MT)	73,80 abA	67,18 aA	70,49 abA	83,94 aA	43,79 aB	63,86 aA
Pastagem (PT)	82,52 aA	68,27 aA	75,40 aA	57,49 bA	37,57 abB	47,53 cA
Lavoura (LV)	33,69 cA	29,74 bA	31,71 cA	61,70 bA	30,62 bB	46,16 cA
so Rotacionado (PR)	66,83 bA	59,44 aA	63,14 bA	63,36 bA	47,28 aB	55,32 bA
Média	64,21 aA	56,16 aB	-	66,62 aA	39,81 aB	-
CV%		39,93			34,22	
<b>-----Santa Luzia D'Oeste-----</b>						

**Note:** Averages followed by the same letter, lowercase in the columns and upper case in the rows, within the same sampling location, do not differ by Tukey test at the 5% probability level.

The highest number of stable aggregates larger than 2 mm (80.96%) in the depth of 0-10 cm was higher than in the depth of 10-20 cm (62.90%), in the use of PR soil in Alta Floresta D'West (Table 2). Stability of larger aggregates in the superficial layers is expected due to the higher levels of MOS (Table 3), where it generally presents greater biological activity.

Greater stability of aggregates greater than 2 mm in pasture soils (PT and PR) was observed. Perusi and Carvalho (2007) also found greater stability of the aggregates in soils under pasture compared to annual crops, and attributed the result to the root system of the grasses that induced aggregation and gave greater stability to the soil structure.

Table.3: Soil organic matter in different soil uses and sampling sites in the state of Rondônia.

MOS												
USO DO SOLO	00-10		10--20		MEDIA	00-10		10--20		MEDIA		
			g.dm <sup>-1</sup>					g.dm <sup>-1</sup>				
	---Alto Alegre dos Parecis--					--Novo Horizonte D'Oeste--						
Mata (MT)	30,2	aA	12,8	aB	21,5 a	23,1	abA	10,9	aB	17,0 ab		
Pastagem (PT)	34,6	aA	13,4	aB	24,0 a	19,1	bA	9,0	aA	14,1 ab		
Lavoura (LV)	30,8	aA	18,2	aB	24,5 a	13,2	bA	8,2	aA	10,7 b		
Pasto Rotacionado (PR)	31,6	aA	17,0	aB	24,3 a	34,1	aA	12,0	aB	23,0 a		
Média	31,8	A	15,3	B	-	22,4	A	10,0	B	-		
CV%	30,70					45,19						
	----Alta Floresta D'Oeste----					-----Rolim de Moura-----						
Mata (MT)	30,1	aA	19,2	aB	24,6 a	44,2	aA	20,4	aB	32,3 a		
Pastagem (PT)	22,0	aA	12,4	abB	17,2 b	14,5	bA	11,9	aA	13,2 b		
Lavoura (LV)	25,3	aA	12,8	abB	19,0 ab	16,7	bA	6,0	aA	11,3 b		
Pasto Rotacionado (PR)	22,6	aA	9,9	bB	16,3 b	24,2	bA	9,9	aA	17,0 b		
Média	25,0	A	13,6	B	-	24,9	A	12,0	B	-		
CV%	22,34					54,03						
	-Nova Brasilândia D'Oeste-					----Santa Luzia D'Oeste----						
Mata (MT)	29,9	aA	7,0	aB	18,5 a	21,0	aA	8,9	aA	14,9 a		
Pastagem (PT)	14,2	bA	4,9	aB	9,6 bc	24,5	aA	13,2	aA	18,8 a		
Lavoura (LV)	8,1	cA	3,2	aB	5,6 c	28,0	aA	6,5	aB	17,3 a		
Pasto Rotacionado (PR)	16,2	bA	4,4	aB	10,3 b	31,1	aA	10,9	aB	21,0 a		
Média	17,1	A	4,9	B	-	26,1	A	9,9	B	-		
CV%	28,31					59,75						

**Note:** Averages followed by the same letter, lowercase in the columns and upper case in the rows, within the same sampling location, do not differ by Tukey test at the 5% probability level.

In the properties located in the municipalities of Alta Floresta D'Oeste, Nova Brasilândia D'Oeste, Novo Horizonte D'Oeste and Rolim de Moura, LV soil use presented the smallest percentage of aggregates larger than 2 mm in the two depths (44.06 and 22.87%), (33.69 and 29.74%), (59.51 and 40.02%) and (47.42 and 35.48%) respectively. In the conventional preparation, operations and soil management, cut and expose SOM to the attack of the microorganisms to make the decomposition and thus decreases the stability of the aggregates (BENITES et al., 2005). As can be seen in Table 3, MOS results were lower in these properties for LV soil use.

The results of the averages of soil organic matter between the soil use factor in the Alto Alegre dos Parecis municipality did not statistically defer (Table 3). This result was not expected, since MT has a great formation of vegetal mass. According to Morais et al. (2012) in an area of native vegetation there is greater formation of

vegetal mass and consequently large amounts of organic residues.

In Alta Floresta D'Oeste the MT presented the highest values for MOS (30.1 and 19.2 g dm<sup>-1</sup>) in the depth of 0-10 and 10-20 cm respectively. This result can be attributed to the fact that organic matter is directly associated with non-human interference, without the use of agricultural implements and cultural treatments. According to Freitas (2015) studying the chemical attributes of a red latosol submitted to different managements in the environment with native forest, it is possible to verify a greater influence of MO and CTC, indicating that the forest removal and the agricultural use reduced the levels of organic C not alone.

In the case of Nova Brasilândia D'Oeste, Rolim de Moura and Santa Luzia D'Oeste, the use of the MT soil presented the highest results in the averages between soil uses (18.5 g dm<sup>-1</sup>, 32.3 g dm<sup>-1</sup> e 21,0 g dm<sup>-1</sup>) respectively. There is a decline in the stock of organic matter after the conversion

of native forests into agricultural systems. According to Portugal et al. (2010) and Freitas et al. (2011), this reduction can be attributed to the increase of soil erosion, to the faster processes of mineralization of organic matter and to lower amounts of organic inputs in managed systems compared to native forests.

In Novo Horizonte D'Oeste, PR use showed the highest result in averages between soil uses for organic matter (23.0 g dm<sup>-1</sup>). Soil preparation and management of rotational grazing may have contributed to root growth and forage mass formation. Fernandes et al. (2013) evaluated the total organic carbon in revegetated areas and desertified areas and found statistical differences between the areas, and the revegetated area showed higher rates of total organic carbon after one year of planting.

All the properties had a higher concentration of SOM in depth of 0-10 cm. FONTANA et al. (2011), when studying the compartments of organic matter in soil with different coverages, found lower values of total organic carbon at higher depths, as well as higher levels of total organic carbon in native forest compared to cultivated soils.

It was verified that the soils under the different uses (PT, PR and LV) had a negative influence on the physical attributes (Total Porosity, Macroporosity, Microporosity and Density) compared with MT (Table 4).

The anthropic soils had a decrease of 9.8 and 8.8% in total porosity and of 47.8 and 42.9% in Macroporosity in the depth of 0-10 and 10-20 respectively. Increase of 13.2 and 8.1% in Microporosity at depths of 0-10 and 10-20 cm respectively.

Table.4: Mean of the percentage of soil physical attributes (total porosity, macroporosity and microporosity) of different soil uses compared to forest soil.

TOTAL POROSITY			MACROPOROSITY			MICROPOROSITY			
USE OF THE SOIL	Depth cm								
	00-10	10--20	Avarage	00-10	10--20	Avarage	00-10	10--20	Avarage
	%								
WOODS	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
ANTROPIZED*	90,2	91,2	90,7	52,2	57,1	54,7	113,2	108,1	110,6

\*Soils with uses for agriculture or livestock: extensive pasture, rotated pasture, crop and Mata. The anthropic soils had a 29.1 and 13.5% increase in soil density and lost 23.3 and 23.1% of organic matter in the depths of 0-10 and 10-20 cm respectively (Table 5).

Table.5: Average of the percentage of soil and organic matter density of different soil uses compared to forest soil.

DENSITY							MATERIA ORGANICA		
USE OF THE SOIL	Depth								
	00-10	10—20	MEDIA	00-10	10--20	MEDIA			
	%								
WOODS	100,0	100,0	100,0	100,0	100,0	100,0			
ANTROPIZED*	129,1	113,5	121,3	76,7	76,9	76,8			

\*Soils with uses for agriculture or livestock: extensive pasture, rotated pasture, crop and Mata.

#### IV. FINAL CONSIDERATIONS

Therefore, soils under different uses (extensive grazing, rotational grazing and coffee cultivation) have negative influences on physical attributes, and in the general average the anthropic soils have a decrease in total porosity, macroporosity and organic matter. And increase in microporosity and density.

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# Modelling the co-existence and survival scenarios of two competing legumes with a low environmental perturbation

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**Abstract**— The occurrence of an environmental perturbation on the outcomes of co-existence and survival for two competing legumes for limited resources is one of the challenging crop science problems that requires a mathematical quantification. We have explored the application of a MATLAB algorithm in this study. We have found that the inclusion of a low random noise intensity value of 0.01 has dominantly predicted more instances of valid co-existence scenarios and fewer instances of degeneracy scenarios provided the inter-competition coefficients outweigh the intra-competition coefficients. We would expect these present novel results to provide a further insight on the crop science ideas of co-existence and survival.

**Keywords**— Environmental perturbation, co-existence, survival, random noise, MATLAB Algorithm, inter-competition, intra-competition.

## I. INTRODUCTION

Within an agricultural setting, the competition between two legumes such as cowpea and groundnut for limited resources can play a significant role in terms of their co-existence, survival and food production. However, the effect of a low environmental perturbation such erosion or an un-expected sea level rise has the potential to shift the expected co-existence and survival scenarios under the simplifying assumption of its impact on the intrinsic growth rates provided the inter-competition coefficients outweigh the intra-competition coefficients. The mathematical

analysis of other related cowpea-groundnut interactions can be seen in the works of

## II. MATERIALS AND METHODS

The model parameters that we have utilized in this pioneering study were derived by Ekaka-a et al (2013) based on the primary growth data by Ekpo and Nkannang (2010) including the several cited articles that supported their full report. For the purpose of this analysis, the intrinsic growth rate parameter values are 0.0225 grams and 0.0446 grams per area of habitat, the intra-competition coefficients are 0.0167 and 0.033, the inter-competition coefficients are 0.02 and 0.035.

### Simplifying Assumptions

The deterministic model formulation follows the popular Lotka-Volterra type which is not the central focus of this analysis. A MATLAB algorithm has been implemented to predict the data below under the implicit assumptions that the said environmental perturbation only affects the intrinsic growth rates provided the inter-competition coefficients outweigh the intra-competition coefficients. For the purpose of clarity, the notations represented by the model parameter  $K$  stand for the biological carrying capacity which is defined as the ratio of the intrinsic growth rate to the intra-competition coefficient while the notations represented by the model parameter  $\alpha$  as the ratio of the inter-competition coefficient to the intra-competition coefficient.

## III. RESULTS

The results of this analysis are displayed as in Table 1 and Table 2 below:

Table.1: MATLAB Algorithm Predicted Data of Co-existence and Survival Outcomes with a Low Random Noise Intensity Value of 0.01: Scenario 1

Example	$C_b$	$G_b$	$\alpha_{12}$	$\frac{K_1}{K_2}$	$\alpha_{21}$	$\frac{K_2}{K_1}$
1	0.71	0.74	1.1976	1.0687	1.0606	0.9357
2	1.22	0.29	1.1976	0.9896	1.0606	1.0105
3	0.65	0.90	1.1976	1.0869	1.0606	0.9200
4	0.24	1.39	1.1976	1.1577	1.0606	0.8638
5	0.77	0.58	1.1976	1.0493	1.0606	0.9530
6	-0.41	1.82	1.1976	1.2785	1.0606	0.7822
7	0.55	0.93	1.1976	1.0990	1.0606	0.9099
8	-0.25	1.77	1.1976	1.2433	1.0606	0.8043
9	1.03	0.46	1.1976	1.0180	1.0606	0.9824
10	0.06	1.45	1.1976	1.1869	1.0606	0.8425

Table.2: MATLAB Algorithm Predicted Data of Co-existence and Survival Outcomes with a Low Random Noise Intensity Value of 0.01: Scenario 2

Example	$C_b$	$G_b$	$\alpha_{12}$	$\frac{K_1}{K_2}$	$\alpha_{21}$	$\frac{K_2}{K_1}$
1	0.44	0.94	1.1976	1.1135	1.0606	0.8981
2	0.06	1.37	1.1976	1.1868	1.0606	0.8426
3	1.92	-0.46	1.1976	0.8694	1.0606	1.1502
4	1.06	0.36	1.1976	1.0048	1.0606	0.9952
5	-0.04	1.50	1.1976	1.2046	1.0606	0.8302
6	-0.10	1.58	1.1976	1.2156	1.0606	0.8227
7	0.44	1.10	1.1976	1.1225	1.0606	0.8909
8	0.05	1.30	1.1976	1.1876	1.0606	0.8420
9	0.84	0.59	1.1976	1.0441	1.0606	0.9577
10	0.67	0.70	1.1976	1.0694	1.0606	0.9351

#### IV. DISCUSSION OF RESULTS

On the basis of our proposed method of analysis and its simplifying assumptions, we have made these valid observations: two instances of degeneracy on the cowpea legume and one instance of degeneracy on the groundnut legume (Table 1 and Table 2). In Table 1 and Table 2, the cowpea legume is about 20 percent more vulnerable to degeneracy whereas the groundnut legume is about 10 percent more vulnerable in the context of two competing legumes. Apart from the degeneracy scenarios, the inclusion of a low random noise intensity value of 0.01 has predicted a dominant instance of co-existing legumes which do not survive together.

#### V. CONCLUSION

A low environmental perturbation has dominantly predicted the feasibility for the co-existence of two interacting legumes which may not necessarily survive together provided the inter-competition coefficients outweigh the intra-competition coefficients and that the low environmental perturbation or a low random noise intensity value of 0.01 only affects the intrinsic growth rates. The effects of these assumptions on other model parameter values which we did not consider in this present study will be the subject of a future investigation.

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# Ergonomic Analysis and Application OWAS Method in a Mechanical Maintenance Shop of Thermoelectric Plant

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**Abstract** — The present work aims to develop an ergonomic analysis of the safety aspects of the mechanical maintenance workshop of the thermoelectric plant, located in the city of Campos dos Goytacazes. Note that it may serve as a support tool for company employees and other organizations that have maintenance workshops. It was envisioned a focus on safety issues for the development of work activities, seeking to identify irregularities in the ergonomic aspects in the execution of activities in the work environment and to propose alternatives to reduce and / or eliminate irregularities and, consequently, to improve the working conditions of employees of this sector. Thus, after a brief description of work safety, the importance and importance of ergonomics and the OWAS method (Ovako Working Posture Analysis System) are emphasized, the importance of furnas in the Brazilian electrical sector. safety engineering and ergonomics and its importance, as already commented, ending with an analysis of the safety in the sector of maintenance of furnas, applications of the method OWAS and the final considerations. The results of

the environmental analyzes and proposed, contributed to a reduction of the index of work accidents in the mechanical maintenance workshop.

**Keywords** — Safety. OWAS Method. Thermoelectric.

## I. INTRODUCTION

For many years, companies neglected safety, hygiene and comfort issues for workers. The central objective was profit, obtained through the increase of production promoted by the exploitation of the labor force. According to the Nucleus of Research in Engineering Sciences (SEGRAC), this negligence resulted in consequences that eventually "forced" the competent bodies of the Ministry of Labor to create standards linked to this issue. Among the consequences referred to above, we can mention the increase in the number of work accidents that would result in a reduction in productivity, including in the Brazilian electric sector, the frequency of occurrence of accidents with and without leave, due to the high hazard index of the labor activities (ABRAO & PINHO, 1999).



The activities performed and services rendered by the electric sector are essential for the entire population, which is a very important element for the development of a country. Currently, the national electric sector is composed of dozens of companies that through the action in the most different states and regions, manage to serve a large part of the national territory. As is well known, the activities developed in the electric sector are of great danger, due to the complexity and high risk inherent to the process. Therefore, this is one of the sectors that present the most work accidents, showing the need to seek prevention measures that minimize the occurrence of these events.

This article aims to analyze a thermoelectric plant sector located in the northern region of the State of Rio de Janeiro, where proposals for improvements in the ergonomic and safety aspects of the mechanical maintenance workshop will be presented. For the development of the work will be used a methodology not known in the northwest of Rio de Janeiro: the Ovako Working Posture Analyzing System (OWAS) method, in addition, a diagnostic of the organizational, safety and ergonomic aspects will be performed, in order to propose quantitative and qualitative improvements in the ergonomic, social and organizational areas and the development of biomechanical and job analysis proposals. Focus will be given to safety issues for the development of work activities, in order to show some abnormalities or points that can be improved, as a way to optimize the process and ensure the welfare of workers. The following are some comments on the importance of engineering work safety, ergonomics, OWAS method and the electrical sector and Furnas. Finally, an analysis of work safety engineering is presented, prioritizing the ergonomic applications in the maintenance sector, followed by the final considerations.

## II. WORK'S SECURITY ENGINEER

The analysis of the history of the emergence of work safety in companies is confronted with a context created by the man himself who has managed through history to ensure its existence on the planet. This history encompasses from the beginning of the labor relationship, where man begins his labor activities through predatory activity, evolves to agriculture and herding, until the period in which the transfer of the handicraft phase to the industrial age occurs. The latter was initiated by the industrial revolution in England, marking the beginning of modern industrialization, which originated with the appearance of the first spinning machine, denoting a process of evolution and the potentialization of the means of production (DE CICCIO, FANTAZZINI, 1993; BORG, 1998).

The capitalist world lived its moment of glory, when those who owned the capital came to dominate the means of production, the high costs of the machines no longer allowed the artisans to own them. Thus, the capitalists, gave rise to the first fabric factories, composed of own machines and people employed to manipulate them (TORREIRA, 1997).

However, the industrial revolution, as far as work safety was concerned, proved to be the main cause of major health problems in this period, since it showed a significant increase in production to the detriment of living and working conditions to which the worker was exposed (SEGRAC, 2010).

Thus, in order to fully cover the security needs of the various work activities carried out within companies, it adds that work safety is linked to several areas such as introduction to safety, hygiene and occupational medicine, prevention and control of risks in machinery, equipment and facilities, psychology in security engineering, communication and training, administration applied to safety engineering, work environment and diseases, work hygiene, research methodology, legislation, technical standards, civil and criminal liability, skills, environmental protection, lighting, fire and explosion protection, risk management and ergonomics (RODRIGUES, 2003).

## III. ERGONOMICS AND THEIR IMPORTANCE WORK CONTEXT

At the beginning of its formation, ergonomics was linked to the study of military activities and industrial production, however, it is possible to notice a greater mobilization focused on ergonomics in the industrial circles (COUTO, 1995).

Unlike other sciences that had their origins in the pre-twentieth-century, such as physics, chemistry, among others, ergonomics has an "official" date of birth: July 12, 1949. However, in 1857, that term had been used by the Polish Wojciech Jastrzebowski, who published the article "Essays on ergonomics or work sciences, based on the objective laws of science on nature." However, it was only with the founding of the Ergonomics Reach Society in the 1950s in England that ergonomics acquired the status of a more formalized discipline (IIDA, 2002; HIGNETT, 2000).

Ergonomics was born of a group of scientists and researchers who had an interest in developing an interdisciplinary science. However, there have been studies on these characteristics since Taylorism, where the workers had the aspect of suffering linked to work. In the era of artisanal, non-mechanized production, for example, there has always been a concern to adapt activities to human needs, always seeking the comfort of the worker. However, it was from the industrial

revolution that issues concerning the worker's suffering aspects became more dramatic. The factories that first emerged bore no resemblance to modern factories, being dirty, dark, noisy, and dangerous. In addition, working hours were up to 16 hours a day, without holidays, and in a semi-slavery regime (MOORE, 1995; GUERIN et al., 2001).

Ergonomics aims at improving the performance of the productive system and seeks to reduce its harmful consequences on the worker. Thus, it seeks to reduce fatigue, stress, errors and accidents, providing workers

with safety, satisfaction and health during their relationship with this productive system (IIDA, 2002, HIGNETT & MCATAMNEY, 2000).

Based on this premise the basic objectives of ergonomics are: safety, health and consumer satisfaction, associated with the efficiency of the whole process. For this to happen in fact, it becomes necessary that the whole productive system is intertwined and in tune. Figure 1 shows a schematic that shows how the interrelationships between systems should be, also showing the various factors that influence the productive system (IIDA, 2002):

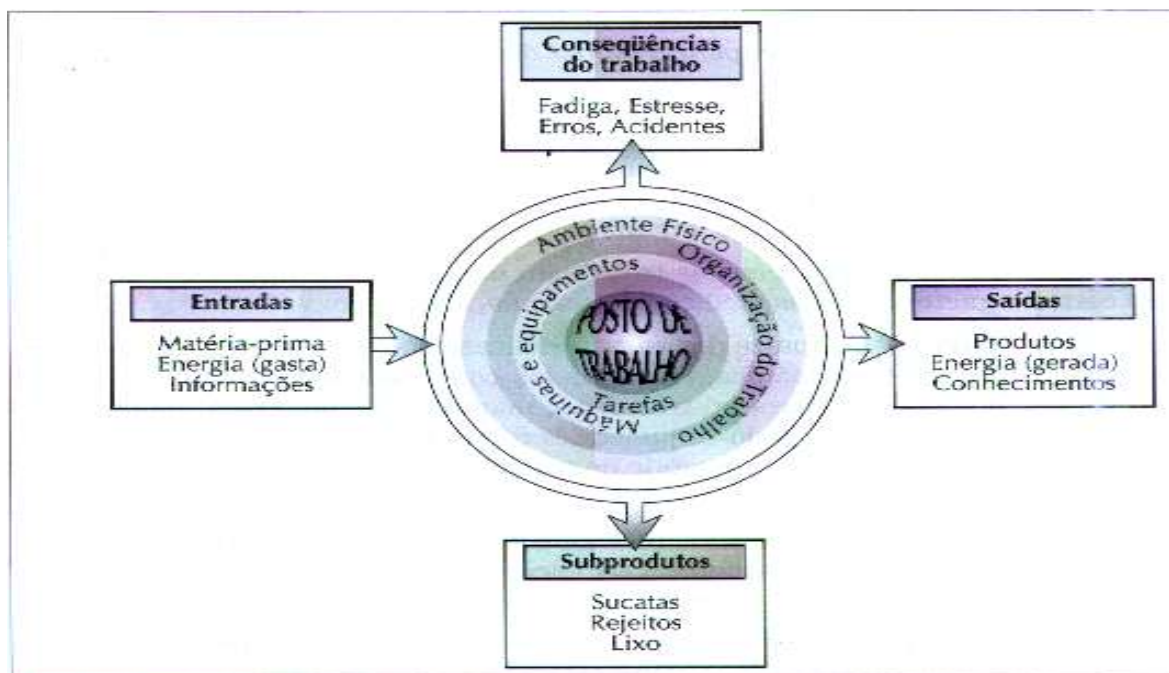


Fig. 1: Several factors that influence the productive system. Source: IIDA, 2002

#### IV. POSTURAL EVALUATION METHODOLOGY OVAKO WORKING POSTURE ANALYZING SYSTEM (OWAS)

The OWAS method was developed by OVAKO OY in conjunction with the Finnish Institute of Occupational Health in Finland, with the aim of analyzing work positions in the steel industry (KARHU et al., 1977a; KARHU et al., 1977b).

In the OWAS method the activity can be subdivided in several phases and later categorized for the analysis of the postures at work. In the analysis of activities, those requiring manual lifting of loads are identified and categorized according to the sacrifice imposed on the worker, although this is not the main focus of the method. Aspects such as vibration and energy expenditure are not considered. Subsequently the postures are analyzed and

mapped by observing the photographic records and filming of the individual in a work situation (JOODE; VERSPUY; BURDOF, 2010).

The system is based on analyzing certain activities in variable or constant intervals, observing the frequency and time spent in each posture. Registration can be done through video accompanied by direct observations. In cyclical activities the whole cycle must be observed and in non-cyclical activities a period (CHAFFIN, 2001).

Thus, to register the postures the procedure is to look at the work in general, checking the posture, strength and phase of the work, then look away and perform the recording. It can, therefore, make estimates of the proportion of the time during which the forces are exerted and assumed postures, according to Figure 2 (COLOMBINI, 2005).

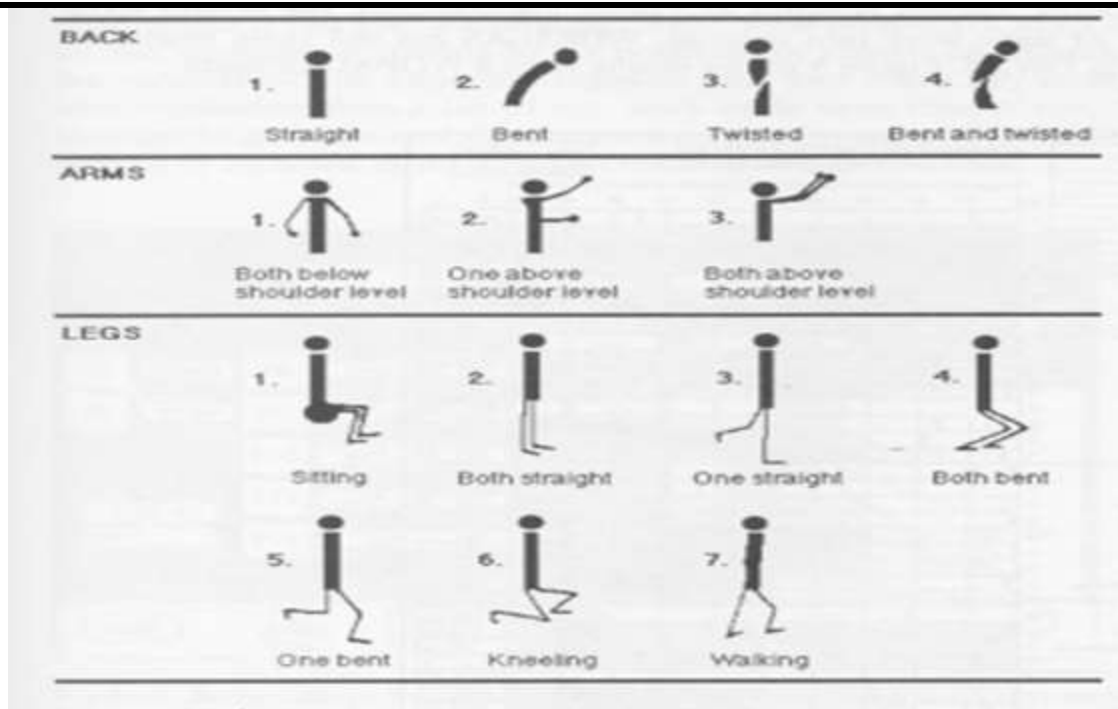


Fig. 2: Positions of the back, arms and legs. Source: IIDA, 2005

The combination of the positions of the back, arms, legs and use of force in the OWAS method receives a score that can be included in the Win-OWAS analysis system, which allows to categorize action levels for corrective measures aimed at the promotion of occupational health.

Despite the positions of the back, arms and legs, they should be analyzed and postulated in the Win-OWAS analysis system as shown in Figure 3 (GUIMARÃES & PORTICH, 2002).

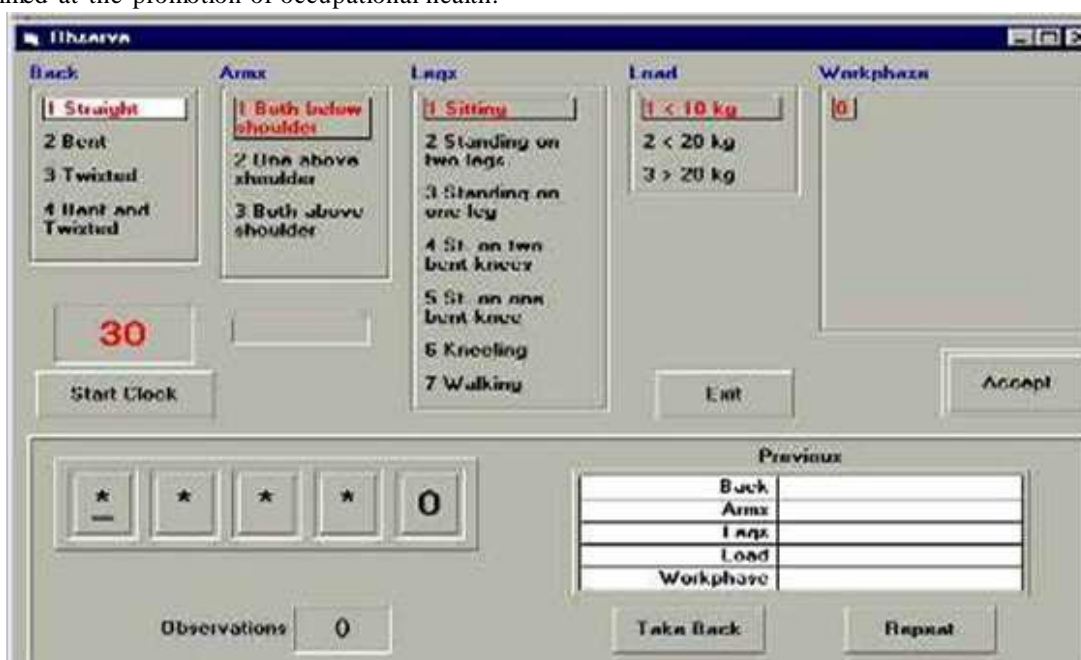


Fig. 3: Win-OWAS analysis system.

## V. ANALYSIS OF THE CASE STUDY

The company under study has a historical context of similar emergence to that occurred with the state-owned company Petrolífera do Brasil. Both emerged in the 1950s with the objective of healing the energy crisis that compromised the supply of the three main socio-

economic centers in Brazil (São Paulo, Rio de Janeiro and Belo Horizonte, OLIVEIRA, 2007).

At the end of the 50s, the company showed signs of the transformations that would occur from its construction: it started the works of dams and tunnels of diversion of the study plant, acquired equipment for the construction of

transmission lines and already had fronts of work in full activity (OLIVEIRA, 2007).

Today, the thermoelectric plants present the success of their trajectory and are present in the main Brazilian states. In addition, it comprises a complex of eleven hydroelectric and two thermoelectric plants, totaling a power of 9919 MW, and also with 19277.5 km of transmission lines and 46 substations, guaranteeing the supply of electric energy in a region where they are located 51% of the Brazilian households and accounting

for 65% of the Brazilian GDP (OLIVEIRA, 2007).

The present study was carried out in the mechanical maintenance workshop at the Thermoelectric Plant in the north of the State of Rio de Janeiro. In this environment are developed various risk activities, where are found several heavy industry equipment, such as: an inductive heater, two lathes, a planer, three radial drills, a donut, a band saw, two grinders, a welding machine and three walruses, as shown in Figure 4.



*Fig. 4: Furnas mechanical workshop equipment.*

The aforementioned equipments, assist the employees of the sector in the development of their work activities. Every day the workshop workers receive a schedule, which includes all the activities they must perform. Among the main activities performed within the workshop, we highlight: repair services in equipment, component welding, replacement of bearings, manufacture of parts for machines, among other activities.

#### **VI. THE IMPROVEMENTS AND IMPLEMENTATION OF THE OWAS METHOD FINAL CONSIDERATIONS**

Among the aspects related to the safety of the workers in their workplace, the following irregularities were found in the environment under analysis: excessive noise, poor lighting, excessive heat and inadequate postures.

- Noise - to measure the noise level of the mechanical maintenance workshop, a decibelimeter model ETB-142 was used. Measurement was performed at various points in the workshop, where noise level variations were identified, however, all values found were

above 85 decibels. Figure 5 shows one of the measurements.



*Fig. 5: Measuring the noise level of the lathe.*

The improvement proposed in this aspect for the reduction of the noise level of the environment, caused by the lathes was the replacement of the same ones by more





Fig. 7: Ventilation points of Furnas mechanical maintenance workshop

effective modern models. Regardless of the brand to be acquired, during the purchasing process, the responsible person must pay attention to the following characteristics of the lathe:

- Luminosity - for the verification of the luminosity of the environment, a model LD 200 (Digital Lux Meter) was used, as shown in Figure 6. The measurement was made in several points of the workshop, where it was verified places with light deficiency.



Fig. 6: Measuring the brightness near the grinder

ABNT, through Brazilian Standards of Regulation (BSR), establishes minimum illuminance values for activities that require artificial lighting. As for the noise of the machines, it becomes a bit more complicated, given the difficulty and often impossibility of reducing the noise of a machine.

The improvements implemented in relation to the low luminosity detected in some points of the workshop, so that new reflectors are installed in the environment, replacing the lamps with other ones of greater power, that would allow a greater illumination of the environment.

- Heat - Due to the unavailability of an appropriate instrument, it was not possible to measure the temperature

of the mechanical maintenance workshop. However, it can be observed that the environment under analysis is too hot, thus compromising the comfort of the employees who need to work in this sector. Two factors were detected as being the preponderant factors for the thermal discomfort situation of this site. They are: reduced points for air intake and low efficiency fans. Figure 7 illustrates the ventilation points of the workshop and the installed fans.

NR-17 establishes in one of its subitems the interval considered as acceptable for the temperature of a working environment (20 and 23 degrees Celsius), which would provide a greater sense of comfort for the workers (MINISTRY OF WORK 2002).

Thus, in order to increase the ventilation of the environment, promoting a more pleasant climatic condition for the employees of the sector and passers of the same, an alternative would be the installation of new extractors in the workshop.

Among the aspects related to the ergonomics of the workers in their work place, it was found irregularity in the environment under analysis with regard to the posture of the workers when carrying out their work activities. It was found that these assume inadequate postures resulting from improper design of construction of some machines and accessories present in the workshop. Figure 8 demonstrates some erroneous positions taken by workers.



Fig. 8: Incorrect worker posture.



By assuming inadequate postures for a long period of time, employees are at serious risk of suffering from severe localized pains in the muscles that are required to maintain these postures.

Through the application of the Ovako Working Posture

Analyzing System (OWAS) and the Nordic questionnaire, it was possible to identify the main postures assumed during the development of the activities, as shown in Figure 9 (a) and (b).

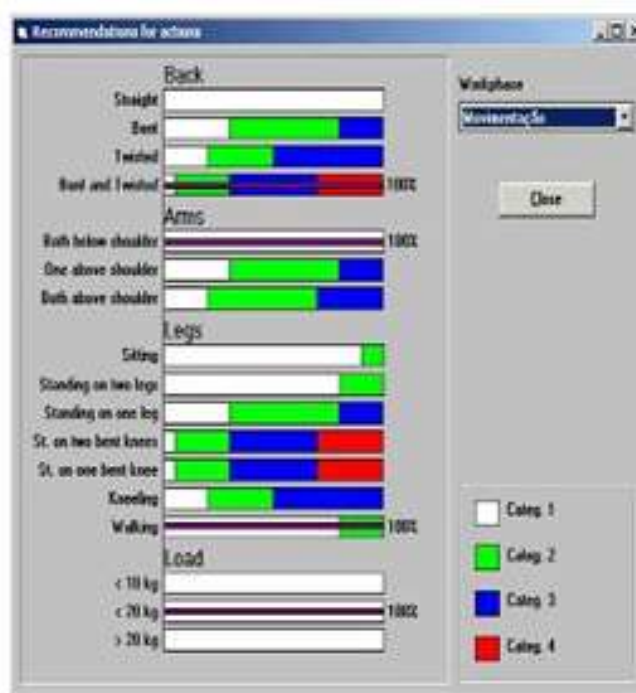


Fig. 9 (a) and (b): Analysis of the posture of the grinder worker.

Legend:

Valuation of positions by the OWAS method

- Class 1 - Normal posture dispenses care, except in exceptional cases.
- Class 2 - Posture that should be verified in the next revision of working methods.
- Class 3 - Posture that should merit attention in the short term.
- Class 4 - Posture that should receive immediate attention.

The graphs above show that during the movement of the equipment the backs of the platform auxiliaries are subject to an excessive effort that deserve attention in the very short term, since it falls into category 4. This situation may require interruption of the work immediately.

In this way, it is essential to verify the relation of cost and benefit of the new projects. From this analysis, it was possible to analyze the investments needed to implement the changes and the other the tangible and intangible benefits that it will provide.

Also, in the characterization of the organization of the work tasks were divided according to the area of specialization, in the case studied the organization was made by specialties that focused on the mechanics team and fit the theory of Taylorism. Communication takes place in a direct (verbal) and indirect way through service or electronic mail.

## VII FINAL CONSIDERATIONS

Thus, after applying several analyzes in the thermoelectric power plant, it is believed that the attention to the results by the company will allow a higher return than the investment, given that through the proposals presented, it is possible to know where the problems are and to act in order to minimize work accidents, thus avoiding the loss of time in operations, promoting greater employee satisfaction and commitment, all of this through a relatively low investment. However, two aspects related to cost / benefit analysis must be considered: investment risks and intangible factors. Investment risks are related to uncertainties that occur unexpectedly and produce unforeseen results. The intangible factors would be those that are not quantifiable in monetary terms.

Once the environmental analyzes have been carried out and the new implementations have been proposed, it is hoped that there will be a reduction in the rate of accidents at work in this workshop. In this way, it can be

concluded that by putting in practice the implements proposed in this work, several improvements in the mechanical maintenance workshop can be glimpsed, promoting greater satisfaction, comfort and, above all, safety of workers.

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# Analysis Fault and Effect Modes – FMEA: Failures Fire Protection System Turbine in Thermoelectric Plant

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**Abstract** — *In the electrical sector, the quality of their systems is extremely important, since the electrical sector works in an interconnected way, in which the occurrence of problems in a generating unit interferes in the transmission system and, consequently, in the final customer. This work aims to use FMEA (Failure Mode Analysis and Effects), as a tool to analyze the occurrence of faults and increase the reliability of a system in a thermoelectric plant. The system chosen in the thermoelectric power plant for the execution of the FMEA is the fire protection of the Turbo-Generator. The methodology used in the development of this work is the formation of a multidisciplinary team for brainstorming, mapping the causes and effects of failures; use of building tools and analytics of the FMEA, the results were efficient in the day to day being important in the cognitive aspect to the entrepreneurs and employees.*

**Keywords** — *Turbo Generator. FMEA. Thermoelectric.*

## I. INTRODUCTION

The studies were developed in a Thermoelectric Plant, applying a case study in one of its systems. Electric power generation is the final product, but the availability for generation without the occurrence of failures is the main focus of the operation and integration of the power plant throughout the electrical system.

A Análise dos Modos de Falhas e Efeitos (FMEA) surgiu em meados dos anos 60 pela NASA, posteriormente, teve uma ampla divulgação nas indústrias aeronáuticas por volta dos anos 70. Esta ferramenta passou a ser utilizada na indústria automobilística na década de 80, ampliando-se para seus fornecedores na indústria de autopeças. A norma americana QS 9000, por exemplo, desenvolvida pelas grandes montadoras nos Estados Unidos, Ford, Chrysler e GM, especifica o FMEA como técnica de análise e prevenção de falhas (ALVES; COSTA, 2004). According to Hellman and Andery (1995), FMEA efficiently assists in the search for the primary causes of the problems, aiming to eliminate the causes with the

elaboration of action plans. Using a set of criteria to prioritize managerial actions in problem solving.

For Palady (2007) the FMEA is a technique that offers three distinct functions: it is a tool for predicting problems; is a procedure for developing and executing new or revised projects, processes or services; is a diary of the project, process or service.

The use of this tool will reduce the chances of the product or process to fail during its operation, that is, it is seeking to increase reliability, which is the probability of failure of the product / process (ALMEIDA, 1998) .

Arthur and Silva (2005) contribute by defining reliability as "the ability of a product to perform its function without failure under specified conditions for a specified period of time or minimum number of cycles or events." Carvalho (2005) adds the previously mentioned concepts and conceptualizes reliability as a related characteristic by the probability that the product performs an expected function, between a time interval and under conditions of use for which it was created. It is usually represented based on average parameters of failure numbers or the time interval between failures.

This article aims to apply a quality tool that improves the level of reliability in the fire fighting system in a gas turbine, reducing the equivalent rate of forced unavailability in the Thermoelectric Power Plant in Macaé / RJ. The following are some comments on quality management, FMEA (Fault Effect Mode) and thermoelectric. Finally, the application performed in the study company is presented, followed by the final considerations.

## II. THE EVOLUTION OF QUALITY IMPROVEMENT

The quality can be observed from the beginning of the manufacturing activities, when the production was totally handmade where the masters-craftsmen used the observation as an instrument of quality control, aiming at avoiding failures in the manufacturing process (ADAM, FOSTER, 2000).

A World War II had a major influence on quality during the 1940s, as the volume of products was larger and the time available for inspection in the process was smaller, thus consolidating statistical control by sampling (GARVIN, 1992).

In the postwar period, since the mid-twentieth century, there has been a major evolution in business management, especially in Japan, motivated by the recovery of its economy. Four basic elements have been developed in the process of quality evolution: Quantification of Quality Costs, Total Quality Control, Reliability Engineering and Zero-Defect Program. Thus begins the Age of Quality Assurance. (GARVIN, 1992; IRVINE, 2000).

Still in the 50s, Armand Feigenbaum presented a more advanced concept, Total Quality Control. The quality was part of the whole productive chain, seen as a competitive strategy (Nilsson et al., 2005; Mizuno et al., 1993).

The application of quality programs gave rise to ISO certifications, which incorporate rigorous parameters of evaluation of organizational performance, evaluating the conformities determined by the organization, through internal processes such as procedures, standards and norms.

Thus ISO 9000 was used as a qualifying criterion in the case of supplier selection, thus eliminating the need for large contingents of auditors, using the certifications and audits of third parties accredited for this purpose. In this context several quality tools were developed among them the FMEA.

## III. ANALYSIS OF FAILURE MODES AND EFFECTS (FMEA)

The national electric sector, increasingly, has been seeking availability of generation of its electric power generating units; and thus, it is necessary to use efficient tools in the minimization of failures (BRAGLIA, MAFMA, 2000).

The FMEA is an engineering technique used to define, identify and eliminate known or potential failures of systems, projects, processes and / or services (STAMATIS, 2003, CARBONE & TIPPETT, 2004).

According to Palady (2007), FMEA, when used as a tool, is a low-risk, high-efficiency technique for problem prevention and identification of the most cost-effective solutions.

This tool is very successful when its application is carried out in a team, because the best evaluations are drawn from a set of ideas. The advantages and disadvantages of each approach can be estimated by relating the cost and benefit associated with each one.

The development of the FMEA performed by a team has its higher costs if compared to one developed individually; however, the chances of better identification and prevention of failure modes when developed by a team are higher, and the quality / reliability return exceeds the FMEA development and maintenance costs (COTNAREANU, 1999; FERNANDES, 2005).

FMEA is considered a proactive tool because it analyzes potential problems before they even occur without the need to create prototypes or wait for the problem to occur during their operation; due to this subjectivity, this method requires a presumptive work in relation to possibilities and their prevention, using the practical experiences accumulated by specialists in the projects, processes or services. In this context, according to Gilchrist (1994) and Magalhães (2008), since the

development of the FMEA in the mid-1960s, two modalities derived from this method emerged.

- Project FMEA
- Process FMEA

There are five basic elements that should compose the

structure of the FMEA, the lack of any of these elements may impair its effectiveness or its success, in terms of quality / reliability, the results can be minimal or zero. The basic elements of FMEA are shown in Figure 1 (GILCHRIST, 1994):

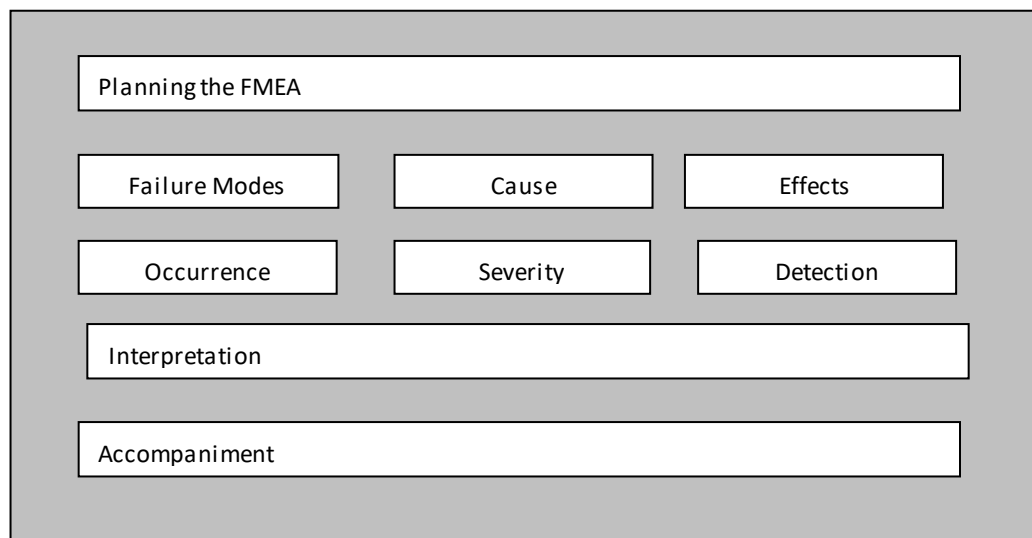


Fig. 1: Basic Elements of the FMEA. Source: Adapted from Palady, 2007

After defining the functions that produce the products / processes are classified and listed their causes and their effects (PUENTE et al., 2002). The next process is to create a scheme to identify the most important failure modes, quantifying and classifying each of the three categories, as shown in Figure 2.

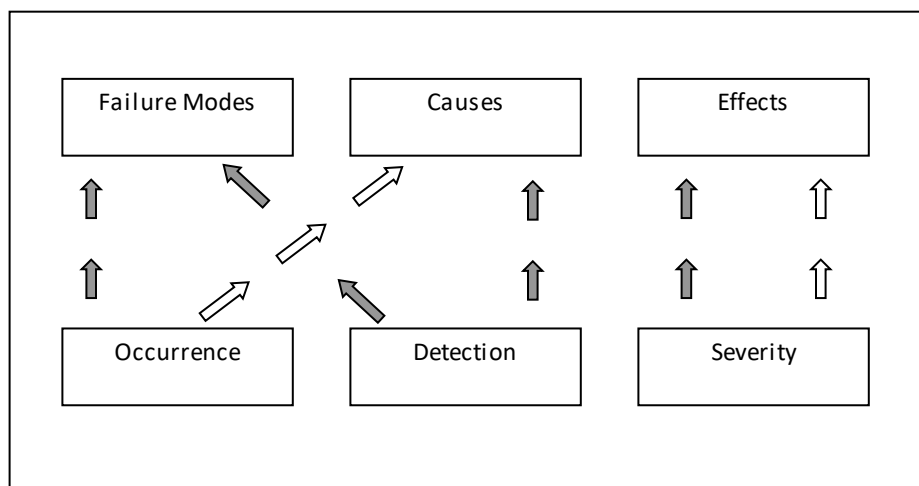


Fig.2: Approach Failure Modes. Source: Adapted from Palady, 2007

#### IV. THE CONTEXT OF THERMOELECTRIC PLANTS IN BRAZIL

The generation of electric energy in Brazil has in its history a differentiated way in the use of its energy sources in relation to the world average. Brazil uses its large water park to generate electricity, while the world average has used its dependence on fossil energy sources (MOREIRA, 2002, ONS, 2002).

The government, anticipating the growth of electricity demand, created the Priority Thermoelectricity Program in 2000, encouraging the implementation of thermoelectric plants in the country, thus increasing the importance of thermoelectric plants in the Brazilian energy matrix (MOREIRA, 2005; SEGISMUNDO, 2008).

In 2001, at the height of the Brazilian energy crisis, thermoelectric plants were built as an emergency because it was a short-term venture compared to the construction of a hydroelectric plant. Figure 3 shows the increase in power generation in Brazil in the years 2007 and 2008, given the growth of the Brazilian productive sectors and the compensation of the levels of the reservoirs.



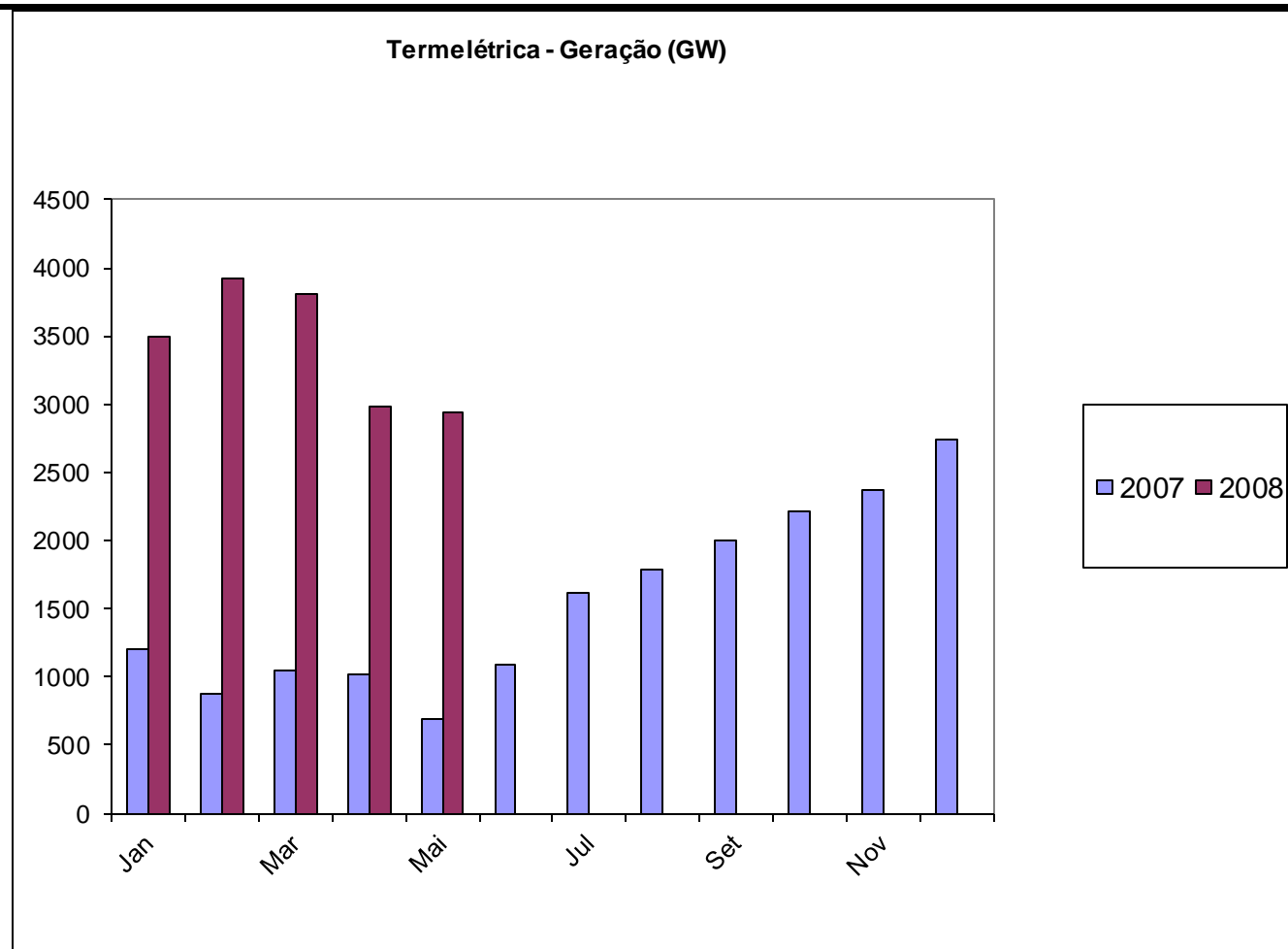


Fig. 3: Electric Generation (GW). Source: National Operator of the Electric System - ONS / 2008

In thermoelectric plants, thermal machines are used to generate electricity, transforming thermal energy into work, the fuel used comes from different sources such as natural gas, diesel oil, sugarcane bagasse, coal, etc. The machines can be grouped according to the type of combustion: internal combustion (engines and gas turbine) or external combustion (steam turbine) (MOREIRA, 2005).

Another type of turbine used in thermoelectric plants is the steam turbine, which has the function of transforming the expansion of the steam produced in the boilers and generate work, as shown in Figure 4. Below are some types of steam turbines (MOREIRA, 2005):

- Back Pressure - The steam after expanding into the turbine is destined for some other process or released into the atmosphere. It is the simplest turbine and is mainly

used in cogeneration circuits.

- Extraction-Backpressure - When processes downstream of the turbine operate at more than one pressure level, turbines with steam extraction are used. There are systems with controlled extractions (control valves) and others where the extraction flow is a function of the flow conditions in the turbine and process pressures.

- Extraction-Condensation - The steam after leaving the turbine yields heat in a condenser, changing phases and being pumped again to the boiler. The turbine may have steam extraction for process. In this system, the flexibility of operation is much greater and the capacitor absorbs the variation of load either in the demand for electric energy or in the demand of steam for process.

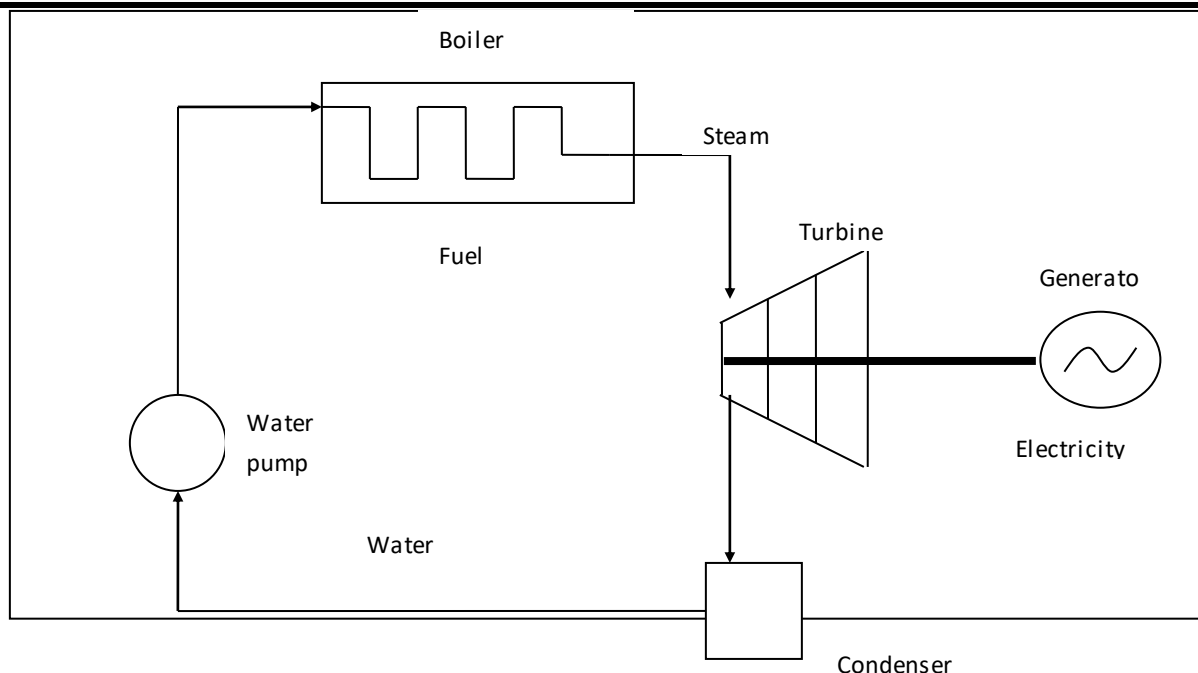


Fig. 4: Simplified scheme - Steam turbine. Source: MONTICELLI, A. & GARCIA, 2003

The turbo-generator's fire protection system is also composed of a combustible gas detection system. This system has three sensor / transmitter assemblies, the sensors being located inside the turbine compartment, while the transmitters are on the outside. There are two levels of gas detection alarm, one with 20% LEL (Lower Explosive Limit) and another 60% LEL, the lowest level (20%) is responsible for alerting the existence of gas and the performance of 60% presence of gas is responsible for

the automatic stop of the turbo-generator, with the activation of the exhaust fans to remove the gases.

The existing protection systems in the plant have been designed and calculated according to National Fire Protection Association (NFPA) standards and codes. Figure 5 illustrates the location and number of sensors that make up the turbine and generator fire protection system

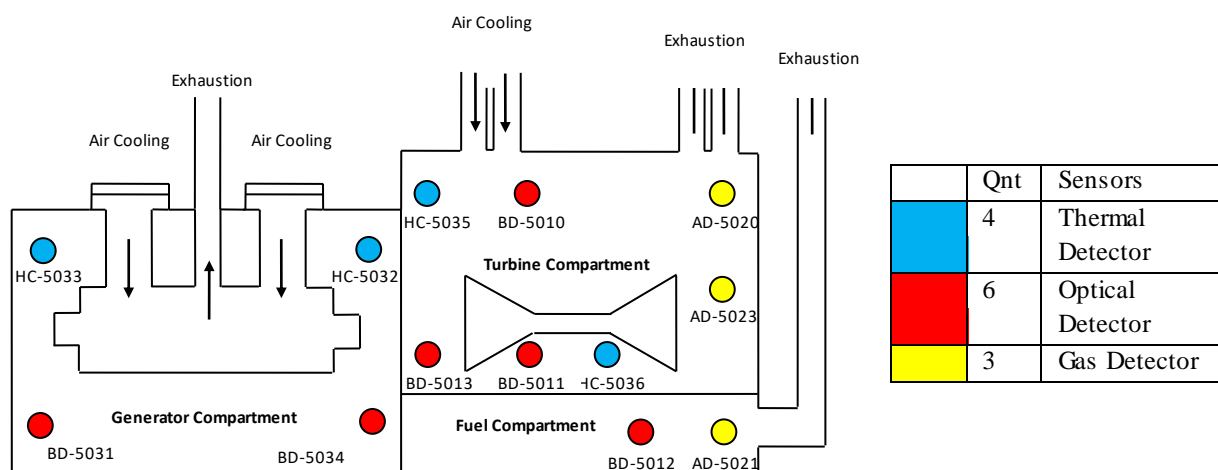


Fig. 5: Sensor distribution in the Turbo-Generator compartments. Source: MONTICELLI, A. & GARCIA, 2003.

## V. FMEA ANALYSIS AND APPLICATION IN THERMOELECTRIC

The FMEA construction team from the block diagram, as shown in Figure 6, can separate the protection system into three parts, so the understanding becomes standardized.

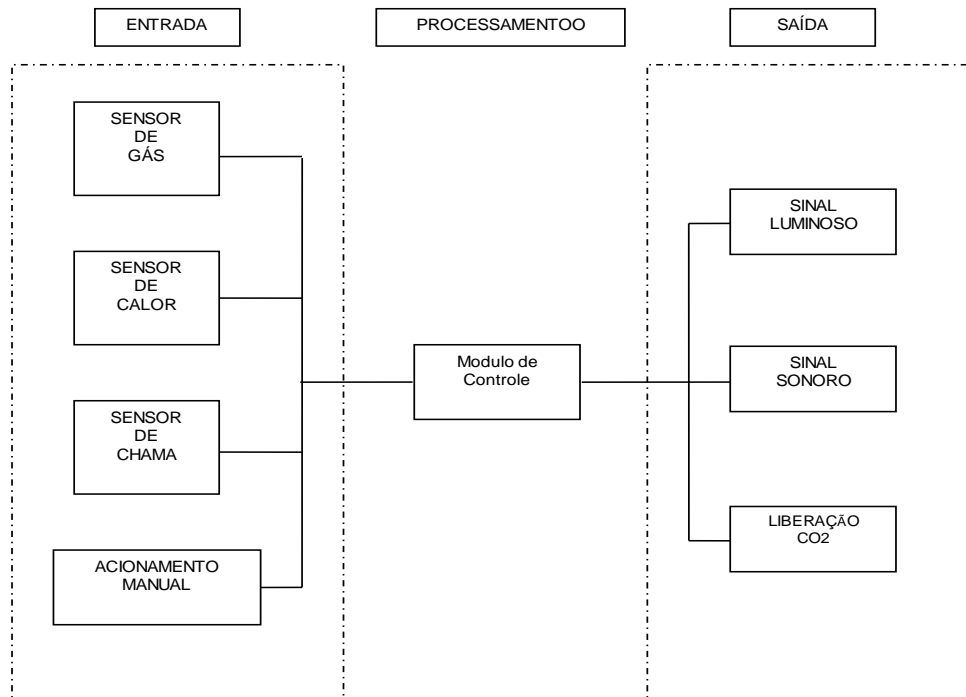


Fig. 6: Block diagram of the fire protection system. Source: MONTICELLI, A. & GARCIA, 2003.

The first brainstorm is performed according to input components, classifying their failure modes and their effects, evaluating severity and detection. The cause of the fault is identified using another tool: Ishikwa Diagram. As for the occurrence, the team uses historical data related to the amounts of failures that occurred in that system. As results of this work, they follow the FMEA frameworks of each component of the fire protection system.

The team chosen to develop this FMEA, is composed of four members, in order to obtain maximum use with the exchange of experience of these professionals. The team

was formed by (Stashevskiy, Elizur, 2000):

- 01 Electrical Engineer
- 01 Production Engineer
- 01 Operator
- 02 Maintenance Technicians

When surveying the documentation of the fire protection system, it was defined that the system would be divided into subsystems and its components would be treated in FMEA for their functionality. For a better understanding of the functionality of the subsystems and their components, a block diagram was constructed, as shown in Figure 7 (FMEA-Sensor) and 8 (FMEA-Strobe Light):

<b>Planilha:</b> Análise de Falhas - FMEA		<b>Processo:</b> Proteção contra incêndio do turbo-gerador – UG01 <b>Sistema:</b> Detecção de Gás. <b>Equipamento:</b> Sensor de Gás						<b>Planilha Nº:</b> 01 <b>Revisão:</b> 0		<b>Coordenador:</b> Gilson <b>Equipe:</b>		<b>Data:</b> 28/10/08 <b>Folha:</b> 1/1	
<b>Descrição do Item:</b> O sistema de detecção de gás é composto por três sensores, sendo dois sensores localizados no compartimento da turbina e um no compartimento de combustível. O sinal dos sensores é enviado aos transmissores, que são responsáveis por transmitir os sinais ao controlador. Ao se detectar a presença de gás ao nível maior que 60% de concentração, o controlador envia um sinal de desligamento da UG (unidade geradora).													
Ítem	Função	Modo de Falha	Efeito da Falha	Causa da Falha	SEV	OCO	DET	RPN	Ações Recomendadas	RESP	FREQ. DA TAREFA	PRAZO	
AD-5020 - Sensor de Gás	Medir a concentração de gás a nível de 0% a 100%	Saturação do elemento sensor	1-Falha no sistema 2-Erro na medição	1- Vapor de óleo 2- Poeira 3-Perda de sensibilidade natural	6 6 6	4 2 5	5 5 5	120 60 150	<ul style="list-style-type: none"><li>Limpeza do compartimento, sempre que houver vazamento de óleo.</li><li>Calibração do sensor.</li></ul>	Operação Manutenção	Ocasional 45 dias	Imediato 30 dias	
		Queima da unidade eletrônica	1-Falha no sistema 2- Indisponibiliza a UG.	1- Baixa isolamento. a) vapor de óleo	7	3	5	105	<ul style="list-style-type: none"><li>Limpeza do compartimento, sempre que houver vazamento de óleo.</li></ul>	Operação	Ocasional	Imediato	

Fig. 7: FMEA – Gas Sensor

<b>Planilha:</b> Análise de Falhas - FMEA		<b>Processo:</b> Proteção contra incêndio do turbo-gerador – UG01 <b>Sistema:</b> Sinalização luminosa. <b>Equipamento:</b> Strobe Light.						<b>Planilha</b> Nº: 06 <b>Revisão:</b> 0		<b>Coordenador:</b> Gilson <b>Equipe:</b>		<b>Data:</b> 28/10/08 <b>Folha:</b> 1/1	
<b>Descrição do Item:</b> Quando existe uma condição de alarme no sistema de proteção contra incêndio, é acionado um aviso luminoso, onde a strobe emite luz da cor vermelha, indicando uma emergência no local.													
Ítem	Função	Modo de Falha	Efeito da Falha	Causa da Falha	SEV	OCO	DET	RPN	Ações Recomendadas	RESP	FRE Q. DA TAR EFA	PRAZO	
XL-5128 – Strobe Light	Sinal luminoso quando se há presença de alarme no sistema de incêndio.	Queima da lâmpada	1- perda da sinalização luminosa durante uma condição de alarme. 2- Sinal de alarme no módulo de controle, indisponibilizando o sistema.	1- Baixa isolamento. a) alta umidade 2- Vida útil da lâmpada.	4 7	2 3	5 5	40 105	Desenvolver plano de manutenção preventiva.	Manutenção	180 dias	30 dias	

Fig. 8: FMEA – Strobe Light.

Legend figures 7 and 8:

SEV:	Severity
OCO:	Occurrence
DET:	Detection
RPN:	Risk Priority Index

The analysis of Figures 7 and 8 demonstrates the need for implementation of new safety systems and critical improvements in the plant system.

## VI FINAL CONSIDERATIONS

The electric sector is composed of several systems such as generation, transmission and distribution. The study focused on the generation system and presented a case study to a specific system, which was the fire protection system of a turbine. For electricity generation companies, the work is contributing to reduce their costs, mapping the failures of their systems making them more reliable, thus avoiding fines for high forced unavailability rate - TEIF, index used by the National Agency of Electric Energy - ANEEL, which measures the reliability of Generating Plants. For academic training, the work has immeasurable contributions, as it is a result of evolving knowledge, is the use of Production Engineering to the common welfare, contributing to the improvement of electric energy generation and not only the reduction of costs and maximization of profits. The recommendations documented in the FMEA are in the process of being implemented, so a comparative evaluation with historical data is impossible. The results do not depend only on a comparative assessment, since some benefits can be perceived immediately. The faults were mapped, and the treatments were presented; factors that positively influence the increase in reliability.

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# Scientific Literature on Production Planning and Control: A Bibliometric Analysis

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**Abstract**— Learning about the subjects of PPC (Production Planning and Control) for students of production and administration engineering in an emerging economy like Brazil is extremely important. This paper emphasizes the foundations of the phases that encompass the hierarchical stages of the PPC, from the strategic level to the operational level: Sales and Operations Management (S & OP), Aggregate Planning, Master Planning, MRP I (Material Requirement Planning) . Through a qualitative and quantitative approach, this paper makes use of bibliometrics intrinsic to its methodological aspects. The Web of Science database and the Nails software are used to obtain the research resources, which is used to foster and select the theoretical framework of the most pertinent themes of the specific literature of PPC, exposing the main scientific works of international relevance and the state of the art and innovations about the theme. At the end of the article the conclusion about the theme is engendered in the rational aspect of the scientific literature of PPC and its methods of teaching learning in the Brazilian universities. **Keywords**— Production Planning and Control; PPC; Teaching-learning.

## I. INTRODUCTION

Taking as context the university teaching-learning model, practical programmatic content, such as the PPC (Production Planning and Control), can have its improved approach by increasing the efficiency of teaching learning. One of the most unspoken ways of achieving good performance in classrooms is by defining a quality scientific literature.

The themes inherent in the content of PPC addressed in university halls and laboratories should follow not only the basic theory founded by traditional authors, but also the progress and trends that occur in the practical field.

Entering this practical field, we have most of the organizations inserted in a market scenario of high

competitiveness. This requires managers to continually update on new technologies to master large amounts of information and gain assertive decision-making amid increasing amounts of variables.

In this way, it becomes necessary to develop efficient strategies of acquisition and use of information to achieve organizational effectiveness and adapt to the speed with which the market environment progresses. Senior management's primary focus for anticipating future actions and making the right decisions should be to understand the greater number of aspects of the organization and the environment in which it operates.

That is, to plan the chain of aspects intrinsic to the capacity of production (supply) and also aspects related to demand. PPC, which is encompassed by ERP (Enterprise Resource Planning), responds to the decisions of top management by promoting improvements in their production processes.

The development of a theoretical framework about PPC and realization of PPC bibliometrics considering the impact factor of the articles in order to classify their relevance are the major objectives of this paper.

The paper's structure is divided into: Introduction; Background; Method; Webibliomining Analysis; Conclusion and finally, in the last section of the dissertation the Bibliographical References in alphabetical order are displayed.

## II. LITERATURE REVIEW

Following its line of research on Workload Control, Stevenson (2006) focuses on this article in significant conceptual refinements to improve the applicability of the approach methodology to the factory floor characteristics found in practice. The first step is centered on the development of a decision support system based on the concepts of WLC designed for make-to-order companies.

The proposed refinements include changes in the scheduling procedure (of jobs) and the way the jobs are thrown on the factory floor; The problems addressed include grouping machines and determining productive capacities. Using a case study of a real company, the article describes the strategy taken for the successful implementation of the concept of Workload Control, thereby optimizing aspects relevant to the operational sphere of Production Planning and Control of the organization.

Following a similar research line to Stevenson (2006), Hendry et al. (2008) also discusses the Workload Control, addressing its importance to the operational levels of PPC in manufacturing environments subject to demand uncertainty (such as in the make-to-order industry, for example). This paper explores two parallel longitudinal WLC empirical projects in which both have chosen to incorporate the same decision support methodology, providing an ideal platform for cross-comparison.

Another similarity with Stevenson (2006) is that the article focuses on theoretical refinements that need to be made for both cases. The article justifies the need for refinement of Workload Control processes, reporting the time elapsed since the development of the original methodology and the rapid changes in the scenario that occurred; and due to specific characteristics of the companies. Finally, the article also reflects a number of common and routine implementation difficulties for both case studies, providing information on how this could be avoided in the future.

According to Silva, Almeida and Roque (2006) the presentation of MAPP, "Mold: Assistant Production Planner", a decision support system for the mold industry. Therefore, we see that although relevant, the article deals with very specific organizations (mold industry) within the defined macro-field of Production Planning and Control. MAPP approaches the PPC methodology based on the concept of Workload Control, adapted to the context of the mold industry, under a case study of Rapid Prototyping. The objectives of the paper are to present a discussion of the functions of the system at the service of the planning methodology and explain the development decisions in the socio-technical context of the case study company.

On the other hand, the authors Land & Gaalman (2009) aim to provide a deep picture of how existing concepts of PPC fail in small and medium-sized companies through in-depth empirical evidence of research or observations. The case study covers seven companies. In order to distinguish between common problems and specific elements of the company, a comparative analysis was carried out in all cases.

The analysis shows that a significant proportion of PPC problems are tied to a limited set of decision points in the order flow. In addition, most performance losses can be perceived before an order is thrown on the shop floor. Such PPC problems identified as common to the companies studied (which occur prior to the release of orders) were: inadequate capacity planning surveys to support sales decisions; and uncontrolled delays in engineering. The observed problems that appear after the launch tend to be more diverse and specific to the company.

Zäpfel and Missbauer (1993) explain that a considerable number of computer-aided PPC systems were already offered, most based on known MRP logic. As such systems often led to unsatisfactory results, several new concepts for PPC systems were developed. It is noticed that, at the time of the article, there was poor condition of control of information compared to the present day. Therefore, the authors basically describe the concept of traditional PPC and review the concepts available for practical application.

Hendry Huang and Stevenson (2013) presented an implementation of the comprehensive Workload Control concept was presented through longitudinal research using a contingency-based approach to ensure alignment between the company (case study) and the characteristics of the WLC approach; and the expected improvements in performance.

Such improvements include: reduced leadtime; significant improvement in the delays of materials, machinery and labor; reduced costs; improvement of internal and external coordination; and higher quality products. The article also shows that the choice of improvement priorities is related to very particular aspects of the company and cites that trust was a more important competitive priority in this company than speed; and therefore WLC's ability to reduce deadlines has not been fully evaluated. Comprehensive WLC approaches are aligned with the context of wide range / low volume custom manufacturing companies.

As we could realize, the PPC's theme is very wide and represents a large variety of applications services in industries. Next section, it will be presented the methodological structure of this paper.

### III. METHODOLOGICAL ASPECTS

According to Ciribelli (2003) the definition of research focuses on the act of investigation from a problem situation; Its purpose is to broaden the understanding of a particular research topic, maximizing scientific knowledge, improving or developing new theories, and characterizing new principles.

In the view of Rampazzo (2005), research is an activity focused on the solution of problems through the processes of the scientific method; It is characterized as a reflexive, systematic, controlled and critical procedure that allows discovering new facts or data, solutions or laws, in any area of knowledge.

For the present dissertation we used the methodology of bibliographic research that, according to Gil (2002), is developed from an already elaborated material, consisting mainly of books and scientific articles.

In this paper, a qualitative research was carried out. The principle of representativeness presented by Bardin (2011) (quoted by Santos, 2012) was obeyed, where a representative sample of relevant content from a consulted bibliographic universe was extracted rigorously. The quantitative approach also characterizes this work in the webibliomining review where the Web of Science database, an important source of scientific studies of international relevance, was used.

For the background formulation, it has been prioritized the most relevant publications in the literature, elementary quotations that offered a concise basis of understanding for the themes also had greater freedom outside the chronological limit because they represent information of high relevance and therefore enriching the body of the present article.

### 3.1. Webibliomining development

The advent of the Internet and the electronic databases have indicated the variation of the term bibliometry for the terms: webmetrics or webometrics; and, informetria or informetrics, both with own metrics associated to the research through Internet, such as: number of citations in the internet; number of accesses to articles; and, number of downloads, among others (COSTA, 2016).

In the spectrum of bibliometric analysis as a tool, Wormell (1998) classifies the five main types of methodology used as: citation analysis; co-citation analysis; bibliographic grouping; co-word analysis; and "webmetry". In this work the focus is on the methodology of citation analysis and, for this reason, it will specifically focus on this type of study, in its origins, potentialities, applications and limitations.

Regarding the approach of this dissertation project, this can be defined as qualitative and quantitative. This fact implies in qualifying and quantifying the data obtained through information collected through observations, organizational documents and data analysis.

An example of this is the natural subjective behavior of the researcher in relation to the relevant content generated by the bibliometry of the subjects

carried out through the Web of Science database and classified by the Nails software. That is, relevance data are generated quantitatively by this software, which analyzes the number of citations and the impact factor of the articles to rank them in order of importance for the research.

However, the subjectivity of the researcher engenders the qualitative character of the research approach when the articles that have greater affinity with the project theme are analyzed, among those considered relevant in the first quantitative analysis.

## IV. WEBIBLIOMINING ANALYSIS

From the use of the bibliometric research feature of relevant scientific articles in the renowned Web of Science database, it is possible to determine the state of the art in the literature on Production Planning and Control as well as its authors and most important study fronts .

One of the most notable aspects of PPC processes is the decision-making model, which according to Erol & Nakiboglu (2017) is relevant in the process that seeks to solve the problem through the generation and evaluation of alternatives and finally, the choice of the best taking into consideration an organization that is oriented towards profitable and efficient results.

The importance of decision-making can also expand to its implementation and control the decision-making process to determine when additional decisions are required. In this case, decision making becomes practically synonymous with management.

In a reference model, with the objective of promoting the learning of the concepts of Production Planning and Control, the decision making enters as one of the main philosophies, since it is an inherent attribute at all levels of PPC and its relevance is easily understood in the concept holistic approach of the planning in question.

Another attribute of such a reference model would be mathematical models adjacent to the (complex) levels of planning, such as mathematical and computational models of inventory.

Nahmias (1997) explains that inventory theory naturally comprises inventory models because of their high complexity of variables. Such models have as their main objective to minimize the total cost of this and to balance the economy of large orders or large production launches against the cost of maintaining the stock and the cost of scarcity.

Still speaking about inventory, but to a greater extent, we have the Supply Chain Management that is an essential part of the PPC methods. Based on data from an international survey of 322 companies in the metal-

mechanic sector, Frohlich and Westbrook (2001) show a positive correlation between the degree of integration of the PPC processes and the performance of the supply chain. This fact corroborates for the establishment of the Supply Chain as one of the foundations of the PPC.

In the specific case of scientific literature about Production Planning and Control, we have the first result for the analysis, the production of articles of this theme over the years, as can be seen in figure 01.

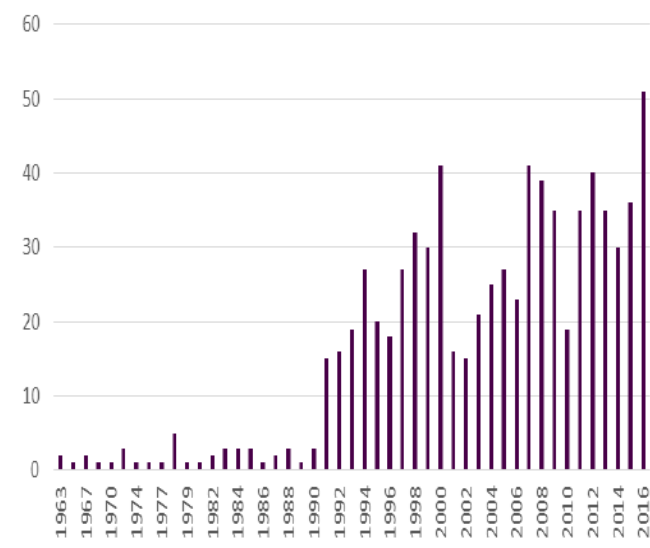


Fig. 1 : PPC articles published per year

There are conditions to notice a huge increase in the production of articles on the themes of PPC from the 1990s. This can be explained, in a cause and effect model, by the intensification of market competition between organizations. With the advent of new technologies it has become plausible and tangible to control more and more variables that affect a company's value chain.

In this context, Girotti and Mesquita (2016) explain that value generation in an organization is dependent on its competitive priorities such as: cost, quality, flexibility, and delivery service; which are like the final variables of business strategy.

Based on this understanding, it is possible to formulate the hypothesis that in the 1990s, there was greater availability of equipment to improve Production Planning and Control, and also, there was a greater need on the part of the organizations to develop in this subject on account of the evolution of competition in the market.

Thus, managers began to explore more and more the data and variables of their organizations..

Another characteristic about the themes of PPC and its correlates that is also observed in the production of scientific articles per year is the lack of regularity in the quantity of articles during the years, after the 1990s.

One of the possible explanatory bases for this result in the graph is to highlight the dynamism of the PPC processes in the industry. The market is rapidly advancing as companies incessantly pursue new methods and procedures in the constant attempt to outdo competitors; or stay at the top, dominating the largest share of sales in the market.

Such market competition can provide a kind of acceptance by managers to try to approach PPC-related philosophies, such as APS, which provides differentiated guidelines for PPC, but which aim to achieve the same ultimate goal of managing production with maximum possible efficiency in its factors.

These factors are described by Mesquita (2008) as reducing production lead times, reducing inventory costs (raw materials, consumables and final products), reducing production costs (idleness, overtime, subcontracting), compliance and agility to respond to changes in demand. It is beyond the scope of this dissertation project to delve into issues related to the PPC, so we will use the fact that these themes exist only as a plausible justification for explaining the variation in the quantity of scientific articles produced since 1990.

Regarding the most relevant authors for the PPC themes, the list of the most cited authors generated by the Nails software was obtained from the bibliometric research data in the Web of Science database. The result is given in figure 02.

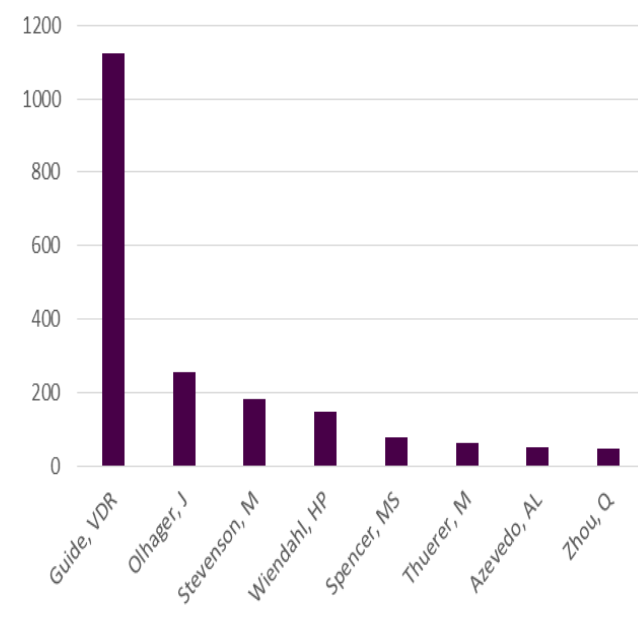


Fig. 2 : Most cited authors on PPC themes

The most cited author, and consequently the most relevant to the fronts of study of PPC themes, VDR Guide addresses the issue of the concept of remanufacturing (remanufacturing), where processes of



the philosophy of PPC have to be remodeled to fit a line with some particularities.

Expanding the explanation of remanufacturing and exploring its theoretical concept, we have that this is consistent in production models where the organization has as input the product used and occurs the transformation of it with activities of disassembly, maintenance, repair of damaged parts and cleaning. The output, in a simplistic approach would be the same input product, however, refurbished, restored, remanufactured.

According to Gray and Charter (2006), a product can only be considered remanufactured when it is conditioned to the same specification of the original manufacturer from the perspective of the consumer.

Thus, a remanufactured product or component can be defined as one that can be brought to the condition of new after being used (or discarded) by the consumer. An example of a remanufacturing process model is given in figure 10.

In the view of Guide (2000), the most cited author, remanufacturing represents a greater form of value-added recovery than material recovery, that is, recycling.

Remanufacturing systems are common and profitable in the United States. However, the author discusses that the management of PPC activities in the remanufacturing processes may differ greatly from management activities in traditional manufacturing and, through his scientific research, proposes a PPC model adapted to this.

Another author considered relevant in the bibliometric research carried out is J. Olhaguer, professor of Supply Chain Management at Lund University. His research is naturally based on topics related to efficiency in supply chain management.

In his main work, Olhaguer (2003) discusses the Order Penetration Point (OPP). According to the author, the OPP defines the moment in the value chain where a given product becomes linked to a specific customer order.

Different manufacturing environments (make-to-stock, assembly-to-order, make-to-order, engineer-to-order) relate to different OPP positions. In these different ways, PPC displays varied strategies in delivering products, having different implications for manufacturing objectives such as customer service, manufacturing efficiency and inventory investment.

Finally, as the third most cited author, we have Stevenson (2006) that explains different approaches to PPC based on methodologies such as Kanban, MRP II, Theory of Constraints, among others.

This author considers factors such as the importance of the step of analyzing customer demand, company size,

degree of customization and factory floor configuration and shows that they play an important role in the applicability of PPC concepts.

In this way, the aspect of raising awareness of researchers and professionals for the flexible options offered by the PPC philosophy to aid in decision-making in the selection of the management model is addressed. The same author stresses the importance of a clear implementation strategy for such a model.

There is, therefore, a dynamism inherent in PPC practices. For the creation of a reference model that serves as a teaching and learning tool on the subject, one should address its basic conceptual principles and foundations.

However, the various processes and their variables (depending on the type of industry, market, production) that impact the final PPC model for a particular organization should also be mentioned in terms of dynamism, flexibility and mutability.

As for the most relevant articles (classified according to the impact factor of the Nails software), we have, besides the authors already cited above, works such as that of Kingsman (2000), who lectures on Work Load Control or WLC), a PPC concept available for practical operations.

According to the author his principle is to control queues in front of the workstations on the factory floor by means of rules and pre-established rules. With better control of waiting times in the overall manufacturing, queues are kept short, increasing the operational efficiency of the organization.

In addition to the objective of controlling the workload and queue length in front of workstations on the shop floor, it is desired at the same time to process the products in order to meet the promised delivery dates with machine and machine capabilities and capabilities. available.

Macro specific aspects inherent to the theme are also frequently cited as: Workload Control and Supply Chain Management. These aspects guide the concept of PPC to be used. Be it a more operational approach such as the WLC, or a more strategic one such as Supply Chain Management.

Basic actions of PPC processes also appear as the most cited words: Optimization and Simulation. And finally, we have Remanufacturing and Make-to-Order as specific production styles often cited in scientific articles on bibliometrics.

Having knowledge about the themes of PPC through the resources obtained from the bibliometric research carried out, one has the necessary knowledge base to foment the structuring of the content that will be

present in the reference model for the learning in said subject.

## V. CONCLUSION

In this paper, it was reflected on the reference of the relevant scientific literature on PPC available for Brazilian students.

In the context of universities, especially those located in countries such as Brazil, where production activities are more operational and focused on Production Planning and Control (PPC). The PPC is responsible for the good planning of activities and resources that will directly influence the availability of the final product to the clients, as well as the economic aspects for the company.

This process is responsible for surveying demand, production planning, capacity planning, materials management, production scheduling, etc. Improvements achieved in terms of PPC can turn in competitive advantage for manufacturing companies in particular.

Most companies, especially small and medium-sized ones, are aware that they must improve their management of PPC activities in order to obtain reductions in time and work in process, thereby achieving greater operational and economic efficiency. However, for the authors, organizations simply do not know how to do this, since the vast majority of research and solutions for PPC are focused on large and complex companies.

In order to become competitive in the industrialized world Brazilian should first become in how efficient the scientific literature use has to be.

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# Breaker Depth Analysis Using Critical Wave Steepness

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**Abstract**— This research developed a breaker depth equation based on the characteristic of the potential velocity solution of Laplace equation. The breaker length equation was obtained using critical wave steepness as boundary condition. Whereas breaker height was obtained from breaker height index equation. The equation is in the form of linear explicit equation with simple calculation.

**Keywords**— breaker depth, critical wave steepness.

## I. INTRODUCTION

In general, breaker index equation has three shapes, i.e. breaker height index  $\frac{H_b}{H_0}$ , where  $H_b$  is breaker height and  $H_0$  is deep water wave height. The second form is breaker depth index in the form of  $\frac{H_b}{h_b}$  where  $h_b$  is breaker depth and the third is breaker steepness index in the form of  $\frac{H_b}{L_b}$  where  $L_b$  is breaker length.

The breaker depth equation developed in this research was obtained by performing one of the conservation characteristics of potential solution wave of Laplace equation, i.e. multiplication between wave number and water depth is constant which means that the multiplication of wave number at breaker depth is similar with the multiplication between wave number and deep water depth. Therefore, there is a relation between breaker depth and the condition of wave at the deep water. There is a breaker length variable at the equation. To eliminate breaker length, the critical wave steepness criteria was performed. Using this method, an equation is obtained based on analysis and the law of conservation.

## II. COMPUTATION OF BREAKER HEIGHT $H_b$

To perform a computation using breaker index in the form of  $\frac{H_b}{L_b}$  and  $\frac{H_b}{h_b}$ , breaker height  $H_b$  should be known. The breaker height is obtained using breaker height index

equation  $\frac{H_b}{H_0}$ . There are a lot of breaker height index equations. This research uses a breaker height  $H_b$  that is the average of several breaker height indexes that produces adjoining breaker height. The breaker height indexes that were used are as follows:

Komar and Gaughan (1972)

$$\frac{H_b}{H_0} = 0.56 \left( \frac{H_0}{L_0} \right)^{-\frac{1}{5}} \quad \dots\dots\dots(1)$$

Singamsetti and Wind (1980)

$$\frac{H_b}{H_0} = 0.575 m^{0.031} \left( \frac{H_0}{L_0} \right)^{-0.254} \quad \dots\dots\dots(2)$$

Larson and Kraus (1989),

$$\frac{H_b}{H_0} = 0.53 \left( \frac{H_0}{L_0} \right)^{-0.24} \quad \dots\dots\dots(3)$$

Smith and Kraus (1990),

$$\frac{H_b}{H_0} = (0.34 + 2.74m) \left( \frac{H_0}{L_0} \right)^{-0.30+0.88m} \quad \dots\dots\dots(4)$$

Gourlay (1992),

$$\frac{H_b}{H_0} = 0.478 \left( \frac{H_0}{L_0} \right)^{-0.28} \quad \dots\dots\dots(5)$$

Rattana Pitikon and Shibayama (2000) :

$$\frac{H_b}{H_0} = (10.02m^3 - 7.46m^2 + 1.32m + 0.55) \left( \frac{H_0}{L_0} \right)^{-\frac{1}{5}} \quad \dots\dots\dots(6)$$

At those equations  $H_b$  is breaker height,  $H_0$  is deep water wave height,  $L_0$  is deep water wavelength and  $m$  is bottom slope. Table (1) presents the result of breaker height computation using those 6 (six) equations above and their average values. The wave used is the wave with wave period  $T = 8 \text{ sec}$ , bottom slope  $m = 0.005$  and water depth  $h_0 = 60 \text{ m}$ , whereas deep water wave height  $H_0$  varies between  $0.60 - 1.8 \text{ m}$ .

Table.1: Breaker height from various breaker height index equations

$H_0$ (m)	Breaker Height $H_b$ (m)						Aver.
	(1)	(2)	(3)	(4)	(5)	(6)	

0,6	0,93	1,07	0,91	1,09	0,96	0,93	0,98
0,9	1,29	1,45	1,23	1,48	1,28	1,28	1,34
1,2	1,63	1,8	1,53	1,84	1,57	1,62	1,66
1,5	1,94	2,13	1,81	2,18	1,84	1,93	1,97
1,8	2,25	2,44	2,07	2,5	2,09	2,24	2,26

Note : (i), number of breaker height index equation

Table (1) shows that even though each equation provides different breaker height, all of them are close enough to the average value.

### III. THE COMPUTATION OF BREAKER DEPTH $h_b$ AND BREAKER LENGTH $L_b$ USING THE EXISTING EQUATIONS.

Relation between breaker depth  $h_b$  and breaker length  $L_b$  is in the shape of implicit equation where there is a dependency between those two variables. There is an explicit equation to compute breaker depth, i.e. SPM equation (1984) and Van Rijn equation (2011). However, at Van Rijn there is a parameter that has to be tested, therefore this research used SPM equation (1984). The wavelength computation cannot be done using dispersion equation of linear wave theory, considering at breaker depth the value  $\frac{H_b}{h_b}$  is quite large, i.e. close to 1, whereas dispersion equation of linear wave theory is formulated at very small  $\left(\frac{H}{h}\right)$  condition. As a consequence, the computation is by doing other breaker index equation.

A. The computation of breaker depth  $h_b$  and breaker length  $L_b$  with SPM equation (1984) and Miche equation (1944)

Breaker depth index from SPM (1984) is in the form of explicit equation for breaker depth as an input.

$$\frac{h_b}{H_b} = \frac{1}{b - \left(\frac{aH_b}{gT^2}\right)} \quad \text{or} \quad h_b = \frac{H_b}{b - \left(\frac{aH_b}{gT^2}\right)} \quad \dots\dots\dots(7)$$

$$a = 43.75(1 - e^{-19.0m})$$

$$b = \frac{1.56}{1 + e^{-19.5m}}$$

$H_b$  = breaker height,  $h_b$  = breaker depth,  $g$  = gravity acceleration and  $m$  = bottom slope. Using (7)  $h_b$  can be calculated using  $H_b$  as an input, then  $L_b$  is calculated with Miche equation (1944). Whereas breaker index from Miche equation belongs to breaker steepness index with the following form.

$$\frac{H_b}{L_b} = 0.142 \tanh\left(\frac{2\pi h_b}{L_b}\right) \quad \dots\dots\dots(8)$$

With the input wave period  $h_b$  and  $H_b$  then breaker length  $L_b$  can be calculated using Newton-Raphson iteration method.

B. The computation of breaker depth  $h_b$  and breaker length  $L_b$  with Rattana Pitikon *et al* equation (2003) and Miche equation (1944).

Breaker steepness equation from Rattana Pitikon *et al* (2003) is

$$\frac{H_b}{L_b} = (-1.40m^2 + 0.57m + 0.23) \left(\frac{H_0}{L_0}\right)^{0.35} \quad \dots\dots\dots(9)$$

Using input  $H_b$  then  $L_b$  can be calculated explicitly with (9),

$$L_b = \frac{H_b}{(-1.40m^2 + 0.57m + 0.23) \left(\frac{H_0}{L_0}\right)^{0.35}}$$

Then  $h_b$  can be calculated using (8), with i Newton-Raphson iteration method.

### IV. THE PROPOSED EQUATION

The potential velocity of linear wave theory (Dean, 1991) is,  $\Phi = G \cos kx \cosh k(h+z) \sin \sigma t$ . This equation was obtained by completing Laplace equation with variable separation method, where potential velocity is considered as consists of  $X(x)$  which is only a function of  $x$ ,  $Z(z)$  is only a function of  $z$  and  $T(t)$  is only a function of time,  $x$  is horizontal axis and  $z$  is vertical axis. In (1),  $Z(z) = \cosh k(h+z)$ . Applying the velocity potential on small sloping bottom, and derive  $\frac{\partial Z(z)}{\partial x} - \frac{\partial \cosh k(h+z)}{\partial x} = \sinh k(h+z) \frac{\partial k(h+z)}{\partial x} = 0$ , in this equation  $\frac{\partial k(h+z)}{\partial x} = 0$  in every  $z$ . With  $k = \frac{2\pi}{L}$  and for  $z = \frac{H}{2}$ , the equation can be written as  $\frac{\partial}{\partial x} \left( \frac{h + \frac{H}{2}}{L} \right) = 0$ , which means that  $\frac{(h + \frac{H}{2})}{L} = c$ ,

where  $c$  is a constant. From this equation, then if the wave moves from water depth  $h_1$  to shallower water depth  $h_2$  where shoaling took place, then there is a relation,  $\frac{h_2 + \frac{H_2}{2}}{L_2} =$

$$\frac{h_1 + \frac{H_1}{2}}{L_1} \quad \text{or,} \quad h_2 = \frac{L_2}{L_1} \left( h_1 + \frac{H_1}{2} \right) - \frac{H_2}{2}. \quad \text{For waves moving}$$

from deep water with  $(h_0, L_0, H_0)$  to breaker depth with  $(h_b, L_b, H_b)$ , there is a relation

$$h_b = \frac{L_b}{L_0} \left( h_0 + \frac{H_0}{2} \right) - \frac{H_b}{2} \quad \dots\dots\dots(10)$$

In (10) there are 3 (three) unknowns, i.e.  $h_b, L_b$  and  $H_b$ . Breaker height can be calculated with breaker height index as was done in section 2. Breaker length  $L_b$  can be obtained from the criteria of critical steepness curve. Critical steepness from Michel is  $\frac{H}{L} = 0.142$ , which states



that if  $\frac{H}{L} \geq 0.142$  the wave will be breaking, and this criteria also applies to breaker point, i.e. breaking occurs when  $\frac{H_b}{L_b} = 0.142$ . However, in this research,  $\frac{H_b}{L_b} = \frac{1}{\pi}$  was used, this criteria was obtained by studying breaking condition with non-linear wave theory, which due to spatial limitation could not be shown in this research, and would be shown in the next research. Therefore, the breaker length becomes,

$$L_b = \pi H_b \quad \text{.....(11)}$$

Substitute to (10),

$$h_b = \frac{\pi H_b}{L_0} \left( h_0 + \frac{H_0}{2} \right) - \frac{H_b}{2} \quad \text{.....(12)}$$

At the deep water depth,  $k_0 \left( h_0 + \frac{H_0}{2} \right) = \alpha$ , where  $\tanh(\alpha) = 1$ , SPM (1984) uses  $\alpha = \pi$  where  $\frac{H_0}{L_0} = 0.5$ , in this research  $\alpha = 1.1\pi$  is used. Substitute  $L_0 = \frac{2\pi}{k_0}$  to (12)

and  $\alpha = 1.1\pi$ , produces

$$h_b = (0.55\pi - 0.5)H_b \quad \text{.....(13)}$$

With input  $H_b$  from breaker height index then breaker depth  $h_b$  can be calculated with (13)

## V. COMPARISON OF THE RESULTS OF THE THREE METHODS

The next section will show the result of breaker depth  $h_b$  and breaker length  $L_b$  computation using the three methods mentioned above. The bathymetry data is similar to the computation of  $H_b$  in section 2. The result of the computation is as follows.

Table.2:  $h_b$  and  $L_b$  the result of the three methods.

$H_0$ (m)	$H_b$ (m)	$h_b$ (m)			$L_b$ (m)		
		(3)	(1)	(2)	(3)	(1)	(2)
Wave Period ( $T$ ) : 7 sec.							
0,6	0,92	1,13	1,14	1,07	2,92	12,85	21,59
0,9	1,25	1,54	1,55	1,47	3,98	17,22	25,5
1,2	1,56	1,92	1,94	1,84	4,95	21,15	28,69
1,5	1,85	2,27	2,3	2,2	5,87	24,75	31,45
1,8	2,12	2,61	2,65	2,56	6,74	28,11	33,89
Wave Period ( $T$ ) : 8 sec.							
0,6	0,98	1,21	1,21	1,13	3,12	13,81	25,27
0,9	1,34	1,64	1,65	1,55	4,24	18,55	29,83
1,2	1,66	2,04	2,06	1,95	5,28	22,83	33,57
1,5	1,97	2,42	2,45	2,32	6,25	26,77	36,79
1,8	2,26	2,78	2,82	2,69	7,18	30,45	39,65
Wave Period ( $T$ ) : 9 sec.							
0,6	1,04	1,28	1,28	1,19	3,3	14,68	28,97
0,9	1,41	1,73	1,74	1,63	4,48	19,77	34,2

1,2	1,76	2,16	2,17	2,04	5,58	24,36	38,48
1,5	2,08	2,56	2,58	2,44	6,61	28,61	42,17
1,8	2,39	2,94	2,97	2,82	7,59	32,59	45,45

Note :

- (1) Couple computation between (7) and (8)
- (2) Couple computation between (8) and (9)
- (3) Computation with (11) and (13)

The result of  $h_b$  and  $L_b$  computation using the three methods shows that  $h_b$  produced by (3), i.e. with the proposed method is quite close with methods (1) and (2). Among the three methods, the smallest breaker wave length is produced by (3) with quite realistic wave length.

The computation result of  $\frac{H_b}{h_b}$  and  $\frac{H_b}{L_b}$  with the three methods is presented on table (3). It shows that the value of  $\frac{H_b}{h_b}$  from method (3) looks constant against the changes of deep water wave height and wave period. At method (1) the value of  $\frac{H_b}{h_b}$  is a somewhat affected by the changes in deep water wave height but is constant against wave period. The value of  $\frac{H_b}{h_b}$  at the third method changes against deep water wave height as well as against wave period. The value of  $\frac{H_b}{L_b}$  at method (1) is constant at  $\frac{1}{\pi}$ , since it was designated. At method (1) the constant is at 0.07, no change against the changes in deep water wave height as well as wave period. At method (3), the value of  $\frac{H_b}{L_b}$  changes against the changes in deep water wave height as well as wave period.

Table.3:  $\frac{H_b}{h_b}$  and  $\frac{H_b}{L_b}$  the result of the three methods

$H_0$ (m)	$H_b$ (m)	$\frac{H_b}{h_b}$			$\frac{H_b}{L_b}$		
		(3)	(1)	(2)	(3)	(2)	(1)
Wave Period ( $T$ ) : 8 sec.							
0,6	0,92	0,81	0,81	0,86	0,32	0,07	0,04
0,9	1,25	0,81	0,81	0,86	0,32	0,07	0,05
1,2	1,56	0,81	0,81	0,85	0,32	0,07	0,05
1,5	1,85	0,81	0,8	0,84	0,32	0,07	0,06
1,8	2,12	0,81	0,8	0,83	0,32	0,08	0,06
Wave Period ( $T$ ) : 8 sec.							
0,6	0,98	0,81	0,81	0,87	0,32	0,07	0,04
0,9	1,34	0,81	0,81	0,86	0,32	0,07	0,04
1,2	1,66	0,81	0,81	0,85	0,32	0,07	0,05
1,5	1,97	0,81	0,81	0,85	0,32	0,07	0,05

1,8	2,26	0,81	0,8	0,84	0,32	0,07	0,06
Wave Period (T) : 9 sec.							
0,6	1,04	0,81	0,81	0,87	0,32	0,07	0,04
0,9	1,41	0,81	0,81	0,87	0,32	0,07	0,04
1,2	1,76	0,81	0,81	0,86	0,32	0,07	0,05
1,5	2,08	0,81	0,81	0,85	0,32	0,07	0,05
1,8	2,39	0,81	0,81	0,85	0,32	0,07	0,05

Breaker wave length (3) looks very short. This is in accordance with the wavelength produced by the conservation equation  $\frac{dk(h+z)}{dx} = 0$ . For example, for the ignored wave height, relation  $k_2 h_2 = k_1 h_1$  or  $k_2 = \frac{k_1 h_1}{h_2}$  applies. For a wave with wave period  $T = 8$  second, moved from water depth  $h_1 = 60$  m to water depth,  $h_2 = 2$  m, then  $k_2 = \frac{k_1 60}{2} = 30k_1$ , if  $k_1$  is calculated using dispersion from linear wave theory, it produces  $k_1 = 0.049932$  and wave length  $L_1 = 125.835575$ , produces  $k_2 = 1.497951$  and  $L_2 = 4.195$  m. It shows that equation  $\frac{dk(h+z)}{dx} = 0$  does produce a very short wave length at shallow water.

From the result above, a simple calculation method of breaker parameter can be produced, i.e.:

- Breaker height  $H_b$  is calculated with one of the breaker height index equation or by taking average values of various breaker height indexes.
- Breaker depth  $h_b$ , is calculated with  $\frac{H_b}{h_b} = 0.81$
- Breaker length  $L_b$ , is calculated with  $\frac{H_b}{L_b} = \frac{1}{\pi}$

## VI CONCLUSION

The result of breaker wave steepness computation with breaker wave steepness index equation produces breaker wave steepness value that is more or less constant toward wave period as well as deep water height. This shows the presence of critical steepness wave on a wave curve.

The proposed equation uses critical wave steepness criteria. The equation uses wave condition in deep water and in the form of explicit equation that is easy to use. In addition, the equation is an analytical product based on the law of conservation. The critical wave steepness criterion is quite important in the development of a simple breaker index; therefore, a research is needed on critical steepness wave, in the laboratory as well analytical.

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# Analysis Mapping Logistic Processes of People Offshore Company located in Brazil

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**Abstract** — The present research had the objective of analyzing mapping personnel logistics process company located Macaé, Rio de Janeiro, Brazil, through the analysis of existing processes. The company chosen to be the source of the study, has been working in the area of submarine engineering for almost 30 years, has as one of its main focuses the client, a key part of the process to be studied. To carry out the work, a bibliographical research was carried out around the concepts of logistics and its various ramifications besides the mapping of the internal processes that served as a theoretical basis for the research and assisted in the design of the work. In addition, company documents were used to provide support and field surveys were performed with the technical assistance team involved, I was able to carry out the direct observation of the process studied. It was made a survey of the advantages and disadvantages of the process that is currently used, stating that the company should focus on the disadvantages encountered during the work to begin a process of continuous improvement in the personnel logistics department, where currently the absence of a procedure that designing all processes involved in people logistics hampers process efficiency and hampers cost reduction. It is suggested to set up an

action plan in order to correct the disadvantages encountered, and to maximize existing well-defined processes.

**Keywords** — Logistics, mapping processes, offshore, shipment.

## I. INTRODUCTION

According to Rodrigues (2000), the emergence of the word logistical comes from the seventeenth century, from the term logistique, which is derived from a position existing in the French army, where the soldier occupying such a post was responsible for the activities related to displacement, accommodation and camp of the troops in campaign, referring to practices of moving armies.

Logistics first emerged as part of the military art, used in wars that were usually long-lasting and distant. Logistics was the area that took care of planning several important items, storing, distributing and maintaining various types of materials, such as weapons, clothing, food, hospital materials, transportation and even the movement of people.

At first, the logistics were made only as value-added for sale and manufacturing processes, from the raw material

to the finished product, and with time, the need for logistics as a post-sale instrument became visible.

The objective of this work is to analyze the processes of logistics of offshore personnel of a company that operates in the oil industry of the city of Macaé, mapping the processes used, raising good practices and possible flaws that interfere in logistics efficiency.

In the next topics will be analyzed the introduction of logistics, personnel logistics, process mapping, the company to be analyzed, as well as the mapping of personnel logistics, as well as methodology and final considerations.

## II. LOGISTICS AND ITS DEFINITIONS

According to Novaes (2007, p.35), logistics is the process of efficiently planning, implementing and controlling the flow and storage of products, as well as associated services and information, covering from the point of origin to the point of consumption, with the aim of meeting the requirements of the consumer. According to Novaes (2007), logistics processes were focused with the sole objective of meeting the needs and preferences of the final customer.

Logistics is a growing area, since organizations are turning their focus to quality, since most of them understood that when they present quality, that is, a product or service that is well finished, delivered on time and has a reasonable cost, profit would only be a consequence, so it can be assumed that logistics contributes decisively in order to improve the economic standard of life of all involved in its process and that its activities are known as bridges connecting production sites and distribution markets through time and distance (KUEHNE, Jr, 2008).

The revolution mentioned above generated some initial discomfort in companies, but with the passage of time these companies adopted differentiated strategies focusing on process improvement, a mechanism that contributes significantly to the logistics process, despite the costs incurred in the change, in the long run the entrepreneurs glimpsed in logistics a competitive advantage.

"Competitive efficiency can be as relevant a promotional element as personalized sales, advertising, price discounts, training, among others. The presence of special transportation, constant inventory availability, faster order processing, and reduced transport losses or damage, in most cases, can affect customers' perceptions and, consequently, sales" (BALLOU, 2001).

Nowadays, a company must operate in a high-level economy, with good efficiency of logistics activities, becoming a survival factor and competitive advantage favorable to the market. In this way, logistic activities provide the link between the producing regions and their

markets, which can now be separated geographically. With this, logistics efficiency becomes a major competitive factor for the company at national and international level, and its management enables the integration of all the company's operations, he says (BALLOU, 2001).

The present work prioritizes and understands that the greatest resource of any organization is the human resource and it is fundamental to maintain a great effort to put the right people in the right moment, attending to the main demands of growth and control of the organization.

Personnel logistics is understood as the act of moving people neatly for a specific purpose, that is, ensuring that an employee is at the right time for a given function. This branch of logistics is extremely new, since until recently everything was included as logistics or allocated to other departments, such as human resources.

Correctly executed personnel logistics become an important tool to increase the levels of internal and external customer satisfaction, such as the after-sales sector, that is, customer loyalty by adding value to the product. Understanding value as the relationship between the benefits provided by the product, the price paid by the customer plus the costs of accessing the product or the associated service, creating value for the customer through after-sales means reducing these costs. Logistics is a strategic weapon for business competitiveness.

In the company researched the work of personnel logistics is heated, since there is a need for mobility of employees throughout the national territory, aiming at customer service whenever requested.

This work goes beyond logistics, but an effective logistics begins from the negotiation of the contract to the service itself, this is because every company needs a time to attend a request, this time should be discussed and evaluated with the aim of be as small as possible, but enough for movement.

## III. COSTS OF MATERIAL LOGISTICS AND THEIR IMPORTANCE FOR STAFF LOGISTICS

Logistics itself is about creating value for all stakeholders. The added value of logistics is manifested primarily in terms of time and place, products and services are worthless unless they are in the right time and place. Good logistics management interprets each activity in the supply chain as a contributor to the value-adding process, when the value added is small, the existence of this activity will be questionable. Logistics is becoming an increasingly important process of value adding for many reasons (BALLOU, 2006).

Over many years, numerous studies have been carried out to determine the cost of logistics for the economy as a whole and for each company, resulting in estimates of

cost levels for all tastes and preferences, size and disparity between each of them, according to the International Monetary Fund (IMF), logistics costs account for 12% of the world's gross domestic product on average. Logistic costs over more than two decades estimate that logistics costs represent 9.9% of gross domestic product (GDP) or 921 billion for the US economy (BALLOU, 2006).

During the last decade the costs of physical distribution fluctuated between 7 and 9% of sales, there may be a trend of rising costs for companies although, research shows that in the same period logistic costs as the percentage of Gross Domestic Product (GDP) reduction of about 10%. Logistics costs in most companies are second only to the cost of goods sold (purchasing cost) which accounts for about 50-60% of sales to the average manufacturer (BALLOU 2006).

The calculation of cost in the previous paragraph in the logistics of people is extremely applicable; people deliver certain services, and most often deliver these services out of their work bases. An entrepreneur in negotiation of a specific contract must raise all possible hypotheses regarding the movement of its employees to be providing the contracted service, the logistic cost must be included in some way in the value of the service, so that the value earned by the entrepreneur is enough to cover all your obligations including the logistics costs and still achieve a positive result.

The calculation of cost is important in the logistics of personnel and material, for this currently the process mapping tool is used, which is relevant in this context.

#### IV. MAPPING PROCESSES

For Rosemann (2006), process mapping seems to exist since man has mastered symbol writing.

According to Barabará (2006), in an organizational environment are numerous agents with different levels of training, the difference between the agents leads the organization the most diversified information occurring improperly within the company. The impropeness is due to the incorrect treatment of this information, occurring in the poor quality of the information generated. Communication among the agents of an organization is an object of great concern, this flow of information should be extremely important, because through it are made assessments of the functioning of various areas of the organization.

According to BPM (2008), the behavior of companies is determined by their procedures, which are specific sequences of activities to be developed as a result of company policy and the pursuit of their objectives, procedures guide employees in how to perform their tasks, this sequence of activities within a company, is called the customer-supplier chain.

Insofar as improvements are made in the flow of information, improvements are usually made in the process as a whole, having this registered flow helps in visualizing the operating deficiencies and consequently in the possible changes that may be implemented in the processes and as part of the process. system of communication (NASCIMENTO, 1999).

For this author, the most important part of process mapping is information considered as an indispensable resource in organizations, their treatment, flow and the evaluations that can be extracted (NASCIMENTO, 1999). The information flows in a company are presented in the following forms: information flow collected outside the company, but used by it as suppliers, customers and competitors that influence the existence, operation, actions and decisions; flow of information produced by the company and destined to the market, this information is generated within the company intended for external agents, such as purchase orders, invoices or advertising campaigns; flow of information produced by the company and destined to itself, this type of flow is generated and consumed internally as accounting information, production reports and internal communications (LESCA and ALMEIDA 1994).

Process mapping is a management and communication tool that is intended to help improve existing processes or to deploy a new process-oriented framework. Mapping helps the company to clearly see strengths and weaknesses and is a great way to improve understanding of processes and increase business performance. The objectives of this tool are to seek a better understanding of existing and future business processes, with the aim of improving the level of customer satisfaction by increasing business performance (LECIONI, 2006).

According to Villela (2000), process mapping is an analytical and communication management tool that intends to help improve existing processes or to implement a new process-oriented structure. This analysis allows cost reduction in the development of products and services, reduction in system integration failures, and improved organizational performance, as well as helping to simplify existing processes.

Observed by Mello and Salgado (2005), in order to manage a process, it is necessary to first visualize it. Thus, the mapping is performed to represent the various tasks required and the sequence they occur for the realization and delivery of a product or service.

The main techniques of mapping processes are (LEAL, 2003):

- Process flowchart - used to register a process in a compact way, using some standardized symbols (BARNES, 2004);
- Mapofluxogram - used to represent the process in a plant or in the area in which the activity develops



(BARNES, 2004).

- Integrated Computer Aided Manufacturing (IDEF) - allows a complete analysis of processes through their inputs, outputs, constraints and interactions using the family (MAYER; PAINTER; WITTE, 1992);

- Systematic diagram of Unified Modeling Language (UML) - created for software systems development and adapted to model diverse systems other than software systems (WILCOX & GURAU, 2003);

- Service Blueprint - a technique developed for the mapping of service processes, differentiating itself from the flowcharts by considering the aspect of customer interaction representing all the transactions that constitute the service delivery process, including those of the back-end activities (WILCOX & GURAU, 2003);

- Map of the service - a service mapping technique derived from the Service Blueprint that involves the management of the service as a whole, it is a management technique to chronologically represent the tasks and activities performed by the client, front line staff and support personnel in the performance of a service (KINGMAN-BRUNDAGE, 1995).

## V. METHODOLOGY

For the classification of the research, it is based on the taxonomy proposed by Vergara (2009) that qualifies it in relation to two aspects: as to the ends and the means:

- Regarding the ends, the research was exploratory, explanatory, and descriptive. Exploratory because, although the theme tools for improving personnel logistics are not widespread in developed countries, there is little accumulated and systematized knowledge in Brazil. Explanatory, as it aimed to clarify factors that contribute to the process of movement of people in the offshore market.
- As for the media, the research was bibliographical and documentary, as it will be based on a systematic study based on material accessible to the general public published in books and articles, with an investigation on the subjects: concepts, mapping of processes, perspective theory, behavioral tendencies. As well as telematics, since several documents available on websites will be used, since this theme in Brazil is still very recent.

The literature search focused on the search for studies that portray concepts and models of logistics focused on the mobility of people to perform a specific job, within a highly competitive and vulnerable scenario, which is the Oil and Gas market. journals and dissertations. It analyzed as a result the understanding of the human behavior as an improvement of the effectiveness of the decision making, as well as the generation of a referential.

## VI. THE COMPANY

The company that bases its studies in this work is a multinational company of services and technology, currently the company operates in several business areas such as manufacturing of lamps, appliances, aircraft turbines, financial branch among others. The basis for research is the oil exploration and production branch, the manufacture of Wet Christmas Trees, Wellhead and BOP (Blow Out Preventer) (THOMAS et al., 1998). The company was founded in 1980 taking as a brand the invention of the lamp.

The researched company is a global company focused on research and innovation, has been present in Brazil since 1919 providing innovative products, services and solutions collaborating with the country to overcome the challenges of infrastructure improving people's lives. To contribute to the continuous improvement of humanity, it operates in the health, energy, household and financial markets; made history in the first radio transmission and changed the transmission speed for the time (THOMAS et al., 1998).

The company city Macaé, the main business is manufacturing and maintenance of submarine equipment, for that it has approximately 500 employees, 190 with offshore contracts and the other onshore.

In recent years company X and all its competitors have received an increase in demand from oil discoveries in a deep layer called pre-salt. The pre-salt is a layer of oil reserves that lies beneath a deep layer of salt, forming one of several rocky layers of the marine subsoil. In Brazil the pre-salt layer extends over 800 kilometers encompassing the states of Santa Catarina and Espírito Santo beyond the Campos and Santos basins. Its nomenclature is given by the time scale in which oil, its formation took place thousands of years and was covered by salt over the years.

## VII. LOGISTICS STAFF MAPPING MACAE COMPANY

The main purpose of the job is to use the tools available to improve personnel logistics, moving people quickly, quality and safety.

The base company for this research works with maintenance of Christmas Trees and Wet and Well Head, which are equipments that are part of the petroleum production process.

Christmas tree is an equipment consisting of a set of valves type drawers that allow to control the activities required in the production of oil, allows the flow of fluids from the reservoirs to the production platforms, as well as injects fluid into the reservoir, and can even intervene in the wells when necessary; cleaning, stimulation, control and tamponade for abandonment.

The wet christmas tree is an equipment for submerged use

consisting basically of a set of drawer valves, a set of flow lines and a control system to be interconnected to the panel located on the production platform. The studied company works with wet Christmas tree as shown in figure 1.



Fig. 1: Christmas tree. Source: Tomas et al. (2006)

The company studied provides service to company Y (customer). The demand for work arises in the department called active, undergoing an analysis of the Department of Operations Planning and Underwater Equipments (POES), and the Subsea Equipment Planning (EQSB). The employee of company X interfaces between the ATIVO and EQSB departments, when the project is approved it arrives at the EQSB and enters Operations

Planning (OP), as can be seen in figure 2.

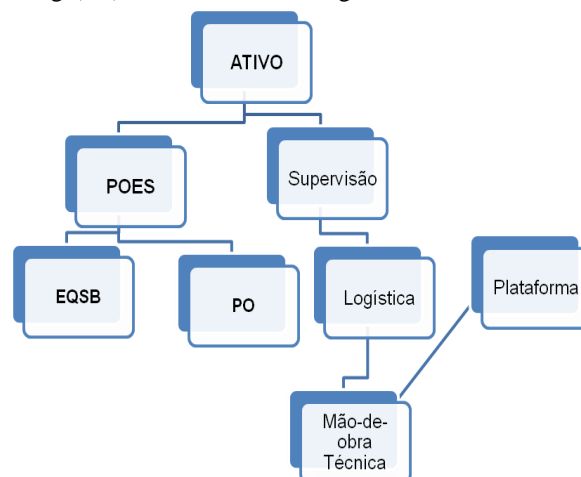


Fig. 2: Flowchart Client - Company X. Source: Own.

Microsoft Excel is software for creating and maintaining spreadsheets. It is used as a control tool in the logistics of personnel, such as counting of days on board, control of clearances, control of double shipments, control of the mandatory training for the function, control of queue of shipment and control of official to qualify.

[illegible]

Fig. 3: Board of control of shipment - Partial - company X. Own Source.

The Excel software allows the control of the days of shipment of offshore employees, allowing the logistics to control the days of shipment not allowing the folds that increases the cost and the risk of accidents.

The motivation of the employees with respect to the function performed, allows a greater ease in the contact of the logistics with the employee in offshore regime and a quick assimilation of the requested work.

The disadvantage is a contract with a single tourism company, responsible for supporting logistics in the

search for airline tickets and hotels throughout the country, with the best price and location, through the daily practice was raised that the company meets the requests of the best possible, but that the creation of a competition could bring benefits to company X in order to reduce costs and the effectiveness of the operations themselves.

Absence of a procedure that raises all the particularities of personnel logistics, minimizing doubts and possible injustices. The logistics expressed doubts on some issues

and claims to try to raise all the relevant points, but report that you feel insecure, for not having a procedure that ties up all the necessary issues.

### VIII. FINAL CONSIDERATIONS

The case study was carried out based on the personnel logistics process of an oil and gas company from Macaé and was based on the identification of a reality that needs to be constantly improved, improving the personnel logistics process. With the aid of a bibliographical research, internal documents of the company and direct observation, a mapping of processes was done, raising all the pertinent points from the beginning of the process of logistics of people in offshore regime until its outcome with the landing and beginning of the clearance. During the course of the work some advantages and disadvantages of the process were raised.

The company should focus on the disadvantages encountered during the work, to begin a process of continuous improvement in the personnel logistics department, building and improving over time a personnel logistics procedure that contains all the pertinent particulars, with the purpose of procedural work and reduce errors by increasing the range of companies providing taxi services and tourism agencies.

It is concluded that the tools used to assist people's logistics effectively assist the process itself, but there is a need for a well-written procedure that addresses all the peculiarities pertinent to the people logistics process, knowledge of all, aiming at the improvement in the movement of employees and the reduction of costs.

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# Antimicrobial activity of common endodontic materials on *Enterococcus faecalis* NEWP 0012

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**Abstract**— The elimination of the microorganisms in its totality, during the endodontic therapy, although desired, is hard to be achieved. Even after the canal filling, the microorganisms are able to be into the dentinal mass and into the periapical region. This essay aims to evaluate the antimicrobial activity of endodontic materials against to the *Enterococcus faecalis* NEWP 0012. The inoculation of this microorganism in the glass plates was done using swabs pressing the cotton against the wall of the pipe. The bacterial suspension was sowed evenly on the sterile surface of the Ágar MH. The plates were incubated by aerobic conditions, in a constant temperature in the range of 35° a 37°c, for 24 hours. The endodontic materials tested were: Sealer 26, Endofill, AH plus, MTA Filapex, calcium hydroxide paste associated to the chlorhexidine, Maxxion R glass ionomer, MTA and MTA HP. After material manipulation, they were impregnated into absorbent paper discs of 5mm of diameter and distributed sporadically on the plates that contained the microorganism. The experimental data were obtained by the measurement of the inhibition halo in the period of 24h, 72h, 7, 15 and 21 days; thus, the microorganism was classified as resistant or sensible to the different products. From the results, it was possible to verify that the calcium hydroxide paste associated to the chlorhexidine presented superior antimicrobial activity on *Enterococcus faecalis* NEWP 0012. It was concluded that the calcium hydroxide paste associated to the chlorhexidine has satisfactory antimicrobial activity

against the *Enterococcus faecalis* NEWP 0012 in the period between 24h to 21 days.

**Keywords**— Calcium hydroxide, Endodontics, Odontology.

## I. INTRODUCTION

The most common cause of the pulp commitment is the infection by microorganisms due to the dental caries. Even the pulp necrosis that occurs by aseptically reasons, sooner or later, it is infected. The necrotic pulp tissue is very easily infected because the cells and the molecules of the host immune system does not function in necrotic tissue conditions and the apical periodontium cells and molecules cannot reach the inner necrotic root zone [1,16,19].

Many experiences show that the dental pulp can recover itself of an acute inflammation, this is directly dependent of the quantity of microorganisms that will be invading the pulp. In conventional rats and *germ-free* the pulp alterations after the exposition in a mouth area are variable. In the *germ-free* there is formation of dentin bridges and absence of inflammation, although they present necrosis in the exposal area surface. Sometimes the necrosis occurs in the pulp near the exposition to the mouth area and this is considered as caused by the accumulation or impaction of foods. In the conventional rats, after two days there is the presence of an infiltrated of neutrophils in the high layer and beginning of necrosis.



After seven days the pulp necrosis is more extensive, with periradicular inflammation [13].

The infecting microbiota has the capability of organize itself in a biofilm, changing the own metabolic ways surviving to nutrients scarcity periods or less improper conditions to the development. This association in biofilm do that these microorganisms synthesize and excrete, in the run of the metabolic process, substances with antigenic action that trigger off the host inflammation, that traduce itself sometimes in chronicle clinical manifestations, sometimes in acute manifestations. The organization of the microorganisms in biofilm also offers its way of protection against aggressions and, in this way, the elimination of organized microorganisms in biofilm constitutes a much more complex objective [3,17].

A fundamental stage in the endodontic treatment is the root canals system disinfection. This stage is accomplished by the employ of cut instruments that lengthen the root canal aiming, by the use of an auxiliary irrigator solution, to the removal of the microorganisms that colonized the root canal. As the instruments frequently are not able to cut all the walls of the root canal, the not-touched areas can stay colonized, mainly if there is the presence of biofilm [1-4,16].

In this context the auxiliary irrigation solution takes a fundamental role to reach regions where the endodontic instrument is not able to reach. Therefore, this stage of the endodontic treatment is defined as chemical-mechanical prepare, because it demands the employ of instruments with mechanical action (cut) associated to the employ of an irrigator solution with effective antimicrobial action [10-16].

Many chemical substances have been proposed with the purpose of to provide an effective irrigator solution, but it was not developed still a substance that get together all the desirable qualities. Between the various desirable characteristics to an ideal irrigator solution, its antimicrobial efficiency against bacterial biofilm seems to constitute a fundamental point. In the aid to the combat to the microorganisms to the intracanal medications, endodontic cements and biomaterial can be used [8,12,16,19].

It is observed that the antimicrobial capability of the calcium hydroxide and of the chlorhexidine digluconate is complementary, as the other properties (the virtue of one complement the fails of the other). By this reason, the association of these two substances in the manipulation of the intracanal medication using between sessions is instigator and seems plausible that an additive or synergic antimicrobial effect can results of this association [5]. In fact, the combination of the calcium hydroxide with the chlorhexidine digluconate in the

manipulation of intracanal medications used between seeing being sessions, since a short time, widely analyzed and defended, mainly in cases of persistent apical periodontitis associated to pulp necrosis or to failed endodontic fillings, even with the limited availability of information respect to this association [5,12,19]. The combination of the calcium hydroxide with the chlorhexidine in 2,0% is, at least, as effective as the calcium hydroxide vehiculed in sterile deionized water in relation to the disinfection ("in vivo") of the root canal dentine of teeth with failed endodontic filling. The authors reported that, in fact, the combination of the two active principles presented better results, however, the reduced sample led to the non-significant statistic difference between the two groups [21].

With the advent of this material, this study aims to evaluate the antimicrobial activity of endodontic materials by the diffusion tests in agar and by direct contact. Thus, the objective of this essay was to evaluate the antimicrobial activity of endodontic material to the *Enterococcus faecalis* NEWP 0012.

## II. MATERIAL AND METHODS

It was used reference bacterial strains, used as standard for quality control at Microbiology laboratories and susceptibility tests to antimicrobials, commercialized by NewProv. Each microorganism was stabilized in freeze-dried discs in a concentration above 100.000 UFC/mL. It was used the *Enterococcus faecalis* NEWP 0012.

The discs that contained the microorganisms were revitalized with a flambé and cooled tweezers, the discs were aseptically removed of their original bottles and put into 3 mL of BHI nutritive broth (Brain Heart Infusion). The pipes were identified and incubated in  $35^{\circ} \pm 2^{\circ}$  until the visible turbidity (2 – 3 hours). After, with aid of a 100-microliter calibrated handle, it was inoculated the microorganisms in a non-selective medium plate (Blood agar) by the technique of exhaustion and again they were incubated in  $35^{\circ} \pm 2^{\circ}$  by 24 hours.

It was used 5 different types of endodontic materials commercially acquired by the formulation of gel or solution or freeze-dried: G1 – white MTA Angelus®, G2 – MTA Angelus® HP, G3 – Filapex Angelus® cement, G4 – AH plus cement, G5 – chlorhexidine gel 2% and sodium hydroxide (Farmácia Formula & Ação SP- Brazil). The manipulation of the white MTA Angelus®, of the MTA Angelus® HP, of the Fillapex Angelus® cement and AH plus was accomplished accord to the fabricant instructions. The paste manipulation, gel 2% and sodium hydroxide was accomplished in the 1/1 proportion. after the manipulation of these materials, they were impregnated into absorbent paper discs (Figure 01).



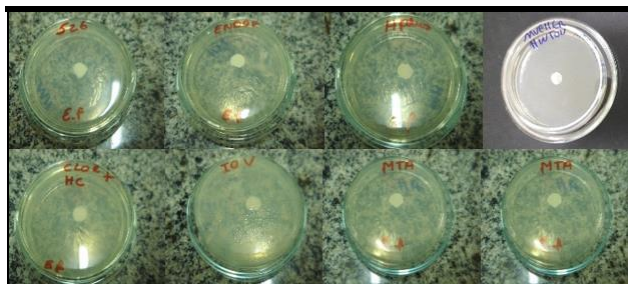


Fig.1: Absorbent paper discs soaked in the endodontic materials in test applied on the petri plates.

## 2. Test of antimicrobial sensibility in vitro – antibiogram (Diffusion method with Bawer and Kirby discs).

The preparation of plates and growth mediums: the Mueller-Hinton Agar (MH) medium was prepared previously fused, sterilized and cooled in 45-50°C. Then, it should be spilled in petri plate of 150mm of diameter until reach a thickness of about 4mm. In the sequence, it was accomplished the preparation of the inoculums and the pure culture of bacteria (NEWPROV) were cultivated in nutritive broth in 37°C by about 12 hours after the revitalization, enough time that the bacterial suspension presents moderated turbidity. The density of the inoculums from then on, was controlled by dilution with saline to obtain a turbidity density equivalent to that obtained by the addition of 0,5mL of BaCl<sub>2</sub>-2H<sub>2</sub>O (0,048M) solution in 99,5mL of H<sub>2</sub>SO<sub>4</sub> 0,36N – McFarland Escal.

For the inoculation of the plates, cotton swabs were submerged into the bacterial suspension and the excess was removed pressing the cotton against the pipe wall. The bacterial suspension was sowed evenly on the sterile surface of the MH Agar and the discs of antibiotics or of endodontic materials will be sporadically distributed on the inoculums. The antibiogram plates were incubated by aerobic conditions, in a constant temperature in the range of 35-37°C, for 24 hours and/or 7 days.

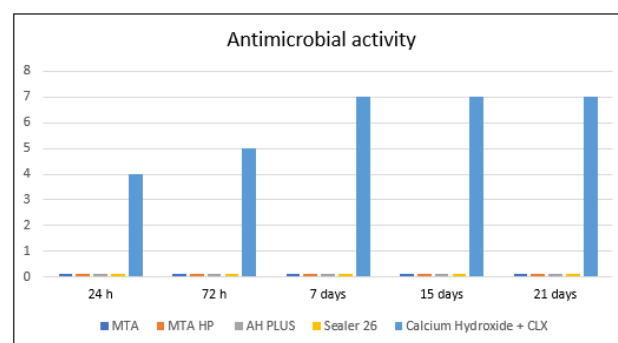
## III. RESULTS

The obtained results about the antimicrobial activity of the endodontic materials, was measured although millimeter rulers. The inhibition halos were measured and compared in the first 24 hours, and again after 72 hours, they were been evaluated in until 21 days, in three different tests. The *Enterococcus faecalis* demonstrated that it is resistant to the most part of the materials, that did not present any bacterial inhibition halo, and they are: white MTA Angelus®, MTA Angelus® HP, Filapex Angelus® cement, sealer 26, AH Plus® and Maxxion R. in the first test was observed inhibition halo in the materials: chlorhexidine gel 2% and calcium hydroxide

(Table 1 and Graphic 1). They were the two-last observed in until 14 days, from this there were decrease of the antimicrobial action. However, the calcium hydroxide and chlorhexidine gel 2% were effective in all tests in until 21 measured days (Figure 2).

Table.1: Inhibition halos of the materials according to the tested time.

Experimental groups	7 days	15 days	21 days
Sealer 26	Absent	Absent	Absent
Endofill	Absent	Absent	Absent
AH Plus	Absent	Absent	Absent
MTA Fillapex	Absent	Absent	Absent
Calcium Hydroxide + Chlorhexidine	Present	Present	Present
Ionômero de vidro Maxxion R	Absent	Absent	Absent
MTA	Absent	Absent	Absent
MTA HP	Absent	Absent	Absent



Graphic.1: Antimicrobial action of the substances over the days under test.

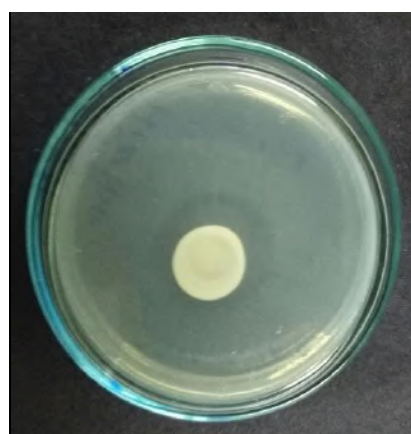


Fig.2: Calcium Hydroxide Paste + Chlorhexidine (Inhibition halo).

## IV. DISCUSSION

The chemical-mechanical prepare reduce a big part of the microbiota of the infected root canals [1,12,16,22], however, other authors emphasized the need of the use of

intracanal measure with the purpose to avoid that the survivor bacteria to the chemical-mechanical prepare, in a enough number and in a favorable environment, multiply themselves in the interval between the treatment sessions [3,25]. Therefore, it becomes evident the need to maintain the canal disinfection obtained by the chemical-mechanical prepare, and this is possible using a proper intracanal medication that presents antimicrobial properties and that functions as physical barrier, of an ideal filling of the root canal systems and of a proper crown sealing. Besides that, the intracanal medication has the intention to reduce the periradicular inflammation, to solubilize organic material, to neutralize toxic products, to control the persistent exudation, to control the inflammatory extern dental reabsorption and to stimulate the reparation by mineralized tissue. With this objective, some options of intracanal medications are been researched. Studies prove the efficiency of ones, more than others, which were present in the clinical routine. It was used the method of diffusion in agar, due to be considerate standard and of easy execution. Other study already used this methodology. The tested materials in this study were Sealer26®, AH Plus®, Fillapex Angelus®, white MTA Angelus®, MTA Angelus® HP, Restorative glass ionomer MaxxionR®, Calcium hydroxide with Chlorhexidine in gel 2% and Cotosol® [29]. But only the Calcium hydroxide with Chlorhexidine has real efficiency against the *EnterococcusFaecalis*, that was the chose microorganism to the accomplishment of the experiments, because it has a considerable resistance to auxiliary chemical substances and commonly used medications in Endodontic, besides being frequently associated to the presence of periradicular lesions and to the failure in the endodontic treatment. It is an anaerobic facultative microorganism, relatively easy to be cultivated and of high clinical relevance [4]. It can be commonly isolated of clinical samples, presents peculiar resistance to the calcium hydroxide, especially, to the elevated level of the pH that results of the dissociation of the hydroxyl ions that occurs in aqueous medium [1,21].

Because it is in powder form, the calcium hydroxide can be associated to other substances to be inserted into the root canal. Usually, the calcium hydroxide used in the endodontic practice is manipulated with saline that is water soluble and as they are an association, that have together chemical characteristics of dissociation, diffusibility and filling ability that are determinant to the biological behavior [13]. However, according to other studies, specific microorganisms, mainly *Enterococcus faecalis*, have been showed resistant to the  $\text{Ca}(\text{OH})_2$  [6,10] and besides that, the antimicrobial efficiency of the pastes in a long term has been questioned [24]. In this way, researches as this have been developed adding

active vehicles with antimicrobial properties associated to the calcium hydroxide increasing this activity, without losing its other characteristics [16].

Estrela et al. (1995) [13], discussed the mechanisms of action of the calcium hydroxide in the treatment of the endodontic infections. The authors highlighted that the calcium hydroxide effect is linked to the increase of the pH resultant of the dissociation, in aqueous medium, in hydroxyl ions and calcium ions. The calcium hydroxide actuates in the activation of the host tissue enzymes as the alkaline phosphatase that participates in the recovery of the mineralized tissues affected by the endodontic infection. In the bacteria, it actuates changing the integrity of essential sites promoting the inactivation of the cytoplasmic membrane enzymes interfering, in metabolic and homeostatic processes, growth and cell division. Therefore, the actions of the calcium hydroxide occur in two fronts, biological, favoring the defense mechanisms and the host affected tissues reparation, as also bacteriological, through the antimicrobial action. This therapeutic action makes that the calcium hydroxide prevails between the active principles of the intracanal medication, but, despite the particular efficiency in the action by direct contact in the main canal, its actuation in the pH into the dentinal tubules and in the cement, region is not so significant, demonstrating a deficiency.

The calcium hydroxide presents some limitations, as for example, a low solubility and low diffusibility, and action only for direct contact, that impedes the arrival of this substance to the hard to reach places in teeth that present anatomic variations, as isthmus, apical deltas, recesses, places where the bacteria are protected of the action of the intracanal medications. The solution of chlorhexidine digluconate 2%, when applied for 10 minutes, previously to the endodontic filling, can enter the dentinal tissue and to provide the antimicrobial action for more than 12 weeks, even if this capability is reduced in function of the time, becoming a great ally to the calcium hydroxide. The use of the chlorhexidine digluconate 2% as intracanal medication can be indicated in cases with primary infection. In retreats, the use of the chlorhexidine can be further important, using alternately as irrigator solution during the chemical-mechanical prepare or as intracanal medication between the sessions [32].

The activity of the chlorhexidine digluconate 0,2% in the reduction of the remaining antimicrobial population after the instrumentation of the canal as delay dressing was showed [8] due to its broad antimicrobial spectrum, the chlorhexidine has been widely used in the Endodontic. Its use has been proposed in form of digluconate salt, liquid or in gel, in different concentrations, as intracanal medication. A recent study

evaluated the antimicrobial activity of six irrigator against anaerobic bacteria and reported that the chlorhexidine was the most effective. When used as intracanal medication, the chlorhexidine had a better effect than the calcium hydroxide in the elimination of *Enterococcus faecalis* into the dentinal tubules. It is the material that demonstrates most efficiency against this microorganism, in the tests accomplished by this essay [22].

Lenet et al. (2000) [18] compared, in vitro, the residual antimicrobial activity of the chlorhexidine gel 0,2% and 2%, in a system of controlled liberation, and of the calcium hydroxide associated to a saline solution, as intracanal medication, in bovine incisors, for 7 days. After the experimental period, the specimens were inoculated in *Enterococcus faecalis* for 21 days. The results showed that the chlorhexidine gel 2% had absence of viable bacteria in all the dentin depth. The chlorhexidine gel 2% presented most antimicrobial activity. The association of the calcium hydroxide with the chlorhexidine gel 2% decreased the antimicrobial activity of the chlorhexidine, however, potentialized the activity of the calcium hydroxide [30].

Studies demonstrates that the chlorhexidine presents more capability to eliminate the *Enterococcus faecalis* than the calcium hydroxide [31]. Nonetheless, other results were found to be unsatisfactory to chlorhexidine, mainly related to the inability to inactivate the LPS liberated by Gram-negatives bacteria. However, the calcium hydroxide can neutralize bacterial endotoxins, especially, the lipopolysaccharide (LPS) present in the cell wall of the Gram-negative bacteria through the lipid hydrolysis that composes part of the LPS molecule [27]. It highlights that the "Lipid A", that is responsible to the biological or antigenic action of the LPS, is hydrolyzed when is submitted to extremely high pH levels, as the generate by the calcium hydroxide in an aqueous medium [13]. The chlorhexidine digluconate does not change the pH of the medication with calcium hydroxide, it presumes that its antimicrobial action and the inactivation capability of the bacterial LPS is not altered [26,28]. Other effect of the association of the calcium hydroxide to the chlorhexidine is increase the antimicrobial capability of the calcium hydroxide, boosting its penetrability capacity into the dentinal tubules. Also, there was observed in this association, the fact that calcium hydroxide can actuate as physical barrier while the chlorhexidine, in function of its substantivity, maintains the canal free of microorganism [1,14,17-21,28].

Even the calcium hydroxide presenting low solubility in water (1,2 g/L to 25°C) and this limits its diffusibility, it is observed diffusion halos in agar to all the associations based in calcium hydroxide. However, it was verified the inefficiency of the calcium hydroxide itself

against the *Enterococcus faecalis* as was observed by other researchers [1,28].

## V. CONCLUSION

It concludes that the calcium hydroxide paste associated to the chlorhexidine possess satisfactory antimicrobial activity against *Enterococcus faecalis* NEWP 0012 in a period of 24h to 21 days.

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# Fractional Order Butterworth Filter

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**Abstract**—Fractional order Butterworth filter derived from the conventional 3<sup>rd</sup> order Butterworth filter by the transition of the ordinary derivative to the fractional one as in [1] is investigated in this paper. The change of the filter characteristics is studied depending on the order of the fractional derivative. Effects of the transformation on the components' behaviors of the filter is formulated. Design of the filter in the sense of choosing the filter parameters to satisfying the given specifications is described.

**Keywords**—Butterworth filter, control system, fractional order.

## I. INTRODUCTION

Fractional calculus (FC) [2,3] provides more accurate models than classical calculus for many of the physical systems showing intrinsic fractional order (FO) behavior [4-6]. Fractional derivative takes into account the past history when memory like behaviors exhibit in components [7-10]. The same advantages appear in some electrical circuits as well [11-16].

In [1], a method is given for obtaining fractional order differential equation (FODE) from ordinary differential equation (ODE) keeping the consistency of dimensionality in physical systems. This method is used to find the natural response of a FO RLC circuit by F. Gomez at al. [17].

In this paper, FO Butterworth filter (FOBF) is derived by using a method similar to Gomez's method. The ordinary derivative is replaced by FO derivative) by the transformation

$$\frac{d}{dt} \rightarrow \frac{1}{\sigma^{1-\gamma}} \frac{d^\gamma}{dt^\gamma} \quad (1)$$

where  $\gamma$  is an arbitrary parameter defining the order of derivative and the auxiliary parameter  $\sigma$  has the dimension of second. Time and frequency response characteristics of the obtained FOBF is investigated according to the transformation parameters  $\gamma$  and  $\sigma$ .

The paper is organized as follows: In Section 2, a brief summary of the FC relevant to the content of this paper is presented. Section 3 covers the short introduction of the conventional Butterworth filter. Section 4 describes the evaluation of the FOBF and the related formulas. In Section 5, the time and frequency domain characteristics

of the FOBF is investigated. Finally, conclusions are included in Section 6.

## II. FRACTIONAL CALCULUS

It is well known that Caputo fractional time derivative [16, 17] of a function  $f(t)$  is defined by

$$\begin{aligned} \frac{d^\gamma}{dt^\gamma} f(t) &= {}_0^C D_t^\gamma f(t) \\ &= \frac{1}{\Gamma(n-\gamma)} \int_0^t \frac{f^n(\tau)}{(t-\tau)^{\gamma-n+1}} d\tau \quad (2a) \end{aligned}$$

where  $\tau \in R, n-1 < \gamma \leq n \in N = \{1, 2, \dots\}$ ,  $f^n$  represents the ordinary derivative of order  $n$ , and  $\Gamma$  is the Gamma function. For  $\gamma = 1$ , Eq. (2) gives the usual derivative. It is assumed in the scope of this paper that  $t$  represents the time in seconds (s), and  $n = 1$  so that (2) reduces to

$$\frac{d^\gamma}{dt^\gamma} f(t) = \frac{1}{\Gamma(1-\gamma)} \int_0^t \frac{f^n(\tau)}{(t-\tau)^\gamma} d\tau. \quad (2b)$$

We note that Eq. (2b) yields

$$\left. \frac{d^\gamma}{dt^\gamma} f(t) \right|_{t=0} = \frac{1}{\Gamma(1-\gamma)} \int_0^0 \frac{f^n(\tau)}{(t-\tau)^\gamma} d\tau = 0. \quad (2c)$$

Laplace transform of Eq. (2a) is

$$\begin{aligned} \mathcal{L}\{ {}_0^C D_t^\gamma f(t) \} \\ = s^\gamma F(s) - \sum_{k=0}^{n-1} s^{\gamma-k-1} f^{(k)}(0_+), n-1 < \gamma \leq n. \quad (3a) \end{aligned}$$

For  $n = 1$ , that is  $0 < \gamma \leq 1$ ,

$$\mathcal{L}\{ {}_0^C D_t^\gamma f(t) \} = s^\gamma F(s) - s^{\gamma-1} f(0_+), 0 < \gamma \leq 1. \quad (3b)$$

Considering the inverse Laplace transform, a few useful formulas are listed as follows:

$$\mathcal{L}^{-1} \left\{ \frac{s^{\alpha-\beta}}{s^\alpha - \lambda_k} \right\} = t^{\beta-1} \mathcal{E}_{\alpha,\beta}(\lambda_k t^\alpha). \quad (4a)$$

Where  $\mathcal{E}_{\alpha,\beta}(\cdot)$  is the 2-parameter generalization of the Mittag-Leffler function. It is defined by

$$\mathcal{E}_{\alpha,\beta}(z) = \sum_{k=0}^{\infty} \frac{z^k}{\Gamma(\beta + \alpha k)}, \alpha, \beta, z \in \mathbb{C}; \operatorname{Re}(\alpha) > 0, \quad (4b)$$

which reduces to the original Mittag-Leffler function for  $\beta = 1$ :

$$\begin{aligned} \mathcal{E}_\alpha(z) &= \mathcal{E}_{\alpha,1}(z) \\ &= \sum_{k=0}^{\infty} \frac{z^k}{\Gamma(1 + \alpha k)}, \alpha, z \in \mathbb{C}; \operatorname{Re}(\alpha) > 0. \quad (4c) \end{aligned}$$

### III. LOW PASS BUTTERWORTH FILTER

The transfer function of the 3<sup>rd</sup> order low pass Butterworth filter (LPBF) normalized with the 3 dB cutoff frequency of  $\omega_0 = 1$  r/s is given by

$$H(s) = \frac{1}{(s+1)(s^2+s+1)} = \frac{1}{(s^3+2s^2+2s+1)}. \quad (5a)$$

One of the circuit realizations of this transfer function is done as the voltage ratio transfer function as it is shown in Fig.1. The analysis of the circuit results the following transfer function:

$$\frac{V_R(s)}{V_S(s)} = H(s) = \frac{\frac{R}{L_1 L_2 C}}{s^3 + \frac{R}{L_2} s^2 + \frac{L_1 + L_2}{L_1 L_2 C} s + \frac{R}{L_1 L_2 C}}. \quad (5b)$$

Equating the coefficients of the transfer functions in Eqs. (5a) and (5b) and using the normalized resistance  $R = 1 \Omega$ , the following component values are obtained for the filter.

$$L_1 = 1.5 H, L_2 = 0.5 H, C = \frac{4}{3} F, R = 1 \Omega. \quad (5c)$$

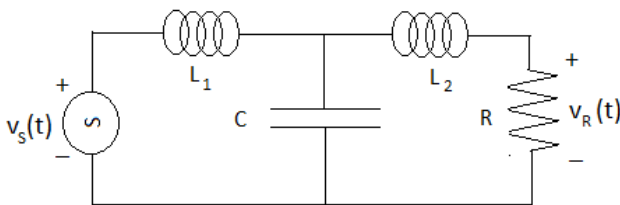


Fig.1: 3<sup>rd</sup> order Butterworth filter with  $\omega_0 = 1$  r/s.

The differential equation relating the input voltage  $v_s(t)$  to the output voltage  $v_R(t)$  is obtained from Eq. (5c) by inserting the Laplace operator  $s$  with the derivative operator  $d/dt$  and arranging the terms; the result is

$$\frac{d^3}{dt^3} v_R(t) + \frac{R}{L_2} \frac{d^2}{dt^2} v_R(t) + \frac{L_1 + L_2}{L_1 L_2 C} \frac{d}{dt} v_R(t) + \frac{R}{L_1 L_2 C} v_R(t) = \frac{R}{L_1 L_2 C} v_S(t). \quad (6)$$

The frequency domain characteristics, namely gain and phase responses of the filter are obtained replacing  $s$  by  $j\omega$  in Eq. (5a); the result is

$$H(j\omega) = M(\omega) e^{j\Phi(\omega)}, \text{ where} \quad (7a)$$

$$M(\omega) = |H(j\omega)| = \frac{1}{\sqrt{1 + \omega^6}}, \quad (7b)$$

$$\Phi(\omega) = \text{Arg}\{H(j\omega)\} = -\tan^{-1} \frac{(2 - \omega^2)\omega}{1 - 2\omega^2}, \quad (7c)$$

are the phase and phase characteristic, respectively. From Eq. (7a), it is obvious that the gain decreases from its value 1 at  $\omega = 0$ , and it becomes equal to its half power value  $M = 1/\sqrt{2}$  at  $\omega = 1$ , it decays to zero as  $\omega \rightarrow \infty$ . And the phase start from 0 at  $\omega = 0$ , it decreases monotonically to  $-270^\circ$  as  $\omega \rightarrow \infty$ . The time and frequency characteristics are not plotted at this stage since

they will appear as the special case of the fractional Butterworth filter considered in the next section.

### IV. FRACTIONAL ORDER LOW PASS BUTTERWORTH FILTER

Applying the fractional transformation to the components of the LPBF in Fig. 1, we have the following time and Laplace domain element behavior equations in the circuit:

$$v_R(t) = R i_R(t), \quad V_R(s) = R I_R(s), \quad (8a)$$

$$v_{L_i}(t) = L_i \frac{1}{\sigma^{1-\gamma}} \frac{d^\gamma i_{L_i}(t)}{dt^\gamma}, \quad V_{L_i}(s) = L_i \frac{1}{\sigma^{1-\gamma}} s^\gamma I_{L_i}(s), \quad i = 1, 2, \quad (8b)$$

$$i_C(t) = C \frac{1}{\sigma^{1-\gamma}} \frac{d^\gamma v_C(t)}{dt^\gamma}, \quad I_C(s) = C \frac{1}{\sigma^{1-\gamma}} s^\gamma V_C(s). \quad (8c)$$

The frequency and time domain analysis of the circuit with these component behavior equations, or direct substitutions  $s \rightarrow \frac{s^\gamma}{\sigma^{1-\gamma}}$  in Eq. (5b) and  $\frac{d}{dt} \rightarrow \frac{1}{\sigma^{1-\gamma}} \frac{d^\gamma}{dt^\gamma}$ ,  $\frac{d^2}{dt^2} \rightarrow \frac{1}{\sigma^{2(1-\gamma)}} \frac{d^{2\gamma}}{dt^{2\gamma}}$ ,  $\frac{d^3}{dt^3} \rightarrow \frac{1}{\sigma^{3(1-\gamma)}} \frac{d^{3\gamma}}{dt^{3\gamma}}$ , in Eq. (6) yield

$$\begin{aligned} \frac{V_R(s)}{V_S(s)} = H(s) &= \frac{\frac{R\sigma^{3(1-\gamma)}}{L_1 L_2 C}}{s^{3\gamma} + \frac{R\sigma^{(1-\gamma)}}{L_2} s^{2\gamma} + \frac{(L_1 + L_2)\sigma^{2(1-\gamma)}}{L_1 L_2 C} s^\gamma + \frac{R\sigma^{3(1-\gamma)}}{L_1 L_2 C}} \\ &= \frac{\frac{d^{3\gamma}}{dt^{3\gamma}} v_R(t) + \frac{R\sigma^{(1-\gamma)}}{L_2} \frac{d^{2\gamma}}{dt^{2\gamma}} v_R(t) + \frac{(L_1 + L_2)\sigma^{2(1-\gamma)}}{L_1 L_2 C} \frac{d^\gamma}{dt^\gamma} v_R(t) + \frac{R\sigma^{3(1-\gamma)}}{L_1 L_2 C} v_R(t)}{v_S(t)}. \end{aligned} \quad (9a)$$

respectively. The characteristic equation is obtained by equating the denominator polynomial of the transfer function in Eq. (9a) to zero:

$$s^{3\gamma} + \frac{R\sigma^{(1-\gamma)}}{L_2} s^{2\gamma} + \frac{(L_1 + L_2)\sigma^{2(1-\gamma)}}{L_1 L_2 C} s^\gamma + \frac{R\sigma^{3(1-\gamma)}}{L_1 L_2 C} = 0. \quad (9c)$$

The characteristic polynomial appearing in the left side of the equality in Eq. (9c) is a commensurate polynomial in power  $s^\gamma$ . So the time domain responses (such as step and impulse responses) of the filter can be obtained analytically by using Mittag-Leffler function [5]. But, these solutions are not included within the content of the paper and it is satisfied by their plots only, instead we are confined to the frequency domain responses.

### V. FILTER CHARACTERISTICS

To find the gain and phase characteristics of the FO LPBF derived in the previous section, we let  $s = j\omega$  in Eq. (9a) and use the identity

$$(j\omega)^\gamma = \omega^\gamma \left( e^{j\frac{\pi}{2}} \right)^\gamma = \omega^\gamma e^{j\frac{\pi}{2}\gamma}$$

$$= \omega^\gamma \left[ \cos\left(\frac{\pi}{2}\gamma\right) + j\sin\left(\frac{\pi}{2}\gamma\right) \right]. \quad (10)$$

The result is

$$M(\omega) = \frac{b_0}{\sqrt{A^2 + B^2}}, \quad (11a)$$

$$\Phi(\omega) = -\text{Arctan}\left(\frac{B}{A}\right), \quad (11b)$$

where

$$A = \omega^{3\gamma} \cos(1.5\pi\gamma) + a_2 \omega^{2\gamma} \cos(\pi\gamma) + a_1 \omega^\gamma \cos(0.5\pi\gamma) + a_0, \quad (11c)$$

$$B = \omega^{3\gamma} \sin(1.5\pi\gamma) + a_2 \omega^{2\gamma} \sin(\pi\gamma) + a_1 \omega^\gamma \sin(0.5\pi\gamma), \quad (11d)$$

$$a_2 = \frac{R\sigma^{(1-\gamma)}}{L_2}, \quad a_1 = \frac{(L_1 + L_2)\sigma^{2(1-\gamma)}}{L_1 L_2 C}, \quad (11e, f)$$

$$a_0 = b_0 = \frac{R\sigma^{3(1-\gamma)}}{L_1 L_2 C}. \quad (11g, h)$$

The gain and phase characteristics on the logarithmic scale (Bode plots) of the filter for  $\sigma = 1$  and different values of  $\gamma$  is shown in Fig. 2 where the conventional 3<sup>rd</sup> order Butterworth filter characteristics is shown by the

thick dashed red line ( $\gamma = 1$ ); The details of the numerical data is given in Table 1 where  $M_p$  (in dB) is the peak gain at the peak frequency  $\omega_p$  (in rad/s),  $M_1 = M_2 = M_p - 3$  are the gains at the cut off frequencies  $\omega_1$  and  $\omega_2$ ,  $BW$  is the bandwidth which is defined as  $\omega_2 - \omega_1$  if a peak exist (the case  $\gamma = 1$ ); otherwise  $BW = \omega_2$  (the cases  $\gamma = 1, 0.75, 0.50$ ). The quality factor  $Q = \omega_2 / (\omega_2 - \omega_1)$  is defined only for  $\gamma = 1.25$  for which the gain characteristics has a peak exceeding the 0 dB level and the filter can be considered as of bandpass type as well. It is observed from Fig. 2 and the data given in Table 1 that the first cut off frequency  $\omega_1$  and the associated gain  $M_1$ , and  $Q$  are defined only when the characteristic is handled as a BP type for which  $BW = 0.221$ . In general, the bandwidth ( $BW$ ) and hence the cut off frequency ( $\omega_2 = BW$ ) decreases with decreasing  $\gamma$  values for the LP filter.

The phase characteristics decrease from  $0^\circ$  to  $-180^\circ$  as  $\omega: 0 \rightarrow \infty$  but with a faster rate at the intermediate frequencies with increasing  $\gamma$ .

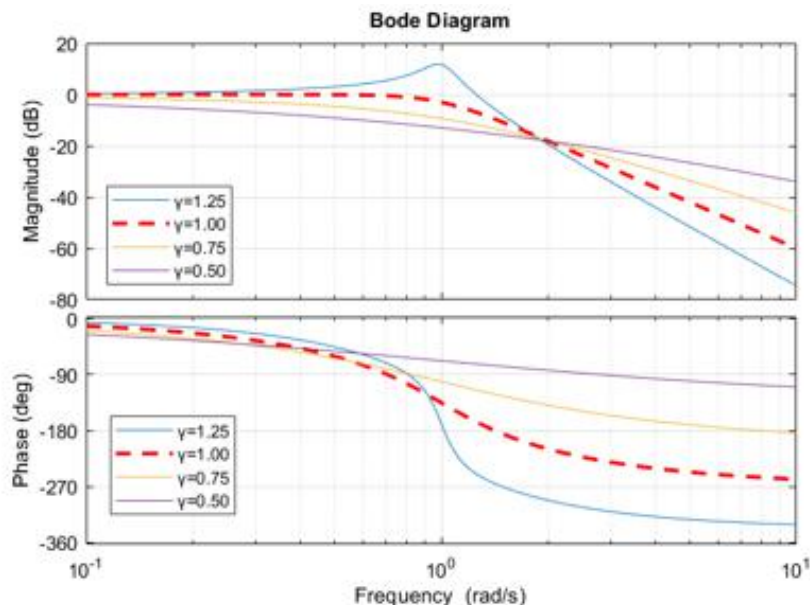


Fig.2: Bode plots of the transfer function for  $\sigma = 1.00$ .

Table.1: Numerical data for frequency response curves when  $\sigma = 1$  for the filter.

$\gamma$	$\omega_1 - (M_1)$	$\omega_2 - (M_2)$	$\omega_p - (M_p)$	$BW - (BP)$	$Q - BP$
1.25	0.852 - 8.841	1.073 - 8.867	0.979 - (11.844)	1.073 - (0.221)	4.430
1.00	---	1.000 - (-3)	0 - (0)	1.000 - (---)	---
0.75	---	0.313 - (-3)	0 - (0)	0.313 - (---)	---
0.50	---	0.058 - (-3)	0 - (0)	0.058 - (---)	---

The step response of the filter is shown in Fig. 3 for values of  $\gamma = 1.25, 1.00, 0.75, 0.50$ . It is seen that all the responses start from 0 at  $t = 0$  and approaches to  $\infty$  as  $t \rightarrow \infty$ , which is a typical property for a LP filter.

The response is highly oscillatory for  $\gamma = 1.25$ , the case in which the filter can be interpreted as a BP filter as well. There is a smaller overshoot for the ordinary 3<sup>rd</sup> order Butterworth filter (case  $\gamma = 1.00$ , thick red dashed line).

The rise time and the settling time decreases as  $\gamma$  takes smaller values. See Table 2 for the detailed numerical data, where  $T_r$ : rise time,  $T_r$ : rise time,  $T_{p1}, T_{p2}, T_{p3}$ : peak times,  $M_{p1}, M, M_{p3}$ : peak values,  $T_s$ : settling time all

in seconds. Some of the data could not be detected since the simulations are done up to 40 s. Rise time increases with decreasing  $\gamma$  and the minimum settling time occurs for the conventional filter ( $\gamma$ ).

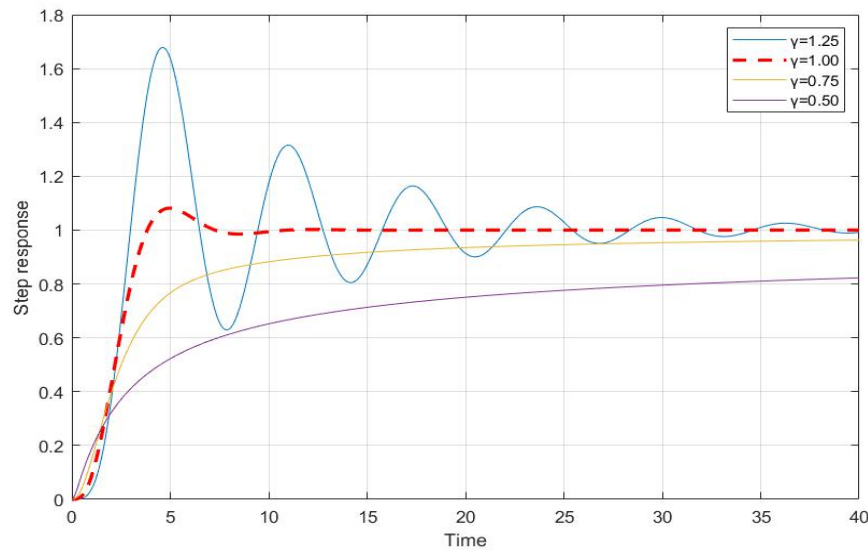


Fig.3: Step responses of the transfer function when  $\sigma = 1.00$ .

Table.2: Step response characteristics for  $\sigma = 1.00$ .

$\gamma$	$T_r$	$T_{p1} - M_{p1}$	$T_{p2} - M_{p2}$	$T_{p3} - M_{p3}$	$T_s$
1.25	1.49	4.56 - 1.678	10.95 - 1.315	17.27 - 1.634	24.63
1.00	2.29	4.93 - 1.082	12.10 - 1.002	-----	5.98
0.75	11.25	-----	-----	-----	27.51
0.50	-----	-----	-----	-----	-----

Similar characteristics for  $\sigma = 0.1$  and the same different values of  $\gamma$  considered before are presented in Fig. 4 and Table 3. The general arguments discussed for the case  $\sigma = 1$  hold. For  $\gamma = 1.25$ , all the critical frequencies are increased whilst the critical gains and the quality factor remain the same. For  $\gamma = 1.00$  the responses are hardly

affected. For  $\gamma \leq 1$ , all the critical frequencies decrease with decreasing  $\gamma$ .

Considering the phase characteristic, it is slightly increased (decreased) for  $\gamma = 1.25$  ( $\gamma < 1.00$ ) and almost unaffected for  $\gamma = 1.00$ .

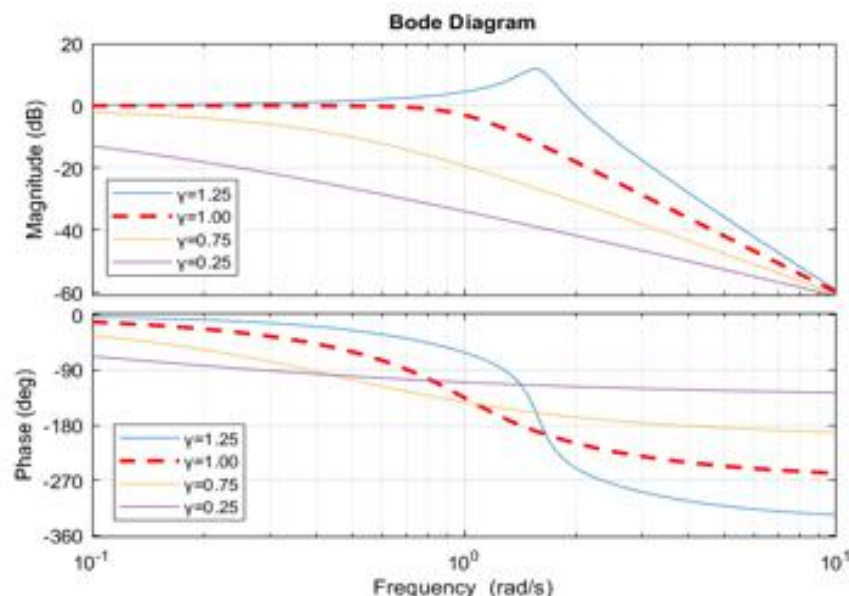


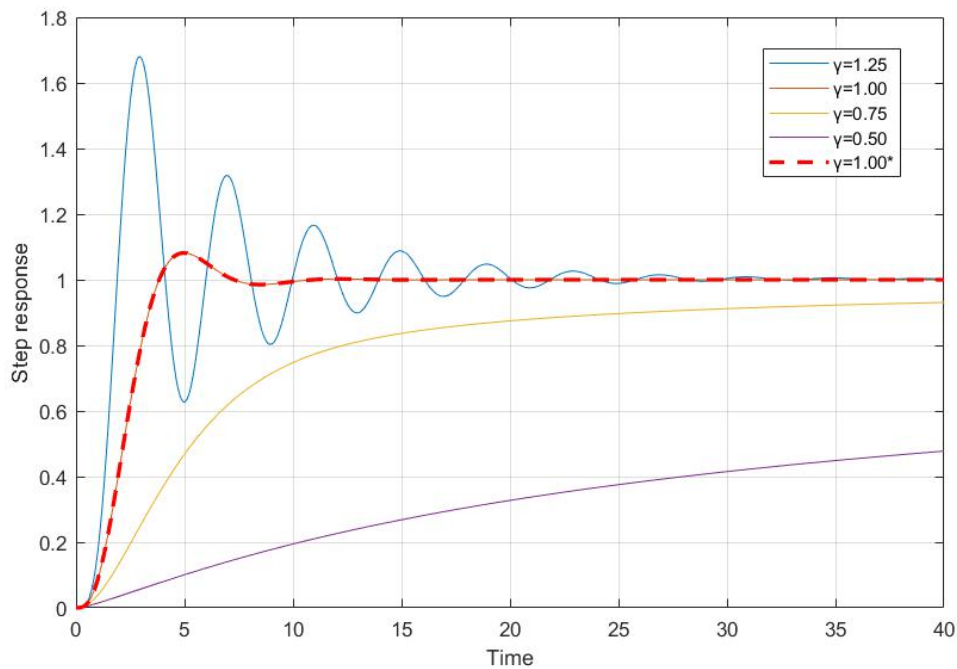
Fig.4: Bode plots of the transfer function for  $\sigma = 0.1$ .

Table.3: Numerical data for frequency response curves when  $\sigma = 0.1$  for the filter.

$\gamma$	$\omega_1 - (M_1)$	$\omega_2 - (M_2)$	$\omega_p - (M_p)$	$BW - (BP)$	$Q - BP$
1.25	1.350 - 8.835	1.701 - 8.854	1.552 - (11.844)	1.701 - (0.351)	4.422
1.00	---	1.000 - (-3)	0 - (0)	1.000 - (---)	---
0.75	---	0.145 - (-3)	0 - (0)	0.145 - (---)	---
0.50	---	0.006 - (-3)	0 - (0)	0.006 - (---)	---

Step response of the filter for  $\sigma = 0.1$  is shown in Fig. 5. It is seen that the conventional Butterworth filter response is not affected by  $\sigma$  when  $\gamma = 1.00$  (see the legends  $\gamma = 1.25$  and  $\gamma = 1.25^*$ ). Further, the peak values of oscillations are not affected by changing  $\sigma$  from 1 to 0.1.

But there is an apparent time lead (squeeze) for  $\gamma = 1.25 >$ , and time lag (spread) for  $\gamma = 0.75 < 1$ . The lag (spread) is higher for  $\gamma = 0.50$ . See Table 4 for numerical details. The time lead (lag) is used in the sense of faster (slower) motion.

Fig.5: Step responses of the transfer function when  $\sigma = 0.1$ .Table 4: Step response characteristics for  $\sigma = 0.1$ .

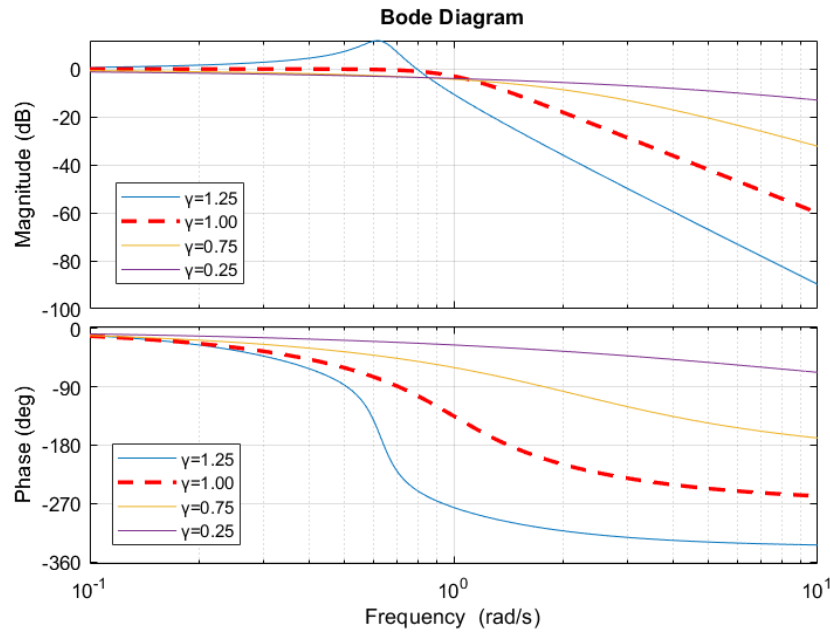
$\gamma$	$T_r$	$T_{p1} - M_{p1}$	$T_{p2} - M_{p2}$	$T_{p3} - M_{p3}$	$T_s$
1.25	1.49	2.88 - 1.678	6.91 - 1.315	10.90 - 1.634	15.54
1.00	2.29	4.93 - 1.082	12.10 - 1.002	19.35 - 1.000	5.98
0.75	24.24	-----	-----	-----	-----
0.50	-----	-----	-----	-----	-----

Similar frequency characteristics for  $\sigma = 10$  and the same different values of  $\gamma$  considered before are presented in Fig. 2 and Table 1. The general arguments discussed for the case  $\sigma = 1$  hold. For  $\gamma = 1.25$ , all the critical frequencies are decreased whilst the critical gains and the quality factor remain almost the same. For  $\gamma = 1.00$  the

responses are hardly affected. For  $\gamma \leq 1$ , all the critical frequencies decrease with decreasing  $\gamma$ .

Considering the phase characteristic, it is decreased (increased) for  $\gamma = 1.25$  ( $\gamma < 1.00$ ) and almost unaffected for  $\gamma = 1.00$ .



Fig.6: Bode plots of the transfer function for  $\sigma = 10$ .Table.5: Numerical data for frequency response curves when  $\sigma = 10$  for the filter.

$\gamma$	$\omega_1 - (M_1)$	$\omega_2 - (M_2)$	$\omega_p - (M_p)$	$BW - (BP)$	$Q - BP$
1.25	0.537 - 8.815	0.677 - 8.868	0.618 - (11.844)	0.677 - (0.140)	4.414
1.00	---	1.000 - (-3)	0 - (0)	1.000 - (---)	---
0.75	---	0.145 - (-3)	0 - (0)	0.145 - (---)	---
0.50	---	0.006 - (-3)	0 - (0)	0.006 - (---)	---

Step response of the filter for  $\sigma = 10$  is shown in Fig. 5. It is seen that the conventional Butterworth filter response is not affected by  $\sigma$  when  $\gamma = 1.00$  (see the legends  $\gamma = 1.25$  and  $\gamma = 1.25^*$ ). Further, the peak values of oscillations are not affected by changing  $\sigma$  from 1 to 10.

But there is an apparent time lag (spread) for  $\gamma = 1.25 > 1$ , and time lead (squeeze) for  $\gamma = 0.75 < 1$ . The lead (squeeze) is higher for  $\gamma = 0.50$ .

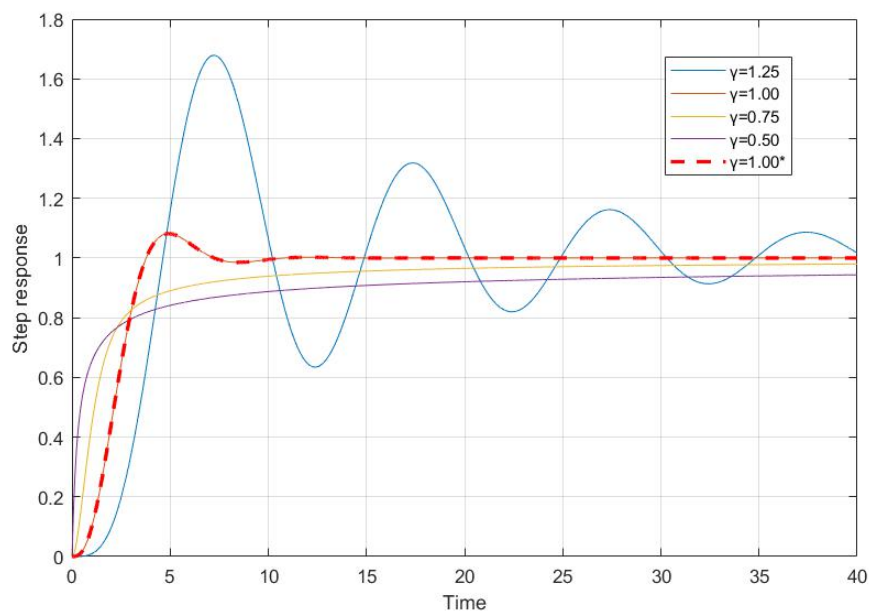
Fig.7: Step responses of the transfer function when  $\sigma = 10$ .

Table.6: Step response characteristics for  $\sigma = 10$ .

$\gamma$	$T_r$	$T_{p1} - M_{p1}$	$T_{p2} - M_{p2}$	$T_{p3} - M_{p3}$	$T_s$
1.25	2.38	7.23 - 1.678	17.35 - 1.315	27.37 - 1.634	39.05
1.00	2.29	4.93 - 1.082	12.10 - 1.002	19.35 - 1.000	5.98
0.75	5.22	-----	-----	-----	12.77
0.50	12.63	-----	-----	-----	-----

## VI CONCLUSION

A FO Butterworth filter derived from the conventional 3<sup>rd</sup> order Butterworth filter by the IO derivative to FO derivative transformation with two parameters  $\gamma$  and  $\sigma$  as in [17] is investigated in this paper. It is arrived the following conclusions.

1. A variety of low pass filters can be obtained by changing the parameters  $\gamma$  and  $\sigma$ .
2. For  $\gamma > 1$ , the classical frequency response curve of the Butterworth filter disappears, and a peak occur in the frequency response.
3. When  $\gamma = 1$ ,  $\sigma$  does not effect on the characteristics.
4.  $\sigma$  dominantly affect the time characteristics, critical magnitudes of the time responses are not changed, but increase of  $\sigma$  causes a slower (faster) response for  $\gamma > 1$  ( $\gamma < 1$ ). That is  $\sigma$  effects like a time scaling operator.
5. Effect of  $\sigma$  on the phase characteristics is that increase of  $\sigma$  decreases (increases the phase if  $\gamma > 1$  ( $\gamma < 1$ )).
6. For  $\gamma > 1$  and as  $\gamma \rightarrow 1.38$  the filter can be used a high-Q narrow band pass filter as well. But in the limit case the filter becomes unstable.

Having in mind these conclusions, fractional order low pass filters and/or band pass filters can be designed.

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# Frequency Response of a Fractional Order Shunt Resonator of the Class $R-RL_\beta C_\alpha$

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**Abstract**—Frequency domain analysis of a fractional order parallel shunt resonator of the class  $R-RL_\beta C_\alpha$  is conducted. The voltage and current waveforms are computed in the frequency domain. It is shown that the circuit exhibits all three types of basic filtering characteristics; namely low-pass, band-pass, and high-pass.

**Keywords**—Fractional order derivative, frequency response, fractional inductance, fractional capacitance.

## I. INTRODUCTION

Although the fractional order (FO) derivative is not new in mathematics [1], it has gained great popularity in the application of fractional calculus in the last few decades at various areas of science and engineering [2-7]. In particular, electrical circuits having FO components have been dealt with many authors [8-11]. In [12], Walczak and Jacubowska studied the series FO  $RL_\beta C_\alpha$  circuit. And a recent paper by Ciszek and Walczak has covered the transients states of a parallel circuit composed of fractional order inductor and capacitor branches are analyzed.

Ciszek and Walczak presented the results of transient analysis in a parallel circuit containing a real coil  $L_\beta$  and a supercapacitor  $C_\alpha$  modelled as fractional elements in their paper [13]. Current and voltage waveforms are obtained with different current source excitations for both cases of real and complex poles. But they hardly concerned with the frequency response characteristics of the circuit. In this contribution, we study the frequency response characteristics of the similar circuit but added with a load resistance  $R$  which can be treated as (or combined with) the source resistance as well. The resulting circuit is shortly denoted by  $R-RL_\beta C_\alpha$ , and as far as the author's knowledge, it has not been studied before.

The paper is organized as follows; Section 2 introduces the  $R-RL_\beta C_\alpha$  circuit and its formulation. Section 3 covers the derivation of the transfer functions. Frequency response properties and time domain step responses are studied on the base of examples in Section 4. Finally, Section 5 covers the conclusions.

## II. $R-RL_\beta C_\alpha$ CIRCUIT

The FO parallel resonator circuit considered in this paper is shown in Fig. 1. The FO coil inductance is  $L_\beta$  and FO capacitance is  $C_\alpha$ ;  $\alpha, \beta \in R^+$ .  $R_L$  is the series internal resistance of the coil,  $R_C$  is the ESR resistance of the capacitor. The circuit is excited by a parallel current source  $I(t)$ ;  $R$  represents either the internal resistance of the source and/or the load resistance of the circuit, if both exist they can be combined.  $I_R, I_L, I_C$  represent currents flowing through the resistor, inductor, and capacitor respectively. According to the Kirchhoff's current law

$$I_R(t) + I_L(t) + I_C(t) = I(t). \quad (1)$$

The component behavior equations are

$$V = RI_R, V_{RL} = R_L I_L, V_{RC} = R_C I_C, \quad (2a, b, c)$$

for the resistances. The FO components are modelled by

$$V_{L_\beta}(t) = L_\beta \frac{d^\beta I_L(t)}{dt^\beta}, I_C(t) = C_\alpha \frac{d^\alpha V_{C_\alpha}(t)}{dt^\alpha}. \quad (3a, b)$$

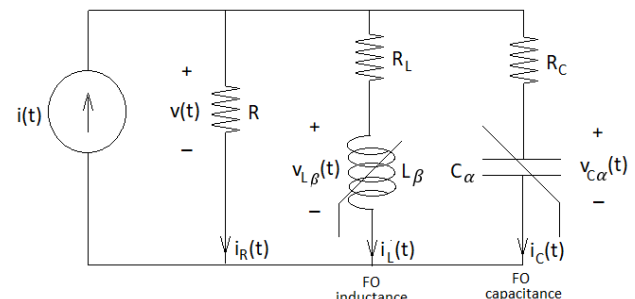


Fig. 1: Fractional order shunt resonator

## III. TRANSFER FUNCTIONS

From the Kirchhoff's voltage law

$$V(t) = R_L I_L(t) + V_{L_\beta}(t), \quad (4a)$$

$$V(t) = R_C I_C(t) + V_{C_\alpha}(t). \quad (4b)$$

Taking the Laplace transform of Eqs. (1-4) with zero critical conditions, we obtain

$$I_R + I_L + I_C = I, \quad (5)$$

$$V = RI_R, V_{RL} = R_L I_L, V_{RC} = R_C I_C, \quad (6a, b, c)$$

$$V_{L_\beta} = L_\beta S^\beta I_L, I_C = C_\alpha S^\alpha V_{C_\alpha}, \quad (7a, b)$$

$$V = R_L I_L + V_{L_\beta}, V = R_C I_C + V_{C_\alpha}. \quad (8a, b)$$

These eight equations in eight unknowns ( $I_R, I_L, I_C, V, V_{RL}, V_{RC}, V_{L_\beta}, V_{C_\alpha}$ ) can be solved in terms of  $I$ ; the resulting transfer functions are

$$H_{VR} = \frac{V}{I} = \frac{\Delta_v(s)}{\Delta(s)}, \quad (9a)$$

$$H_{IR} = \frac{I_R}{I} = \frac{\Delta_v(s)}{R\Delta(s)}, \quad (9b)$$

$$H_{IL} = \frac{I_L}{I} = \frac{\Delta_v(s)}{(L_\beta S^\beta + R_L)\Delta(s)}, \quad (9c)$$

$$H_{IC} = \frac{I_C}{I} = \frac{C_\alpha S^\alpha \Delta_v(s)}{(R_C C_\alpha S^\alpha + 1)\Delta(s)}, \quad (9d)$$

$$H_{VL} = \frac{V_{L\beta}}{I} = \frac{L_\beta S^\beta \Delta_v(s)}{(L_\beta S^\beta + R_L)\Delta(s)}, \quad (9e)$$

$$H_{VC} = \frac{V_{C\alpha}}{I} = \frac{\Delta_v(s)}{(R_C C_\alpha S^\alpha + 1)\Delta(s)}, \quad (9f)$$

$$H_{VRL} = \frac{V_{RL}}{I} = R_L \frac{I_L}{I} = \frac{R_L \Delta_v(s)}{(L_\beta S^\beta + R_L)\Delta(s)}, \quad (9g)$$

$$H_{IRC} = \frac{V_{RC}}{I} = R_C \frac{I_C}{I} = \frac{R_C C_\alpha S^\alpha \Delta_v(s)}{(R_C C_\alpha S^\alpha + 1)\Delta(s)}. \quad (9h)$$

Where, with  $\mu = \frac{1}{GR_C + 1}$ ,  $\eta = GR_L + 1$ ,  $G = \frac{1}{R}$ ,

$$\Delta_v(s) = \mu \left( R_L S^{\alpha+\beta} + \frac{R_L R_C}{L_\beta} S^\alpha + \frac{1}{C_\alpha} S^\beta + \frac{R_L}{L_\beta C_\alpha} \right),$$

$$\Delta(s) = S^{\alpha+\beta} + \frac{R_C}{L_\beta} \left( \mu + \frac{R_L}{R_C} \right) S^\alpha + \frac{\mu G}{C_\alpha} S^\beta + \frac{\mu \eta}{L_\beta C_\alpha}.$$

From (6), the FO differential equation governing the dynamics of the circuit can be obtained by replacing the Laplace operator  $S^\gamma$  with  $\frac{d^\gamma}{dt^\gamma}$ , the result is

$$\begin{aligned} & \frac{d^{\alpha+\beta}}{dt^{\alpha+\beta}} v + \frac{R_C}{L_\beta} \left( \mu + \frac{R_L}{R_C} \right) \frac{d^\alpha}{dt^\alpha} v + \frac{\mu G}{C_\alpha} \frac{d^\beta}{dt^\beta} v + \frac{\mu \eta}{L_\beta C_\alpha} v \\ &= \mu R_L \frac{d^{\alpha+\beta}}{dt^{\alpha+\beta}} I + \frac{\mu R_L R_C}{L_\beta} \frac{d^\alpha}{dt^\alpha} I + \frac{\mu}{C_\alpha} \frac{d^\beta}{dt^\beta} I + \frac{\mu R_L}{L_\beta C_\alpha} I. \end{aligned} \quad (10)$$

Since the scope of the paper is mainly confined to frequency response characteristics, the solution of this fractional order differential equation for  $v(t)$  when different types of excitons (such as impulse, step, sinusoid etc.) is left as a future work. The result will be the generalization of the analytical solutions given in [13] for the case of nonideal current source and/or the existence of a load resistance in the circuit.

#### IV. EXAMPLES

As the first example, assume the numerical values of the components are chosen as follows: a supercapacitor of pseudo-capacitance  $C_\alpha = 10F/s^{1-\alpha}$ , with a series internal resistance of  $R_C = 0.1\Omega$ ; a real FO coil of pseudo-inductance  $L_\beta = 1 + s^{1-\beta}$  with a series interval resistance of  $R_L = 0.1\Omega$ . Coefficients of the FO elements are  $\alpha = 0.5, \beta = 0.25$ . The source and/or load resistance  $R = 4\Omega$ .

The Bode plots of transfer functions  $H_{IR}, H_{IL}, H_{IC}$  are shown in Fig. 2. It is seen that  $H_{IL}$  ( $H_{IC}$ ) exhibits low pass (high pass) filter characteristics, and  $H_{IR}$  has a small magnitude of type band pass, which is due to the

relatively high value of  $R = 4\Omega$ . The gain and phase relations are observed to be consistent with Eqs. (9b,c,d).

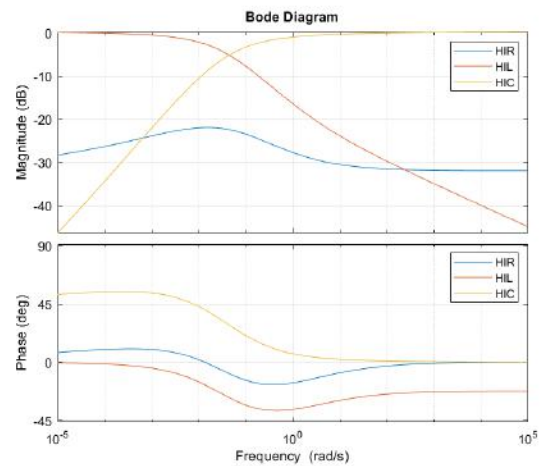


Fig. 2: Bode Plots of  $H_{IR}, H_{IL}, H_{IC}$  for Example 1

Fig. 3 shows the time variations of the currents  $I_{L\beta}, I_{C\alpha}, I_R$ . It is observed that  $I_R$  is smaller than  $I_{L\beta}$  and  $I_{C\alpha}(t)$  due to high values of  $R$ .  $I_{L\beta}$  and  $I_{C\alpha}(t)$  show step responses typical to low pass and high pass filters, respectively. Note also that these three characteristics sum up to unity at any time.

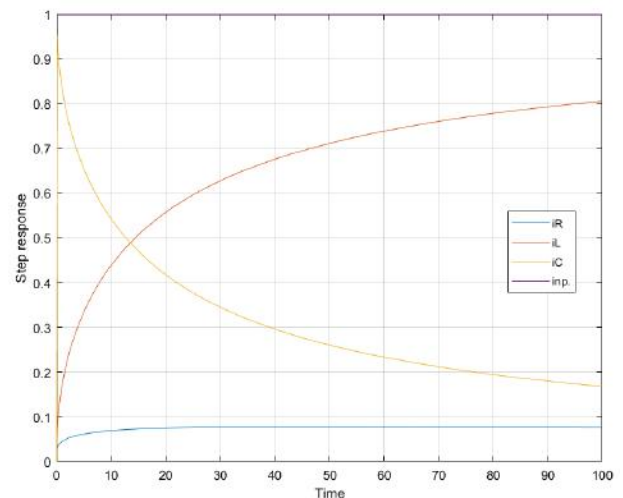


Fig. 3: Step Responses for the Currents in Example 1

Step response for the voltages  $V_R, V_{RL}, V_L, V_{RC}, V_C$  are shown in Fig. 4. Note that Kirchhoff's voltage laws  $V_{RL} + V_L = V_R, V_{RC} + V_C = V_R$  are satisfied.



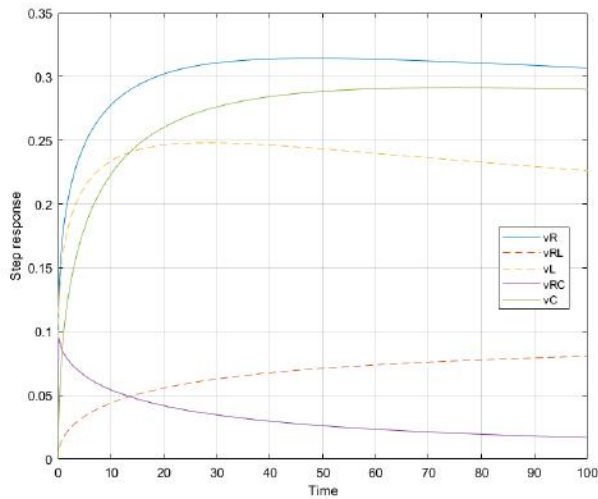
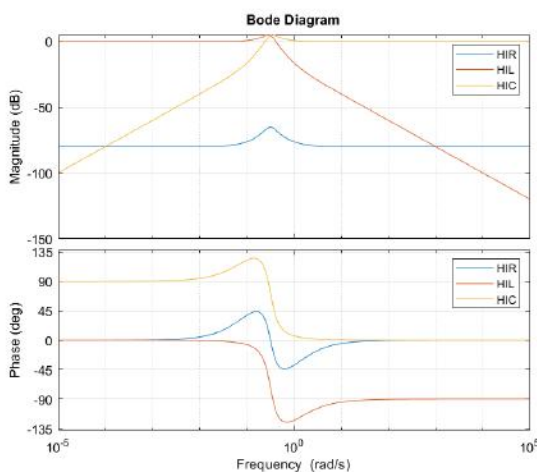


Fig. 4: Step Responses for the Voltages in Example 1

The hole circuit exhibits an overdamped type step response characteristics and highly stable.

As the second example, we consider the same parameters values except,  $\beta = 1.00$ ,  $\alpha = 1.00$  and  $R = 1000\Omega$ . This case corresponds to an integer order circuit with a very slight load  $R$ , whilst the internal losses  $R_L$  and  $R_C$  are present.

The results of the simulations are presented in Figs. 5,6,7. In Fig. 5, the low pass and high pass characteristics of  $H_{IL}$  and  $H_{IC}$  are preserved, but the cut off rate is sharper. It is also apparent that  $H_{IR}$  is much more reduced than in Example 1 due to the high resistance  $R = 1000\Omega$ , though it is still a band pass characteristic. The same sharpening is observed in the phase characteristics as well.

Fig. 5: Bode Plots of  $H_{IR}$ ,  $H_{IL}$ ,  $H_{IC}$  for Example 2

Currents  $I_R$ ,  $I_{L\beta}$ ,  $I_{C\alpha}$  for a unit step are plotted in Fig. 6. It is seen that  $V_R(t)$  is almost zero since  $R = 1000\Omega$ . Further, the currents  $I_R$ ,  $I_{L\beta}$ ,  $I_{C\alpha}$  sum up to the unit input step. The circuit behaves as an underdamped circuit due

to oscillations in the responses. The damping is small due to the small values of internal resistances  $R_L$  and  $R_C$ .

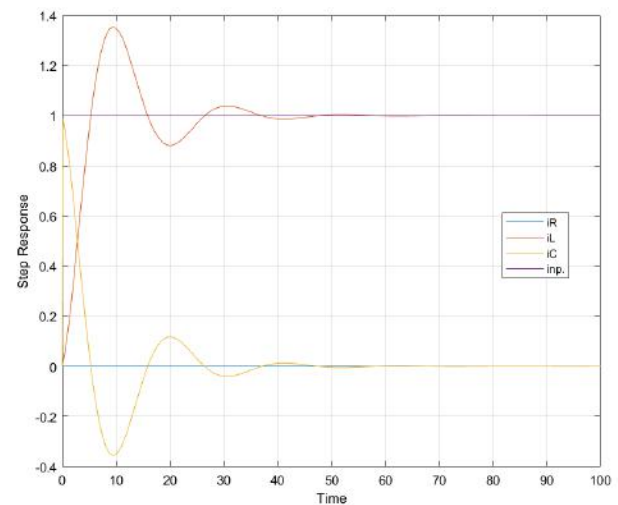


Fig. 6: Step Responses for the Currents in Example 2

Step responses for the voltages  $V_R$ ,  $V_{RL}$ ,  $V_L$ ,  $V_{RL}$  and  $V_C$  are shown in Fig. 7. The underdamped nature of the circuit is observed in all responses. Kirchhoff's voltage laws  $V_{RL} + V_L = V_R$ ,  $V_{RC} + V_C = V_R$  are still observed in all responses.  $V_{RC}$  goes to 0 as  $t$  gets large due to open circuit behavior of the capacitor under steady-state conditions with step input so it hardly passes current, so that  $V_{RC} = 0$ .

Similar argument holds for the inductor; it behaves as short circuit under step input steady-state conditions and the voltage across  $R_{L\beta}$  is generated by the full input current, so  $V_{RL\beta} = R_{L\beta} \cdot 1 = 0.1A$  as  $t$  gets infinity.

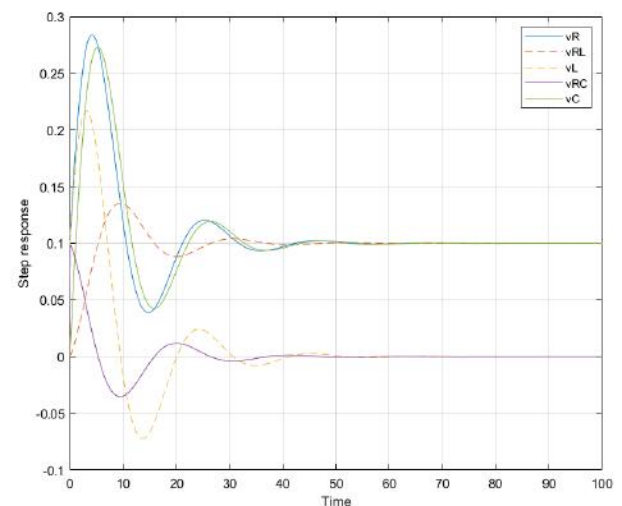


Fig. 7: Step Responses for the Voltages in Example 2.

## V. CONCLUSION

Frequency response characteristics and step responses of a lossy, fractional order, parallel  $RLC$  circuit driven by a current source is investigated in this paper. Since the circuit is loaded and/or driven by a non-ideal current source due to its internal resistance, it is denoted by the

class  $RL_{\beta}C_{\alpha}$ , where the first  $R$  denotes this resistance. The circuit is modelled in both time and frequency domains, but only frequency domain analysis results are given. Three types of filter characteristics are noted each of which due to a branch of the circuit. It is observed that the circuit exhibits the response characteristics of a tank resonator with lossy capacitor and inductor for unity values of the fractional orders. It is avoided from further numerical examples to keep the content substantial. Explicit solutions of different voltages and currents in the circuit when it is excited by several types of source waveforms (such as step, sinusoidal, exponential, poly-harmonic and arbitrary being an element of a Hilbert space) can be found by the Laplace transform method applying the decomposition of FO rational functions to partial fractions. The results will involve single and two parameter Mittag-Leffler function. However, due to the added source and/or load resistance  $R$ , the characteristic polynomial gets more complicated and this will cover much more effort than in [13]. Therefore, that part of the study is left as a future work.

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# Feasibility study of a new approach to removal of nitrates from groundwater by Biological Denitrification

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**Abstract**— The removal of nitrate is essential for water contaminated with nitrate before being utilized, since a large amount of nitrate in drinking water often causes a disease called methemoglobinemia and other health disorders such as hypertension, increased infant mortality, goiter, stomach cancer, thyroid disorder, cytogenetic defects and birth defects. Hence nitrate removal is an important aspect of present day's wastewater treatment process. Physical and chemical processes such as reverse osmosis, ion exchange, electro dialysis and chemical denitrification have been developed for nitrate removal from water. These techniques are effective in removing nitrate from contaminated water; they are very expensive for pilot scale operation with a limited potential application. Owing to these limitations in the removal of nitrate from water and/or wastewater, the most versatile and widely used technology is biological denitrification. Hence in this research work, feasibility study was carried out for removing nitrate from ground water by biological denitrification with optimum amount of carbon source under anoxic condition.

**Keywords**— *Biological denitrification, Bioreactor, Carbon sources, Ground water, Nitrate.*

## I. INTRODUCTION

Water, the best of all things is the nature's free gift for living organisms. It is bound up with man's evolution and doubtless destiny in countless ways. Water has been used for drinking, domestic purpose, industry, agriculture and recreation; it shows the extent to which it is an integral part of our life. Water is absolutely essential not only for human beings, but also for animals, plants and all the other living beings. The basic condition for life on earth is that water should be available in the liquid form. Three-fourth of the earth's surface is covered with water of the total water resource available, about 97.25% is salt water, which is mainly in ocean and 0.68% is available as groundwater. 2.05% as ice caps, 0.001% of atmospheric moisture, 0.005% of soil moisture, 0.01% in lakes, 0.0001% in rivers and 0.00004% in the biosphere (Global

Water cycle: Geochemistry and Environment, 1987). However, very little quantity of water is fit for human consumption.

The rapid urbanization, industrialization as well as agricultural activities has made environmental pollution a growing concern globally. Of all the receptor systems exposed to the contaminants, groundwater has received little attention in the past because of common belief that groundwater was pristine. Groundwater provides drinking water for more than one-half of the nation's population, and is the sole source of drinking water for many rural communities and some large cities. In India, the groundwater contamination with respect to nitrate has been observed in few areas of Andhra Pradesh, Bihar, Delhi, Haryana, Himachal Pradesh, Karnataka, Rajasthan, Tamil Nadu and West Bengal.

The studies carried out in India reveal that one of the most important causes of groundwater pollution is unplanned urban development without adequate attention to sewage and waste disposal. Industrialization without provision of proper treatment and waste and effluent disposal is another source of groundwater pollution. Excessive application of fertilizers for agricultural development coupled with over irrigation is also responsible for groundwater pollution [8].

### 1.1 Importance of groundwater

Groundwater is important to those who have limited prescription each year. Groundwater is the primary source of water for 50% of the American population and 90% of those people in rural areas. In India, 58% of the total population uses groundwater. It plays an important role in the hydrologic cycle. Groundwater is the safest and most reliable source of available freshwater. Only 3% of earth's freshwater are located in streams, lakes, and reservoirs. The remaining 97% of freshwater is underground. Of the public supply systems in India, 43% use groundwater and of the people who live in rural areas in India, 87% use groundwater. About 500,000 individual homes, 425 public water systems and 2,500 non-community water supplies are dependent on groundwater. Groundwater is

vital for Indian's industrial and agricultural growth and development. According to reports in 1985 for India, industry uses an average of 190 million gallons per day during the growing season and livestock operations depend on an average of 45 million gallons per day (Haller et al, 1996)[10]

The availability and quality of groundwater varies widely across the states of India. In general, well yields range from less than five gallons per minute in bedrock aquifers in southwest in India to several thousand gallons per minute well in aquifers beneath and adjacent to India's major rivers. Most freshwater or portable groundwater in India occurs at depths of 40 feet to 300 feet. Highly mineralized waters are usually found at greater depths[8]

### 1.2 Nitrate ( $\text{NO}_3^-$ )

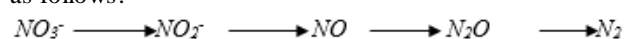
Nitrate compounds are very soluble in water. The nitrate part (ion) is negatively charged, and since soil is also negatively charged, it is repelled by soil surfaces and stays in the solution. When excess water drains through soil, nitrate is washed out (leached). Nitrogen in the form of nitrate in surface and groundwater can be an important consequence of groundwater pollution arising from both rural and urban areas. Nitrate leaching to the water environment is contributed from the application nitrogen fertilizer in agriculture, wastes from grazing animals and soil erosion. If high rainfall occurs after ammonium nitrate fertilizer has been applied, much of the nitrate will be leached, but otherwise nitrate is taken up by plants very quickly. Nitrite ( $\text{NO}_2^-$ ) is one of the several inorganic pollutants contributed by nitrogenous fertilizers, organic manure, human and animal wastes and industrial effluents through the biochemical activities of micro-organisms [8].

### 1.3 Biological Methods

Nitrate removal through biological means is based on denitrification, a microbial process carried out mainly by facultative aerobic bacteria that, under anoxic conditions nitrate as the terminal electron acceptor in their respiratory process. Denitrifying bacteria are ubiquitous in nature; they are found in soils, activated sludge, aquatic sediments in fresh, brackish and sea water, and in living organisms such as honeybee larvae.

### 1.4 Biochemical aspects of denitrification

The reaction requires an electron donor, as well as 10 electrons and 12 protons. The end products of the reaction are dinitrogen gas and  $\text{OH}^-$ , the latter of which makes it an alkalinizing process. Denitrification is an assembly of nitrate reduction, nitrite reduction, nitric oxide reduction and nitrous oxide reduction. The sequence of reactions is as follows:



This sequential pathway involves multiple enzyme systems, those of which are present in and vary among phylogenetically different organisms.

The availability of carbon and energy sources plays a major role in denitrification activity as they are required for cell growth and metabolism. Denitrifiers fall into two metabolic categories: heterotrophic bacteria that utilize organic carbon and energy sources, and autotrophs which use inorganic forms. While these bacteria are ubiquitous in nature, nitrate cannot be removed intrinsically due to limited amounts of carbon and energy in unpolluted groundwater, thus creating a need for engineered denitrification processes.

### 1.5 Heterotrophic biological denitrification

Heterotrophic biological denitrification is a well-established process in the realm of wastewater treatment. Numerous studies reported on the potential of using biological denitrification for nitrate reduction in groundwater supplies in laboratory-scale experiments. The results indicated that fixed-film denitrification can be expected to reduce the nitrate concentration in the influent water supply from as high as 100 mg/L (as N) to levels within the 1.0mg/L (as N) range. These removals translate into an efficiency of nearly 100percent, which is generally not matched by other processes available for nitrate reduction. However, some residual soluble as well as insoluble organic matter should be expected in the denitrified water supply. Further treatment can reduce these solids to levels sufficient to meet prevailing drinking water standards. In heterotrophic biological denitrification, facultative micro-organisms are contacted with the water supply containing nitrates and an added carbon source in an anoxic (oxygen-free) environment. Under these conditions, the bacteria utilize nitrates as a terminal electron acceptor in lieu of molecular oxygen. In the process, nitrates are reduced to nitrogen gas, which is harmless and can be directly discharged to the atmosphere. The extraneous carbon source is necessary since it supplies the energy required by the micro-organisms for respiration and synthesis while serving as an electron donor. Most denitrification studies have used methanol ( $\text{CH}_3\text{OH}$ ) as the carbon source. If a simple carbon source is chosen such as ethanol or acetic acid, then the biomass produced during the process should be correspondingly low; a useful characteristic in that the overall excess biomass production is minimized. Since heterotrophic denitrifying bacteria require an organic carbon source for the respiration and growth, a wide variety of organic compounds have been used.

These organics include methanol, ethanol, acetic acid, glucose, and other more complex organics. While the types of organic compounds may affect the biomass yield, the choice is generally based on economic comparison. The availability of ethyl alcohol from agricultural sources could make this carbon source a strong candidate for denitrification systems. It should be

noted that methanol toxicity is such that it is not recommended as electron donor and carbon source for drinking water denitrification[28].

## II. MATERIALS AND METHODOLOGY

This section describes the procedure followed to conduct various experiments and the materials used in order to meet the objectives of the study.

### 2.1 Details of Materials and Experiments for the Biological Denitrification Study

#### 2.1.1 Bioreactor setup:

The anoxic batch reactor of 2L of working volume was used for denitrification purpose. Synthetic water, seed material and carbon source were added to each batch. Synthetic water sample was prepared by adding a measured amount of potassium nitrate to the tap water to get the required concentration of nitrate. The reactor consisting of sample, cow dung, carbon source is kept closed to maintain anoxic condition.

Cow dung slurry was used as a seed culture since cow dung is rich in heterotrophic bacteria which are responsible for denitrification process. The seed culture was prepared by taking 100 g of fresh cow dung mixed in 1000 ml of water to get slurry from which filtered 300 ml was added to the each anoxic reactor.

In the present study we use three types of carbon sources are paddy straw, ragi straw, and wheat straw. These are agricultural by-product; the dry stalks of serial plants, after the grain and chaff have been removed. In order to find effective carbon source for denitrification paddy straw, wheat straw, ragi straw was added for three reactors separately. Since ragi straw was found to be effective as carbon source in initial studies the same continued for further studies.

Groundwater sample was collected from the bore well of Mysugar industrial area Mandya. Calculated amount of potassium nitrate was added to the groundwater samples to obtain the required amount of nitrate nitrogen, for the study purpose.

#### 2.2 Operational strategy

The entire study was done in five phases, in first phase, feasibility of removing nitrate from synthetic water containing nitrate was studied. In the second and third phase optimization of carbon source was done. In the fourth phase, nitrate removal under various nitrate loading conditions was evaluated. In the fifth phase, evaluation of a treatment system with denitrification, filtration, and disinfection for community water treatment system has been done.

##### 2.2.1 Phase – 1: Feasibility of nitrate removal

A bioreactor was started with carbon source as powdered ragi straw and cow dung slurry as seed culture to study the feasibility of nitrate nitrogen removal. Raw

water used for this study was synthetic water containing 50 mg/L of nitrate nitrogen.

##### 2.2.2 Phase – 2 and 3: optimization of carbon source

Four batch reactors were started with different amount of carbon sources: 0.1, 0.2, 0.4, 0.6 gm/2L of water to be treated along with 100 ml of seed slurry. The nitrate nitrogen concentration in the synthetic water was maintained at 50 mg/L which is slightly more than the drinking water quality standard value of 45 mg/L. Synthetic water was prepared by adding 81.5 mg/L of KNO<sub>3</sub> in 100 mg/L of tap water to get 50 mg/L of nitrate nitrogen. Table 1 provides the reactor details during the optimization of carbon source.

Table.1: Details of anoxic batch reactors

Number of reactors	04
Total reactor volume	2.5 L
Working volume	2 L
Cow dung slurry	100 ml
Nitrate concentration	50 mg/L
Carbon source	0.1, 0.2, 0.4, 0.6 gm/L

The reactors were operated for 2 weeks and the samples were collected on alternate days for analysis. Before analysis the samples were filtered using filter paper and analyzed for nitrate, nitrite, ammonia, COD, pH.

As the COD concentration in the treated water was found more in first batch studies with carbon source concentration of 0.1 to 0.6 gm/L. To reduce this, a second set of batch reactors was started. Totally four reactors were started with 50 mg/L of nitrate concentration in synthetic water and 100 ml of seed slurry. The powdered ragi straw added was 0.025, 0.05, 0.075, 0.1 gm/ 2L in reactors 1, 2, 3 and 4 respectively. This study was conducted for 12 days and the samples were collected on alternate days and analyzed for the above mentioned parameters.

##### 2.2.3 Phase – 4: Various nitrate loading conditions

In this study the carbon source was maintained constant based on previous set of batch studies and the nitrate loading conditions were altered to know the performance of anoxic batch reactor. Four reactors were set up with specified amount of seed (100 ml) and carbon source (0.05 g/ 2L). The nitrate concentration was varied as 60, 70, 80, 90 mg/L. In this study each day samples were collected and analyzed for their nitrate removal efficiency. This study was conducted for four weeks with continuous cycles. When the nitrate concentration was removed then the 1 L of clarified supernatant (treated water) was decanted. The decanted volume was replaced by fresh synthetic water samples for next cycle.



### III. RESULTS AND DISCUSSION

#### 3.1 Effective carbon sources

In the present work, in order to find effective carbon source for denitrification paddy straw, wheat straw, and ragi straw was added for three reactors

separately. These are very cheap and economically available. These carbon sources are effectively remove the nitrate nitrogen and COD during denitrification process.

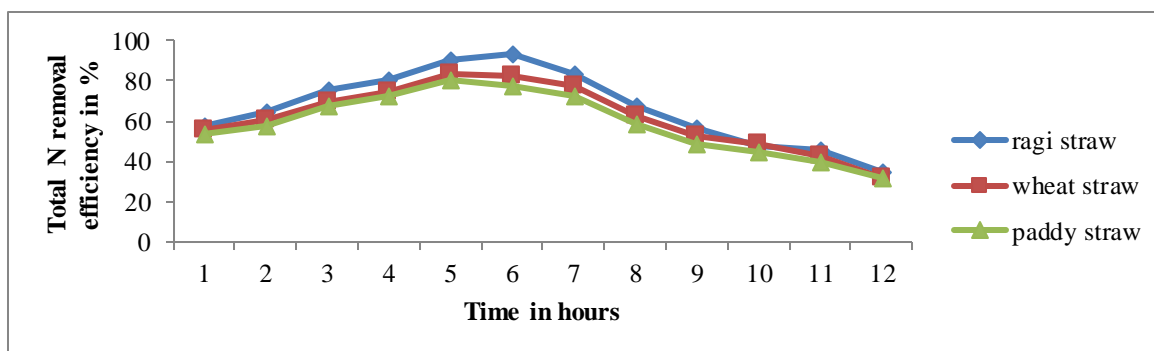


Fig. 1: Total Nitrate removal efficiency of ragi straw, wheat straw and paddy straw

Figure 1 shows, the total Nitrate removal efficiency of ragi straw, wheat straw and paddy straw on initial nitrate concentration of 50 ppm. However, the nitrate removal efficiency is more during the period 6-8 hours for three carbon sources.

From the comparison of experimental results using carbon sources, it was clearly seen that the micro-organism used for the denitrification studies were active for ragi straw as carbon source compared to wheat straw and paddy straw. The use of ragi straw as the carbon

source resulted in the highest nitrogen removal efficiency, followed by wheat straw and paddy straw. The results suggest that the ragi straw is the most efficient carbon source for denitrification of wastewater. Wheat straw is a satisfactory alternative carbon source for nitrogen removal as compared to paddy straw. It is observed that the nitrate removal efficiency is more than 96% with ragi straw as a carbon source. Since ragi straw was found to be effective as a carbon source in initial studies the same continued for further studies.

Table.2: Performance of four anoxic reactors

Parameters	R1		R2		R3		R4	
	0.1 g/2L		0.2 g/2L		0.4 g/2L		0.6 g/2L	
	First day	Last day	First day	Last day	First day	Last day	First day	Last day
Nitrate nitrogen, mg/L	50.2	0	50.5	0	52.6	0	50.5	0
Nitrite nitrogen mg/L	0.014	0.04	0.014	0.08	0.042	0.07	0.042	0
Ammonia nitrogen, mg/L	0	15	0	10	0	12	0	12
COD, mg/L	320	6.4	640	12.8	1280	64	1920	128
pH	7.13	6.97	7.5	7.6	7.09	7.26	7.43	7.15

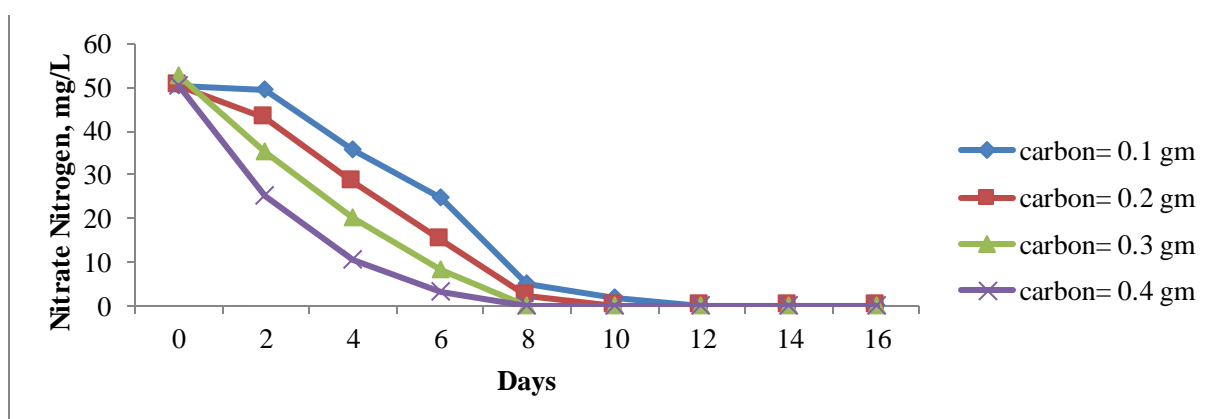


Fig. 2: Comparisons of nitrate removal in four reactors

Figure 2 shows the comparison of nitrate removal in all four reactors containing different amount of carbon source. It can be observed that the removal efficiency of nitrate is almost following the same trend but the COD concentration is more in reactor 2, 3 and 4 compared to reactor 1, in which the carbon source is 0.1 g. It can be noted that on day 8 in all the four reactors the nitrate nitrogen is nearly completely removed and with 0.1 g carbon source nitrate removal was effective. Based on the results of this study in the next batch studies carbon source of less than 0.1 g/2L has been tested.

The second batch studies were conducted for 10 days the reactors were fed with synthetic water containing nitrate nitrogen of 50mg/l and the powdered ragi

straw(carbon source) added were 0.025, 0.05, 0.075, 0.1gm/2L respectively in the four reactors. The results of the study are shown in the table 4.2. From the table it is clear that there remained some amount of nitrate nitrogen in reactor-1 fed with 0.025gm/2L of carbon source while in the other reactors it was below detection limit. The conversion of the nitrate to nitrite and ammonia was very less and this clearly shows that anoxic denitrification was taking place in all the four reactors. During denitrification process, a part of nitrate was converted into ammonia nitrogen but the amount was very less. It can be observed that the pH remains almost constant. In all the four reactors COD reduced to below detection limit at the end of reaction period.

Table.3: Performance of four anoxic reactors with various Carbon loading

Parameters	R1		R2		R3		R4	
	0.025 g/2L		0.05 g/2L		0.075 g/2L		0.1 g/2L	
	First day	Last day	First day	Last day	First day	Last day	First day	Last day
Nitratenitrogen,mg/L	50.5	6.3	54.7	0	50.5	0	52.6	0
Nitrite nitrogen mg/L	0.01	0.15	0	0.05	0	0.028	0	0.022
Ammonia nitrogen, mg/L	0.19	38.3	0.17	37.4	0.24	25	0.23	23.4
COD, mg/L	80	0	150.4	0	240	0	320	0
pH	7.02	7.88	6.92	7.77	7	7.2	6.9	7.55

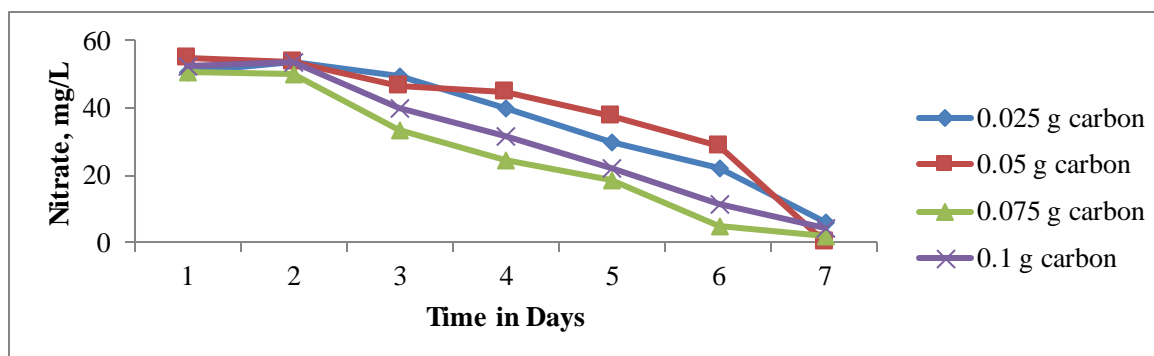


Fig.3: Comparison of nitrate removal in four reactors

From the figure 3 it can be noted that the removal efficiency of nitrate is almost following the same trend for reactor 2, 3 and 4. But the COD concentration is less in reactor-2 but the nitrate removal efficiency is

87.5% where as in reactor-2 it is 100%. Hence optimized carbon source is 0.05gm/2L and the same was maintained in the further studies.

Table.4: Comparison of performance of reactors operated with different nitrate nitrogen loading.

Parameters	R1		R2		R3		R4	
	60 mg/L		70 mg/L		80 mg/L		90 mg/L	
	First day	Last day	First day	Last day	First day	Last day	First day	Last day
Nitratenitrogen,mg/L	56.5	1.6	66.8	3.7	72	6.3	88.3	16
Nitrite nitrogen mg/L	0.012	0.15	0	0.015	0.042	0.07	0.042	0
Ammonia nitrogen, mg/L	0.23	12	0.25	14	0.24	9.6	0.23	7.7
COD, mg/L	256	0	256	6.4	224	0	224	0
pH	7.13	6.97	7.5	7.6	7.09	7.26	7.43	7.15

Figure 4 and Figure 5 shows the variation of COD and nitrate nitrogen with time (Days), in the four reactors fed with synthetic water containing 60, 70, 80 and 90mg/L of nitrate nitrogen and carbon source (ragi straw) added is 0.05gm/2L of water in the reactor. In the first reactor fed with 60mg/L of nitrate nitrogen the COD and nitrate nitrogen removal was rapid and the trends were similar. It was found that at the end of the process nitrate removal efficiency was 97.16% and COD removal was 100%. In reactor-2 wherein the feed containing 70mg/L of nitrate nitrogen was fed initially the COD was 256mg/L and the nitrate concentration was 66.8mg/L. In this reactor also the trends of COD as well as nitrate nitrogen removal was similar in the three cycles. In the second and the third cycle nearly complete COD and nitrate nitrogen removal was observed. At the end of the process nitrate removal efficiency was found to be 94.4% and the COD removals observed was 97.5%. in the reactor-

3 the feed contain 80mg/L of nitrate nitrogen. Initially COD was 224mg/L and the nitrate concentration was 72mg/L and at the end of process nitrate removal efficiency was 91.2% and the COD removal was nearly 100%. When higher concentration of nitrate nitrogen was present in the raw water (90mg/L) it was found that in all the three cycles the nitrate nitrogen removal was not complete and there remained 16-35 mg/L of nitrate nitrogen in the treated water. Also it was found that there was a lag was observed between COD uptake and nitrate nitrogen removal in reactor 3 and 4. At the end of the process nitrate removal efficiency was found to be 81.8% and COD removal efficiency observed was nearly 100%. It is observed that at various nitrate loading conditions (60, 70, 80 and 90 mg/L) nitrate nitrogen removal was effective. In the first 3 reactors the removal efficiency was above 90% whereas in the fourth reactor nitrate removal efficiency was less than 90%.

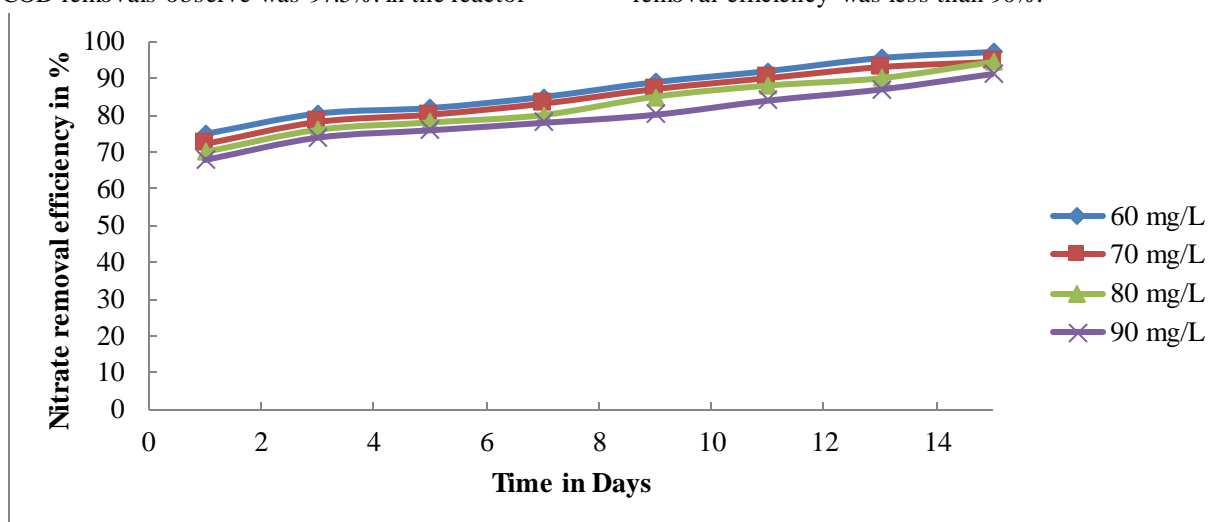


Fig 4: Nitrate removal efficiency in four reactor fed with influent containing different nitrate loading

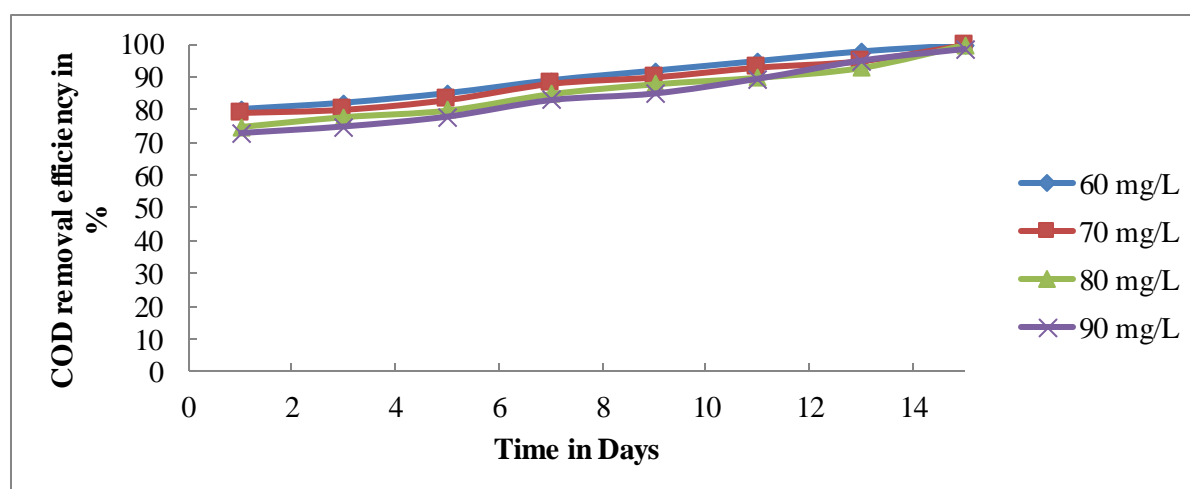


Fig 5: COD removal efficiency in four reactors fed with influent containing different nitrate loading

#### IV. CONCLUSIONS

- Among the three types of carbon source nitrate removal efficiency is more than 96% with Ragi

straw as a carbon source. Hence Ragi straw was found to be effective carbon source for denitrifying

the organisms under anoxic condition for further studies it was used as carbon source.

- Cow dung slurry was used as seed and it was effective in enriching denitrifying organisms.
- For optimization of carbon source added four anoxic batch reactors were operated with different amount of carbon source and nitrate removal was observed in the entire reactor, but the COD concentration in reactor 2, 3 and 4 was more compared to reactor 1.
- 0.05 g/2L of powdered ragi straw was found to be optimal dosage for complete nitrate nitrogen removal.
- From the overall studies biological and physico-chemical methods, both proved to be efficient with their own advantages and disadvantages.
- Biological treatment proved to be very effective and economical for the removal of nitrate. Even though the time required for the treatment is comparatively quite high, it can be preferred over the physico-chemical methods as all the materials used in the system were locally and cheaply available.

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# Estimation of Rainfall-Runoff Relationship Using Artificial Neural Network Models for Muskegon Basin

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**Abstract**— In order to determine the use, protection and economic life of water resources; it is important to make estimations about rainfall-runoff values. However, it is quite complicated to estimate rainfall-runoff. For this reason, Artificial Neural Networks (ANN) and Multiple Linear Regression (MLR) methods, which are widely used today for complex hydrological problems, are preferred for the rainfall-runoff model. For model creation, the hydrological and seasonal data from the United States Muskegon basin are used. Estimation study was done with ANN and MLR methods using 1396 daily rainfall, temperature and rainfall data belonging to the region. According to the model results, it is seen that the ANN method has results with low error and high determination in the rainfall runoff model. ANN method can be used as an alternative way to classical methods in rainfall-runoff predictions.

**Keywords**— Rainfall – runoff relation, Artificial neural networks, Multiple linear regression, Prediction.

## I. INTRODUCTION

Water is one of the most essential requirements for the survival of life. In the hydrological cycle, the only source that determines the localization of the water, the size of the water and the formation of fresh water on the earth is the rainfall. Therefore, the science of hydrology, which deals with the change and amount of water in the earth, uses the rainfall-runoff relationship, temporal and spatial change to determine this requirement. As a result of the analyzes; It is very important to find out the regional water demand, to protect the water resources, to use in the right projects and to have the most beneficial and economical decision.

Hydrological models can be used to estimate changes in hydrological sizes as a result of human effects on nature [1]. Due to the high number of parameters generated by the processing of hydrological data, it is recommended to use approximate methods instead of theoretical analysis.

It is difficult to obtain hydrological data by taking time dependent measurements in terrain conditions, both geographic and topographic, depending on many variables and planning under terrain conditions. Since it poses a major problem in terms of both economic and time, the methods suitable for hydrological laws and the models used in this study are needed.

The analysis is designed with the aid of mathematical and statistical models, made more accurate analysis and in the past has tried to estimate the parameters of the hydrological cycle since. In this hydrological cycle, the rainfall-runoff relationship has particular importance.

Artificial intelligence was applied to dam reservoir level, dam reservoir volume, evaporation and in many different disciplines-areas by many researchers [2-19]. ANN was used for modeling the suspended sediment in a number of works [20-22]. Uneş [23] predicted density flow plunging depth in dam reservoir using the ANN. Demirci et al [24] and Kaya et al [25] investigated that artificial neural network (ANN) approach to the daily forecasting of groundwater levels. Demirci et al [26] estimated the nearshore sandbar crest depth by using neural network (ANN). When the studies are examined, estimations can be made about the operation of watershed and water resources by using obtained hydrological and climatic data. As one of the artificial intelligence techniques, the ANN method is accepted as an alternative to classical methods in the definition and modeling of complex and nonlinear events in hydrology and water resources studies. Sharifi et al. [27] used linear method for rainfall-runoff modeling, support vector machines (SVM) fuzzy logic (ANFIS) and artificial neural networks (ANN). Nacar et al. [28], Haldizen Creek flow values in the East Black Sea Basin were estimated using Multivariate Adaptive Regression Curves and classical regression analysis. When the results of the method were examined, it was observed that the estimation values of Multivariate Adaptive Regression Curves method gave better results than classical regression analysis. Gemici et al. [29],

estimated Kızılırmak river the amount of total flow by using multilayer artificial neural networks, radial-based artificial neural networks and adaptive network-based fuzzy inference system (ANFIS) models with the flow of each slice. In this study, they used the river base slope, the baseline roughness coefficient, the cross-section slice width, the water level passing through the slice and the river cross section width values as input data. Chakravarti et al. [30] examined the ANN model by using the rainfall-runoff data they obtained. According to the model results, they observed that the ANN model gave very good estimations. Tongal and Booi [31] have used their current meteorological data stream flow forecasts for artificial intelligence methods for flow simulation studies.

In this study, Artificial Neural Networks (ANN) and Multiple Linear Regression (MLR) methods were used to obtain rainfall-runoff model estimation model. Data belongs to Muskegon River with station number 04121970. Artificial Neural Networks (ANN) and Multiple Linear Regression (MLR) methods were used to obtain rainfall runoff estimation model.

## II. METHODOLOGY

### 2.1 Artificial Neural Networks (ANN)

Artificial neural networks (ANN); It is an artificial intelligence technique that takes the working structure of human brain as a model and simulates it in its own internal algorithm. This technique can be used in a wide range of fields ranging from civil engineering to mechanical engineering in financial analysis management from economics to medical science.

Figure 1 shows the three-layer and feed-forward ANN architecture. The data flow in this architecture is unidirectional. The data collected for the study will be included as an input in the ANN model and thus the analysis starts.

If the data in the input layer is called  $X_i$ , there is output value  $J_n$ , ( $n=1,2,3,...m$ ) in output nodes up to  $X_i = (i=1,2,3,...k)$ . These input values are multiplied by  $W_{ij}$  ( $j = 1,2,3,...h$ ) in hidden layers and the output values are edited and used as input values of hidden layers. The information in the hidden layer is processed and transmitted to the output layer. In the output layer, the output value is determined and the results are produced and the process is completed.

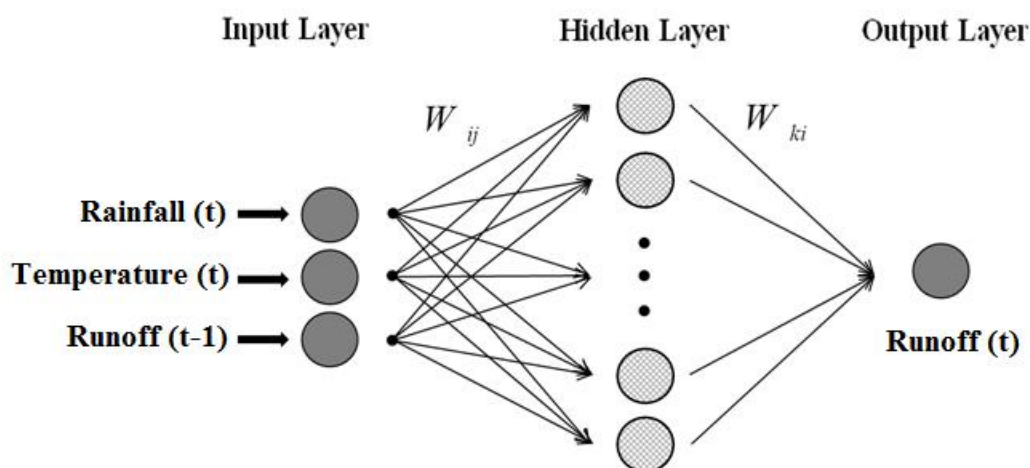


Fig.1: Network architecture used in ANN model

Because the interpretation of results as a model for education and to have a system that can be called with the name ANN. The model uses information from the analysis to interpret new events, such as the human brain, which is the most important difference between other models.

### 2.2 Multiple Linear Regression (MLR)

It is an analysis method to find the variance created by multiple dependent variables with a dependent variable. This regression model is shown in case of the dependent variable  $y$  with the independent variable  $x$  can be written as follows.

$$[y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n + \dots + \varepsilon]$$

Here,  $\beta$  represents the regression coefficients,  $\beta_0$  represents the breakpoint, and  $\varepsilon$  represents the error term.

## III. STUDY AREA AND APPLICATION

### 3.1 Working Area

In this study, the Muskegon River, which meets the water demand of 6100 km<sup>2</sup> area of 348 km in Michigan, has been investigated. 1397 daily temperature, runoff and rainfall data were used. Data set is collected between the dates 14.08.2014 and 11.06.2018 by United States Geological Survey (USGS, [32]). In Figures 2 and 3, Muskegon river location and general views are given.

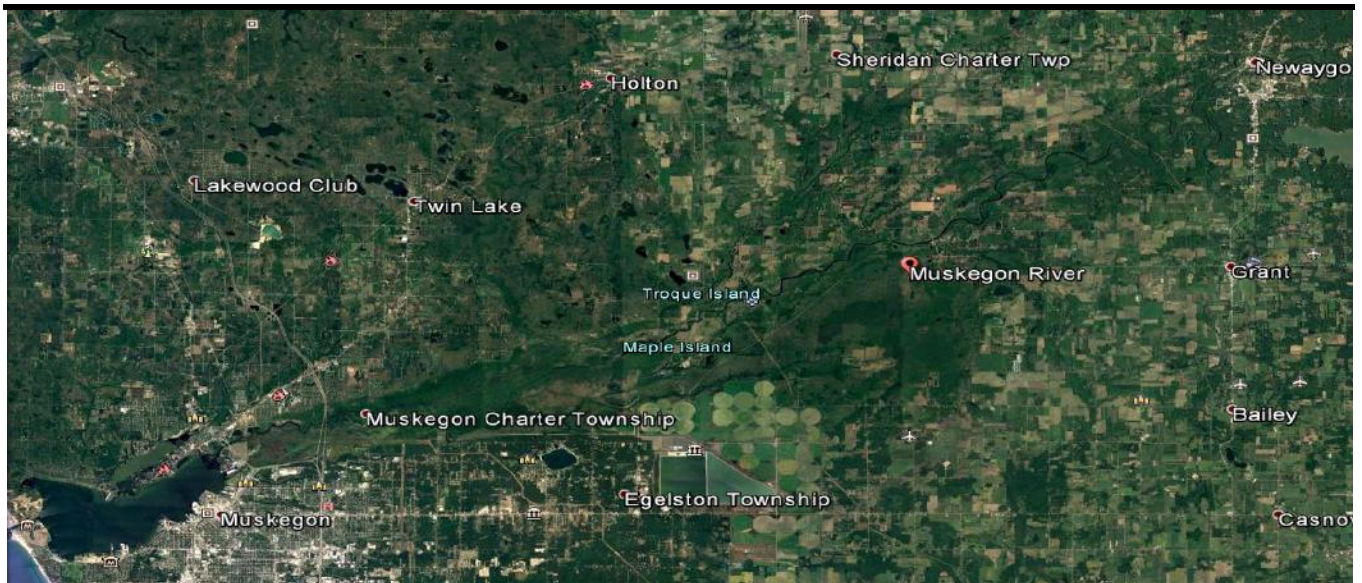


Fig.2: Positional view of the Muskegon river



Fig.3: General view of the Muskegon River

Figure 4, Figure 5 and Figure 6 shows the 1397 daily water temperature, rainfall and runoff change graphs respectively.

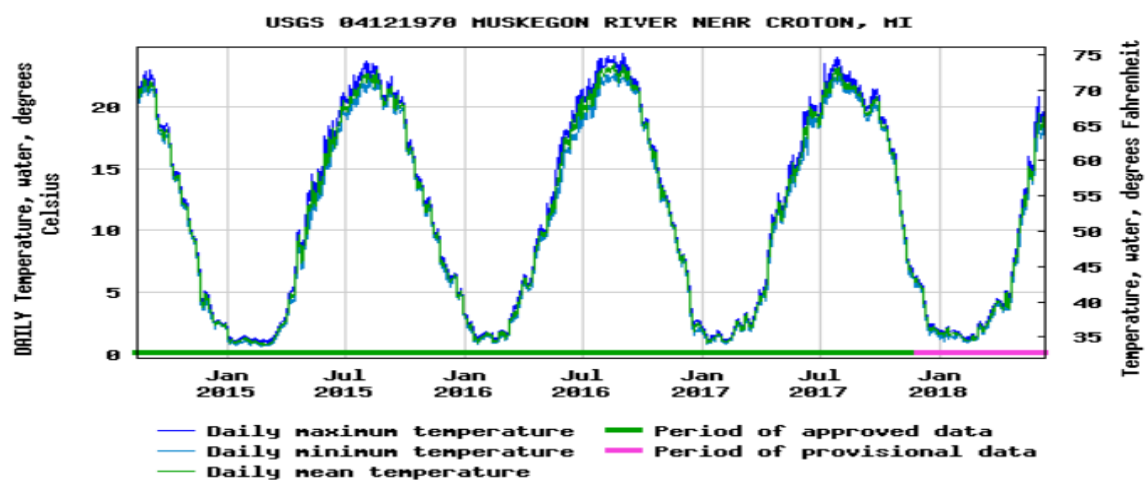


Fig.4: Amount of Daily Water Temperature ( $^{\circ}\text{C}/^{\circ}\text{F}$ ) [32]



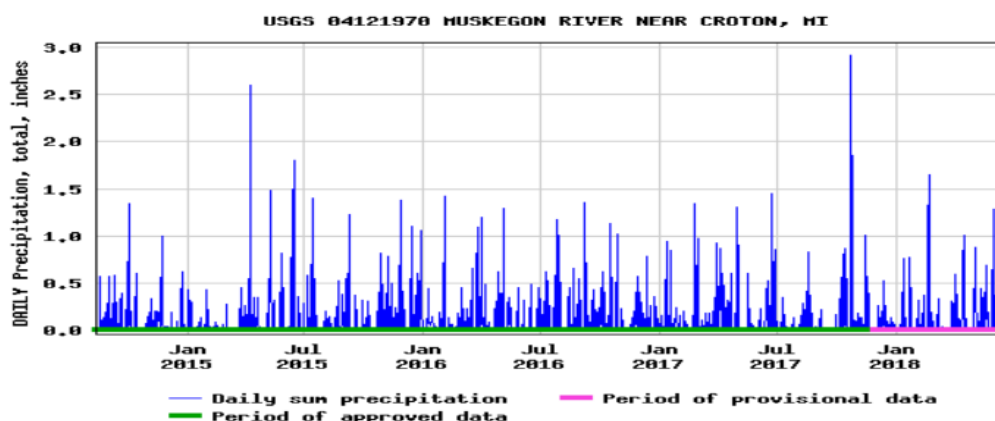
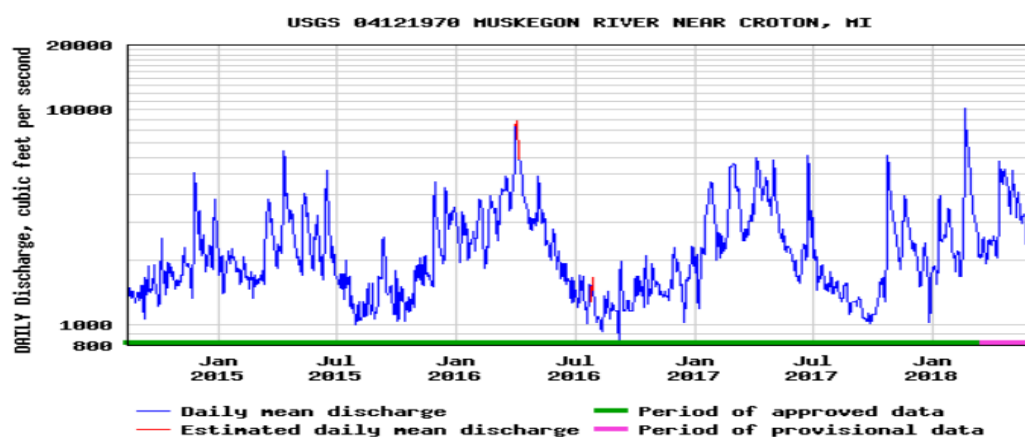


Fig.5: Daily rainfall (inches) [32]

Fig.6: Daily Runoff Amount (ft<sup>3</sup>/s) [32]

### 3.2 Application

In this study, the results of ANN1, ANN2, MLR1 and MLR2 were compared according to the following statistical criteria. Daily water temperature, rainfall and runoff time series and runoff (3 input 1 output) modeling was performed for the model ANN1 and MLR1. In addition, in the model ANN2 and MLR2, runoff modeling was performed with water temperature, rainfall, rainfall time series and runoff time series (4 inputs 1 output).

In this study, 350 of the 1397 daily temperature and rainfall-runoff data were used for testing, while the remaining 1047 were used for training. In the modeling,  $R^2$  (R Square Calculation), MAE (Mean Absolute Error) and RMSE (Root Mean Squared Error) were calculated and the results were interpreted by two evaluations.

$$MAE = \frac{1}{n} \sum_{j=1}^n |Q_{\text{measured}} - Q_{\text{estimate}}|$$

Q : runoff, m<sup>3</sup>/s

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (Q_{\text{measurement}} - Q_{\text{estimate}})^2}$$

Q : runoff, m<sup>3</sup>/s

$$R^2 = \left[ \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)}} \right]$$

The determination coefficient ( $R^2$ ) measures the strength of the linear correlation between the x and y binary values. The fact that the linear relationship is 1 indicates that the result is very close. In this case, the interpretation of the closest value to 1 is the most reasonable and appropriate. The mean absolute error (MAE) measures the accuracy by continuously calculating the mean size of the errors in the estimation without taking into account the aspects of the variables. The root of mean squared errors (RMSE) measures the error average magnitude. MAE and RMSE are used to diagnose the possibility of errors. MAE and RMSE can go from zero to infinite. Lower values mean more useful.

Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and determination coefficient ( $R^2$ ) statistics are calculated for comparison of methods used. ANN results and MLR results are given in Table 1.

Table.1: Statistical results of the models

	MLR1	MLR2	ANN1	ANN2
INPUTS	T, P, $Q_{t-1}$	T, P, $P_{t-1}$ , $Q_{t-1}$	T, P, $Q_{t-1}$	T, P, $P_{t-1}$ , $Q_{t-1}$
MAE	5.38	<b>5.02</b>	5.16	<b>3.28</b>
RMSE	11.53	<b>9.56</b>	9.45	<b>7.12</b>
$R^2$	0.90	<b>0.93</b>	0.94	<b>0.97</b>

The most appropriate result among the models where data is used, as shown in Table 1, gave ANN2 model analysis. Distribution and scatter graphs of ANN1, ANN2 and MLR1, MLR2 models are shown in Figure 7-10 below, respectively.

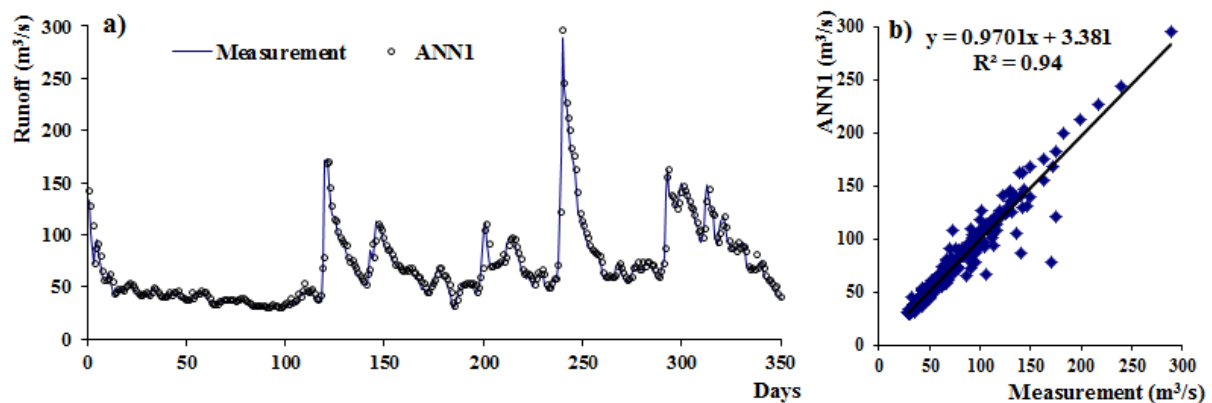


Fig.7: ANN1 model charts for Muskegon River test data

a) distribution chart b) scatter chart

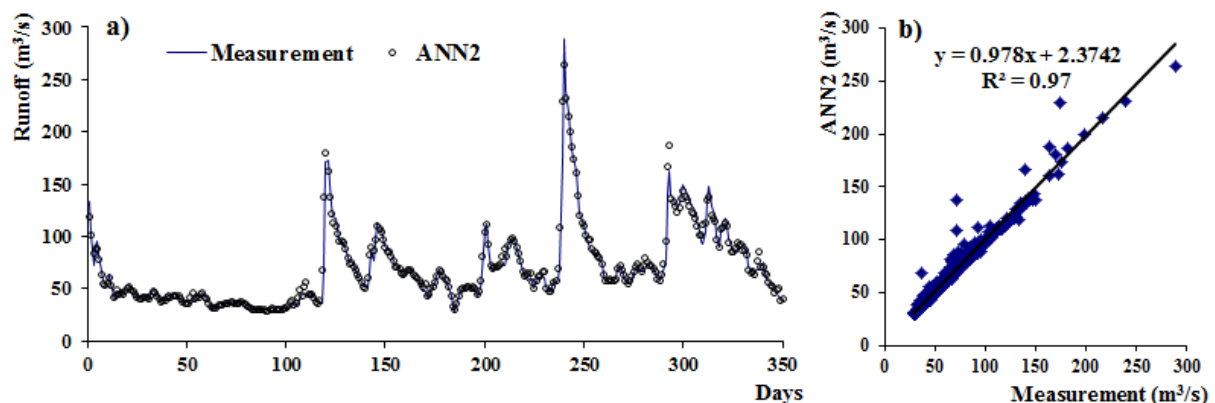


Fig.8: ANN2 model charts for Muskegon River test data

a) distribution chart b) scatter chart

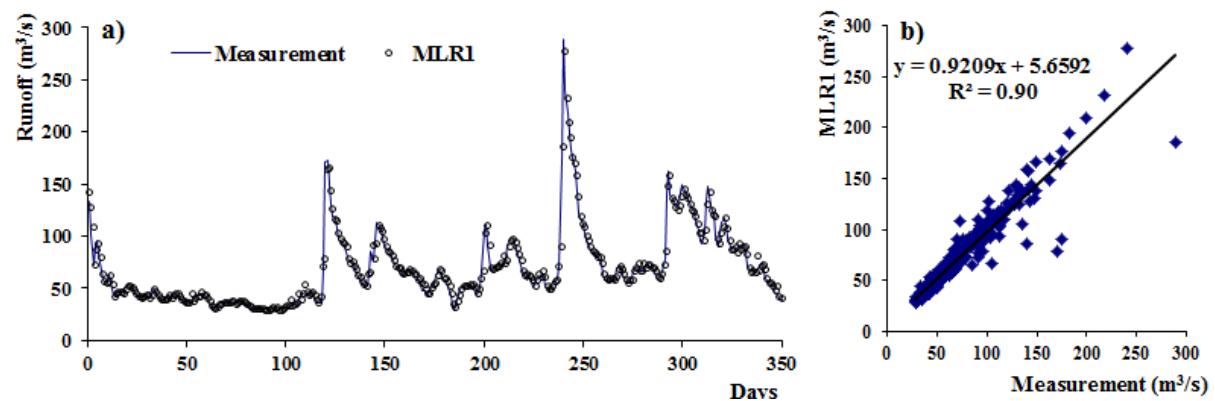


Fig.9: MLR1 model charts for Muskegon River test data

a) distribution chart b) scatter chart



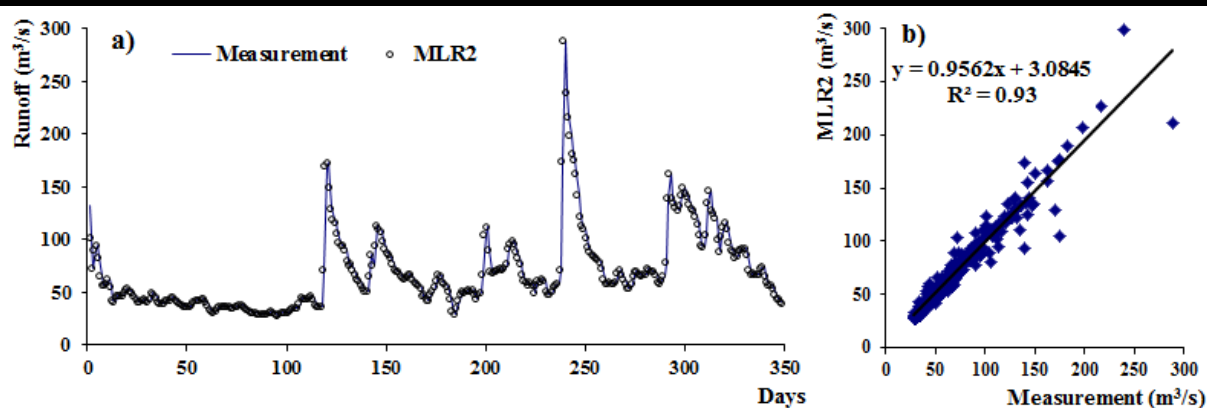


Fig.10: MLR2 model charts for Muskegon River test data

a) distribution chart b) scatter chart

According to Table 1 and distribution-scatter charts, it is observed that all models have good results for the test data. When the table is analyzed, we can express the good results with the high coefficient of determination ( $R^2$ ) and the lowest error amount (RMSE, MAE). Accordingly, the best estimation and low error rate of the ANN2 model and the highest number of determinations ( $R^2 = 0.97$ ) and the lowest RMSE (7.12 m³/s) and MAE (3.28 m³/s) error is seen. In addition, when the MLR were evaluated in itself, MLR2 model has the number of determinations ( $R^2 = 0.93$ ) and RMSE (9.56 m³/s) and MAE (5.02 m³/s) error. As a result of this study, the relationship between rainfall-runoff modeling ANN which is one of the artificial intelligence methods can be presented as an alternative to traditional MLR method.

#### IV. CONCLUSION

In this study, Artificial Neural Networks (ANN) and Multiple Linear Regression (MLR) methods were used to obtain the rainfall-runoff estimation model of the Muskegon River. Water temperature, rainfall, runoff time series and runoff) modeling was performed for the model ANN1 and MLR1. In addition, in the model ANN2 and MLR2, runoff modeling was performed with water temperature, rainfall, rainfall time series and runoff time series (4 inputs 1 output). ANN model results are compared with the measured runoff quantity and the results of the MLR method.

It has been observed that the MLR method gives quite accurate results in the solution of the problem. However, comparison of ANN model and MLR method shows that, ANN has better estimation performance for rainfall-runoff relation.

As a result, the low amount of error (MAE, RMSE) ratios and high determination ( $R^2$ ) provided the desired performance in both methods. However, it has been observed that the ANN model gave better results than the MLR model. The reason for the high correlation of the MLR method is that the relationship between rainfall and runoff is linear. ANN models provide good results in both linear and nonlinear

situations. However, the ANN model generally gives better results in non-linear situations.

Artificial Neural Networks have been found to be a model that can be applied in the estimation of the runoff occurring with rainfall, in the studies which water planning is required and in determining the water level changes. As a final result, it is understood that ANN can be used for hydrological modelling which is necessary for water resources management and planning future requirements.

#### ACKNOWLEDGEMENTS

In this paper, hydrological data were taken from USGS (United States Geological Survey). The authors wish to thank the USGS technical team who are involved in measuring and transferring hydrological data.

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# Estimation of Groundwater Level Fluctuations Using Neuro-Fuzzy and Support Vector Regression Models

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**Abstract**— Estimation of Ground Water Level (GWL) is important in the determination of the sustainable use of water resources and Ground Water resources. Groundwater level fluctuations were investigated using the variable of groundwater level, precipitation, temperature. In the present study, GWL estimation studies were conducted via Neuro-Fuzzy (NF), Support Vector Regression with radial basis functions (SVR-RBF) and Support Vector Regression with poly kernel (SVR-PK) models. The daily data of the precipitation, temperature and groundwater level are used which is taken from Minnesota, United States of America. The results were compared with NF and SVR methods. According to this comparison, it was observed that the NF and SVR models gave similar results for observation.

**Keywords**— Ground water level, Neuro-Fuzzy, Support Vector Regression, Kernel, Modeling.

## I. INTRODUCTION

Estimation of groundwater level is important for effective planning and sustainable groundwater management. Since the available data generally do not fully reflect the sum of the process, the process needs to be modeled in order to make more reliable decisions. Models can be used to generate data for planning and design, or to estimate the future value of processes. In addition to increasing population-related water use, climate change, agriculture and industrialization, taking into account factors such as the need for water in the future, modeling studies are done. The precipitation-evaporation relationship, the interaction between groundwater and surface waters and the quantity, storage and nutritional potentials of the modeling studies should be determined accurately. In the estimation of these parameters, the determination or prediction of the groundwater in the region is important in determining the other parameters of the hydrological cycle.

Groundwater level; It is an indicator of the interaction between groundwater and surface water,

aquifer feeding and water use. Regular measurement of groundwater levels, which is an important variable in determining these mechanisms, is expensive and difficult. However, it is possible to determine the groundwater potential in a region by using meteorological data and ground water levels of previous days. In order to monitor the groundwater level regularly, it is necessary to estimate either directly by means of observation wells or by using different methods for non-observable or missing locations.

Artificial intelligence methods collect information about the samples, make generalizations and then make decisions about the samples by using the information they have learned compared to the samples they have never seen before. Recently, artificial intelligence methods have begun to be frequently used in modeling the suspended sediment [1-4], dam reservoir level [5-7], density flow plunging [8], dam reservoir volume [9-11], sand bar crest [12], evaporation [13-14], and groundwater level [15-16], and in many different disciplines-areas [17-26]. Mohanty et al [27] investigated that artificial neural network (ANN) approach to the weekly forecasting of groundwater levels at river basin. Gong et al [28] used three nonlinear time-series intelligence models for prediction of the groundwater level. They studied 10 years data-sets including hydrological parameters such as precipitation, temperature, past groundwater level and lake level to forecast groundwater level. Guzman et al [29] used nonlinear autoregressive with exogenous inputs (NARX) artificial neural network (ANN) and support vector regression (SVR) methods for daily groundwater level predictions. According to their results, SVR method had a better modeling in prediction of groundwater level. In this study, daily of temperature, precipitation and

In this study, Neuro-Fuzzy (NF), Support Vector Regression with radial basis functions (SVR-RBF) and Support Vector Regression with poly kernel (SVR-PK) models were used estimate groundwater level. Groundwater level data belong to Prairie Island well reservoir

station (PI98-14). Well reservoir station is in the Goodhue County- Minnesota, hydrologic unit is 07040001. All data were taken from United States Geological Survey (USGS).

## II. METHODOLOGY

In this paper, Neuro-Fuzzy (NF), Support Vector Regression with radial basis functions (SVR-RBF) and Support Vector Regression with poly kernel (SVR-PK) models were used. In the all models, daily Mean Precipitation (MP), Mean Temperature (MT), Ground Water Level (GWL+1) were used for the Ground Water Level Estimations. All data obtained from Minnesota in the United States of America.

### 2.1. Neuro Fuzzy (NF)

Adaptive Neuro-Fuzzy System (NF) is a hybrid artificial intelligence method that uses the ability of parallel neural network to calculate and learn artificial neural networks and the inference of fuzzy logic. The NF model developed in 1993 by Jang [30] uses the fuzzy inference model and Hybrid learning algorithm. Adaptive networks consist of directly connected nodes. Each node represents a processing unit. The connections between the nodes indicate an undetermined interest (weight) between them. All or part of the nodes can be adaptive. NF is a universal approximation methodology and is capable of approximating any real continuous function on a compact set to any degree of accuracy. NF with first-order Sugeno fuzzy model which used in this study. For more information, researchers can access Jang [30].

### 2.2. Support Vector Regression

Support vector (SVR) is machine-learning approach in data-driven research fields which founded by Cortes and Vapnik [31]. SVR is based on statistical learning theory. SVR are mainly used to best distinguish between two classes of data. For this purpose, the decision limits or hyper planes are determined. In a non-linear dataset, SVRs cannot draw a linear hyper-plane. Therefore, kernel tricks are used. The Kernel method greatly increases

machine learning in nonlinear data. The process of an SVR estimator ( $y$ ) can be expressed as :

$$y = (K_{xi} \cdot W_{jk}) + b \quad (1)$$

where the Kernel function is  $K_{pi}$ ,  $b$  is bias term of SVM network and  $W_{jk}$  is called as the weight vector.  $K_x$  and  $W$  show Lagrange multipliers.  $K_{xi}$  is a nonlinear function that maps the input vectors into a high-dimensional feature space. The inner product of the inputs is calculated by using kernel functions. Lagrange multipliers show the weights. The output value for a sample in the SVR is equal to the sum of the inner product of the inputs and the independent combinations of Lagrange multipliers. The non-linear Kernel functions used in this study are Poly kernel and radial basis function kernels. Details about SVM can be found in Vapnik [32], Haykin [33], Vapnik [34].

#### 2.2.1. Support Vector Regression with radial basis functions (SVR-RBF)

Lagrange multipliers that obtain the significance of the training data sets for the output data. The kernel function of non-linear radial basis (Hsu et al [35]) is:

$$K_{xi} = e^{-\gamma \|p_i - y_i\|^2} \quad \gamma > 0 \quad (2)$$

and  $i = 1, 2, 3, \dots, n$

where  $K_{xi}$  is a nonlinear function,  $\gamma$  is a user-defined parameter,  $p_i$  and  $y_i$  are vectors in input space.

#### 2.2.2. Support Vector Regression with poly kernel (SVR-PK)

The kernel function of polynomial (Hsu et al [35]) is:

$$K_{xi} = (p \cdot y + c)^d \quad i = 1, 2, 3, \dots, n \quad (3)$$

where  $K_{xi}$  is a nonlinear function,  $p_i$  and  $y_i$  are vectors,  $c$  is the free parameter in input space.

## III. MODEL RESULTS AND ANALYZE

### 3.1. Model Results

To see the relationship between created NF model and observed values distribution graph are drawn in Figure 1 and scatter chart belong to this model was drawn in Figure 2.



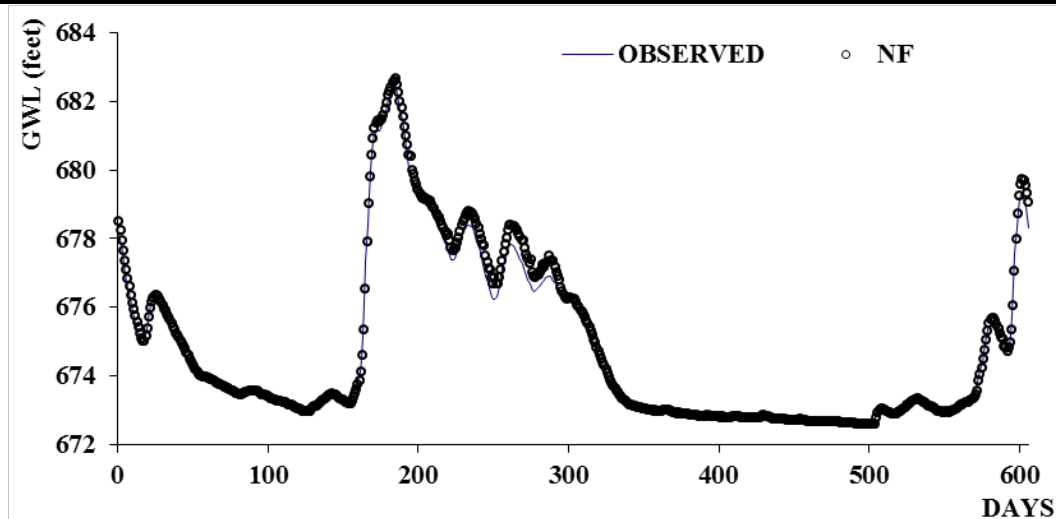


Fig.1: Distribution of NF model

Figure 1. shows that distribution of NF model test results are quite close to observed values of groundwater level for the study area.

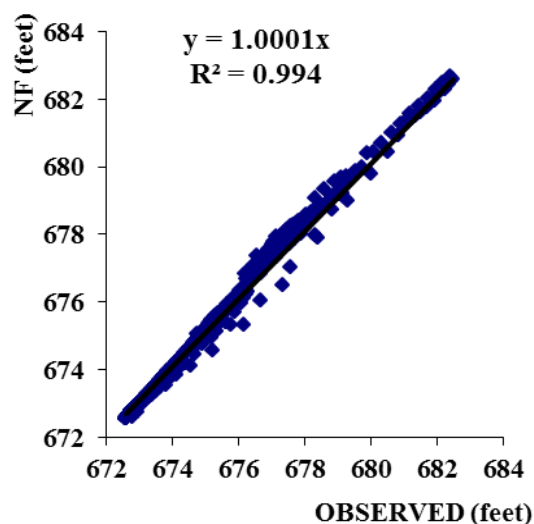


Fig.2: Scatter chart of NF model

As it is seen in Figure 2, determination coefficient is calculated as 0.994 for test set of ANN method. In distribution and scatter charts, values are close to the actual values.

Distribution of SVR RBF method results and scatter chart is given with Figure 3. and Figure 4., respectively.

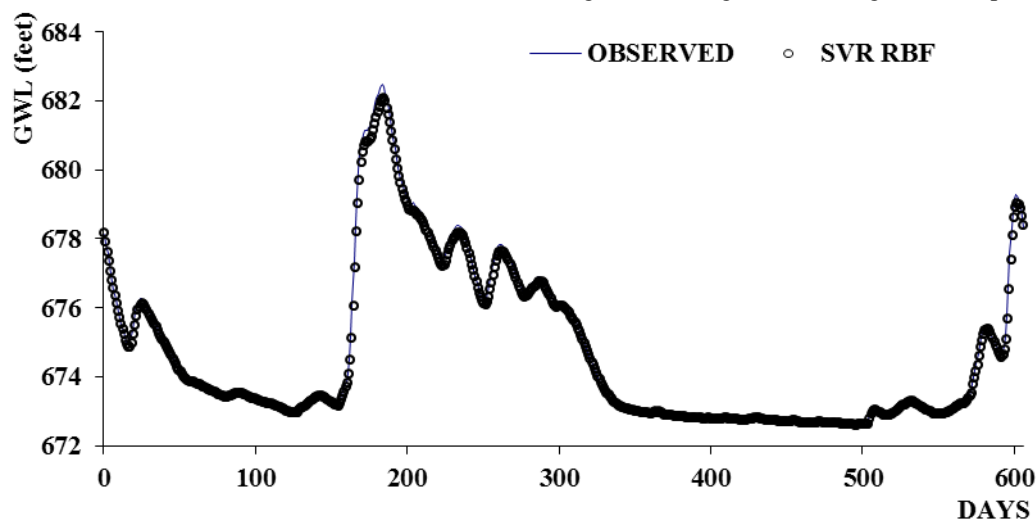


Fig.3: Distribution of SVR RBF model

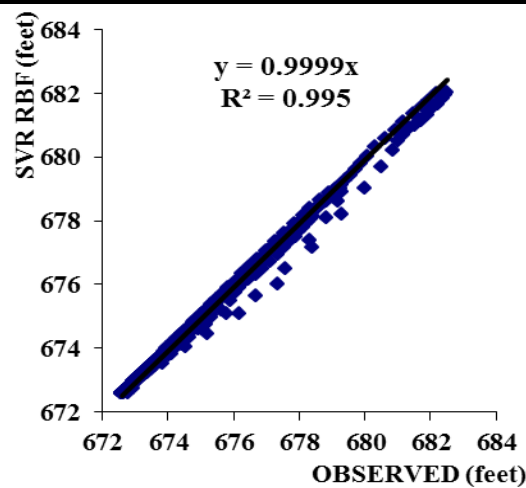


Fig.4: Scatter chart of SVR RBF model

Results of SVR RBF model show that the determination coefficient is high and the groundwater level estimate is closer to the actual values shown in Figure 3. Determination coefficient is calculated as 0.995 for SVR RBF results as it is seen in Figure 4.

Distribution of SVR PK method results and scatter chart is given with Figure 5. and Figure 6., respectively.

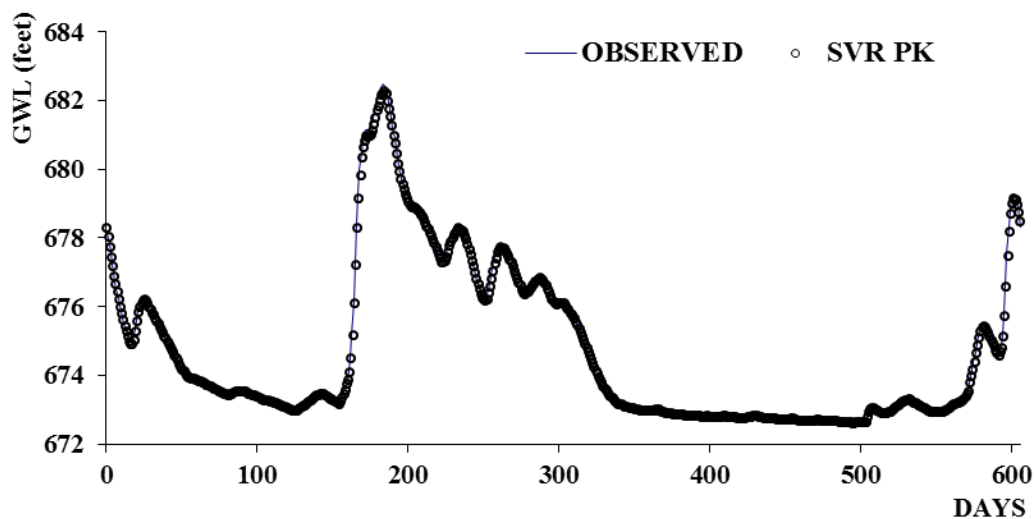


Fig.5: Distribution of SVR PK model

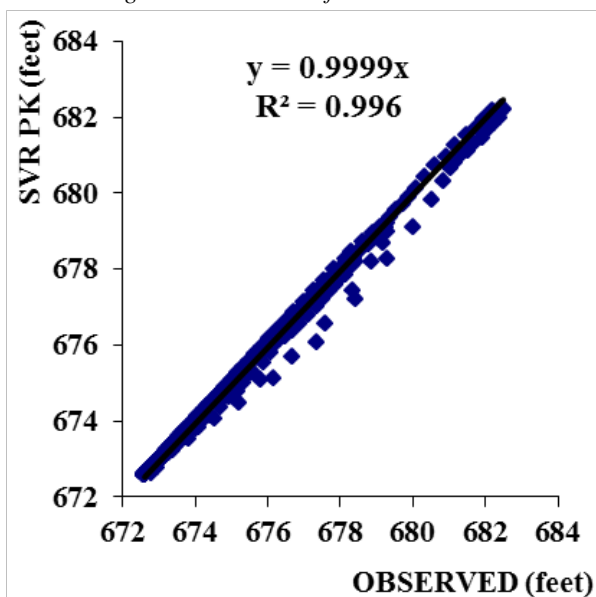


Fig.6: Scatter chart of SVR PK model

Results of SVR PK model show that the determination coefficient is high and the groundwater level estimate is closer to the actual values shown in Figure 5. Determination coefficient is calculated as 0.996 for SVR PK results as it is seen in Figure 6.

### 3.2. Model Analyze

Within the scope of the study conducted for the relationship between Precipitation, Temperature and

Ground Water Level, a total of 2025 daily data was used. 1419 daily data are used for training models and remaining 606 daily data are used for testing. Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and determination coefficient ( $R^2$ ) statistics are calculated for comparison of methods used. NF, SVR RBF and SVR PK results are compared in Table 1.

Table.1: Comparison of NF and SVR model performances

MODEL NAMES	MODEL INPUTS	RMSE	MAE	$R^2$
NF	MP,MT, GWL+1	0.227	0.139	0.994
SVR RBF	MP,MT, GWL+1	0.192	0.090	0.995
SVR PK	MP,MT, GWL+1	0.168	0.074	0.996

RMSE: Root Mean square error, MAE: Mean absolute error,  $R^2$ : Determination coefficient

According to Table 1, it is observed that all models have good results for the test data. When the table is analyzed, we can express the good results with the high coefficient of determination ( $R^2$ ) and the lowest error amount (RMSE, MAE). Accordingly, the best estimation and low error rate of the SVR PK model and the highest number of determinations ( $R^2 = 0.996$ ) and the lowest RMSE (0.168 feet) and MAE (0.074 feet) error is seen. In addition, the NF and SVR RBF models are close to SVR PK prediction performance. When the results were examined, NF, SVR RBF and SVR PK models were found to perform better in GWL estimations.

### IV. CONCLUSION

In this paper, Neuro-Fuzzy (NF), Support Vector Regression with radial basis functions (SVR-RBF) and Support Vector Regression with poly kernel (SVR-PK) models were used for the relationship between the precipitation, temperature and groundwater level. 2025 data of Minnesota observation station was studied model prediction analyze. NF and SVR methods results were compared with the observed real GWL values. When the determination coefficients and error calculations are evaluated it is understood that NF and SVR models gave good and similar results.

### ACKNOWLEDGEMENTS

In this paper, hydrological data were taken from the website of the USGS (United States Geological Survey). The authors wish to thank the USGS technical team, also USGS staff members who are involved in measuring and transferring hydrological data.

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# On the Numerical Solutions of a Wave Equation

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**Abstract**—In this paper we have obtained approximate solutions of a wave equation using previously studied method namely perturbation-iteration algorithm (PIA). The results are compared with the first and second order difference scheme solutions by absolute error. In addition, to prove the effectiveness of the method, we have presented some graphics and tables.

**Keywords**—Initial value problems, wave equation, perturbation-iteration algorithm, difference schemes, error analysis.

## I. INTRODUCTION

Partial differential equations have been used to explain many phenomena in different science and engineering branches such as mathematical biology, physics, image processing, quantum mechanics, fluid flow, viscoelasticity and so on. Therefore, to understand and explain physical interpretation of the problems arise in the above-mentioned fields, a considerable effort has been achieved and numerous methods have been proposed to obtain both numerical and analytical solutions of the partial differential equations. These methods include, Adomian decomposition method (ADM)[1-2], variational iteration method (VIM)[3-4], homotopy analysis method (HAM)[5-6], homotopy perturbation method (HPM)[7-8], finite difference method (FDM)[9-11], differential transform method (DTM)[12-13], etc.

Alongside these methods, a perturbation-iteration method, namely perturbation-iteration algorithm (PIA) has been proposed by Aksoy and Pakdemirli in 2010 [14-15]. In this paper we implement PIA to obtain some approximate solutions of a wave partial differential equation with initial conditions. Obtained results are compared with the known exact solutions and the solutions obtained by the finite difference method via first and second order difference schemes. The findings are satisfactory and the present method produces highly approximate results even for a few iterations.

## II. BASIC IDEA OF PIA

In this section we introduce some fundamental points of the PIA.

Take the wave partial differential equation:

$$F(u_{tt}, u_t, uu_{xx}, u, \varepsilon) = 0 \quad (1)$$

where  $u = u(x, t)$  and  $\varepsilon$  is a small perturbation parameter that will be inserted to the equation later. The perturbation expansion with only one correction term is

$$u_{n+1} = u_n + \varepsilon (u_c)_n \quad (2)$$

Replacing Eq.(2) into Eq.(1) and writing in the Taylor series expansion with first order derivatives only gives

$$\begin{aligned} &F((u_n)_{tt}, (u_n)_t, (u_n)_{xx}, u_n, 0) \\ &+ F_{u_{tt}}((u_n)_{tt}, (u_n)_t, (u_n)_{xx}, u_n, 0)\varepsilon((u_c)_{tt})_n \\ &+ F_{u_t}((u_n)_{tt}, (u_n)_t, (u_n)_{xx}, u_n, 0)\varepsilon((u_c)_t)_n \\ &+ F_{u_{xx}}((u_n)_{tt}, (u_n)_t, (u_n)_{xx}, u_n, 0)\varepsilon((u_c)_{xx})_n \\ &+ F_u((u_n)_{tt}, (u_n)_t, (u_n)_{xx}, u_n, 0)\varepsilon(u_c)_n \\ &+ F_\varepsilon((u_n)_{tt}, (u_n)_t, (u_n)_{xx}, u_n, 0)\varepsilon = 0 \end{aligned} \quad (3)$$

or shortly,

$$\begin{aligned} &\frac{F}{\varepsilon} + ((u_c)_{tt})_n F_{u_{tt}} + ((u_c)_t)_n F_{u_t} \\ &+ ((u_c)_{xx})_n F_{u_{xx}} + (u_c)_n F_u + F_\varepsilon = 0 \end{aligned} \quad (4)$$

where  $F_{u_{tt}} = \frac{\partial F}{\partial u_{tt}}, F_{u_t} = \frac{\partial F}{\partial u_t}, F_{u_{xx}} = \frac{\partial F}{\partial u_{xx}}, F_u = \frac{\partial F}{\partial u}$  and  $F_{u_{tt}} = \frac{\partial F}{\partial u_{tt}}$ .

In the expansion, all of the derivatives are calculated at  $\varepsilon = 0$ . Opening with the initial assumption  $u_0(x, t)$ , in the first step  $(u_c)_0(x, t)$  is determined from Eq.(3) and then subrogated into Eq.(2) to obtain  $u_1(x, t)$ . The iteration procedure continues until a desired solution is obtained.

## III. NUMERICAL RESULTS

Consider the following wave equation [16]

$$u_{tt} - (x + t)u_{xx} = \left( \frac{6t^4 + 4t^2 - 2}{(1 + t^2)^4} + \frac{x + t}{1 + t^2} \right) \sin(x) \quad (5)$$

for  $0 < t < 1, 0 < x < \pi$  given with the initial and boundary conditions

$$\begin{aligned} u(x, 0) &= \sin(x), u'(x, 0) = 0, 0 \leq x \leq \pi \\ u(0, t) &= u(\pi, t) = 0, 0 \leq t \leq 1. \end{aligned}$$

The known exact solution of the problem is

$$u(x, t) = \frac{1}{1 + t^2} \sin(x). \quad (6)$$

Introducing the artificial perturbation parameter  $\varepsilon$  and rewriting Eq.(4) yields the following iteration equation.

$$\begin{aligned} &\varepsilon(u_c)_{tt}(x, t) = \\ &= \frac{(-2 + x + t(1 + t(6 + 2t + t^3 + (2 + t^2)x))) \sin(x)}{(1 + t^2)^3} \\ &- (u_n)_{tt}(x, t) + (t + x)(u_n)_{xx}(x, t), n = 0, 1, 2, \dots \end{aligned} \quad (7)$$

Appropriate to the initial conditions, an initial estimation to begin the iteration process is proposed as  $u_0(x, t) = \sin(x)$ . Subrogating this initial condition in Eq.(4) and solving it gives

$$(u_c(x, t))_0 = \frac{6 - 6t - 7t^3 - t^5 - 3t^2x - 3t^4x}{6(1+t^2)} \sin(x) + \frac{6(1+t^2)(1+tx)\tan^{-1}(t)}{6(1+t^2)} \sin(x) + \frac{3(1+t^2)(t-x)\ln(1+t^2)}{6(1+t^2)} \sin(x) + c_1(x) + tc_2(x) \quad (8)$$

So the first iteration result using the initial conditions is

$$u_1(x, t) = u_0(x, t) + \varepsilon((u_c(x, t))_0) \quad (9)$$

or

$$u_1(x, t) = \sin(x) + \frac{6t^2 + (t+t^3)(6+t^2+3tx)}{6(1+t^2)} \sin(x) - 3 \frac{(1+t^2)(2(1+tx)\tan^{-1}(t))}{6(1+t^2)} \sin(x) - 3 \frac{(t-x)\ln(1+t^2)}{6(1+t^2)} \sin(x) \quad (10)$$

If the procedure continues similarly, we get the following results

$$u_2(x, t) = -\sin(x) + \frac{6t^2 + (t+t^3)(6+t^2+3tx)}{6(1+t^2)} \sin(x) - \frac{3(1+t^2)(2(1+tx)\tan^{-1}(t) + (t-x)\ln(1+t^2))}{6(1+t^2)} \sin(x) + \frac{1}{720(1+t^2)} (4(1+t^2)\cos(x)(t(-30-20t^2+9t^4-150tx+15t^3x) + 30(t+t^3-x+3t^2x)\ln(1+t^2)) - (-1440+2520t^3+4t^8-180t(-12+x)+24t^7x + 12t^5(30+17x)-30t^2(-3-36x+10x^2) + t^6(99+30x^2)-5t^4(-37-216x+54x^2) - 30(1+t^2)(-1+t^4+t(36-8x)-36x+2x^2 - 6t^2x^2)\ln(1+t^2))\sin(x) + 60(1+t^2)\tan^{-1}(t)(-2(-1+t^4-6tx+2t^3x)\cos(x) + (36-3x+6t^2x+t^4x+t(2+36x-6x^2) + 2t^3(1+x^2))\sin(x))) \quad (11)$$

$$u_3(x, t) = \frac{1}{3175200(1+t^2)} \times -21(t+t^3)(8400(-6+x) + t(t(-33600+t(-15350+3t(5040+608t+105t^3))) + 20t(-1778 + 3t(420-399t+22t^3))x + 630(54 - 77t^2+2t^4)x^2 - 180(27 + 1400x)))\cos(x) + 3175200\sin(x) + (1 + t^2)(1260\cos(x)(2(10t^7+70(-6+x) - 210t^4(-2+x) - 420t^2x+56t^6x + 7t(-7+45(-8+x)x) + 63t^5(1+x^2) - 70t^3(2+3x(-4+3x)))\tan^{-1}(t) - (-17-840x+7(2t^6+6t(20-7x) + 30t^5x-90t^2(-4+x)x+9x^2 + 20t^3(6+x)+5t^4(5+9x^2)))\ln(1 + t^2)) + (t(245t^8+2205t^7x + 1260(-47+42(-30+x)x) + 45t^6(-155+126x^2) + 63t^5(560 + 313x+70x^3) - 63t^4(-9262 + 21x(-160+37x)) - 210t^2(326 + 21x(-360+67x)) + 630t(1260 + x(-1304+21x(-200+9x))) - 105t^3(-7980+x(-8966+21x(-120 + 77x))) - 1260(-47+5t^7x+42(-30 + x)x - 315t^2(-8+x)x+35t^4(19 + 12x) + 21t^5x(-2+x^2) + 7t^6(-10 + 3x^2) + 7t(120+x(-104+15(-24 + x)x)) + 35t^3(24+x(35-6(-4 + x)x))\tan^{-1} - 630(-420+5t^7+7t^6x + x(152-21(-40+x)x) + 105t^2x(-13 + 2(-12+x)x) - 63t^5(-6+x^2) - 35t^3(13+6x^2) + 35t^4(12+14x - 3x^3) + 7t(-20+3x(-160+9x)))\ln(1 + t^2))\sin(x)) \quad (12)$$

In this study, the Eq.(5) in [16] is solved by using PIA and the following first-order difference scheme

$$\begin{cases} \tau^{-2}(u_{k+1} - 2u_k + u_{k-1}) + A_k u_{k+1} = f_k, \\ A_k = A(t_k), f_k = f(t_k), t_k = k\tau, \\ 1 \leq k \leq N-1, N\tau = T, \\ \tau^{-1}(u_1 - u_0) + iA_1^{1/2}u_1 = iA_0^{1/2}u_0 + \psi, u_0 = \varphi. \end{cases}$$

studied in [17] and the second-order difference scheme

$$\begin{cases} \frac{u_{k+1} - 2u_k + u_{k-1}}{\tau^2} + A_k u_k + \frac{\tau^2}{4} A_k^2 u_{k+1} = f_k, \\ A_k = A(t_k), f_k = f(t_k), t_k = k\tau, 1 \leq k \leq N-1, N\tau = T, \text{stu} \\ (I + \tau^2 A_0) \tau^{-1}(u_1 - u_0) \\ = \frac{\tau}{2}(f_0 - A_0 u_0) + \psi, f_0 = f(0), u_0 = \varphi. \end{cases}$$

died in [16]. The results are compared and discussed.

## IV. FIGURES AND TABLES

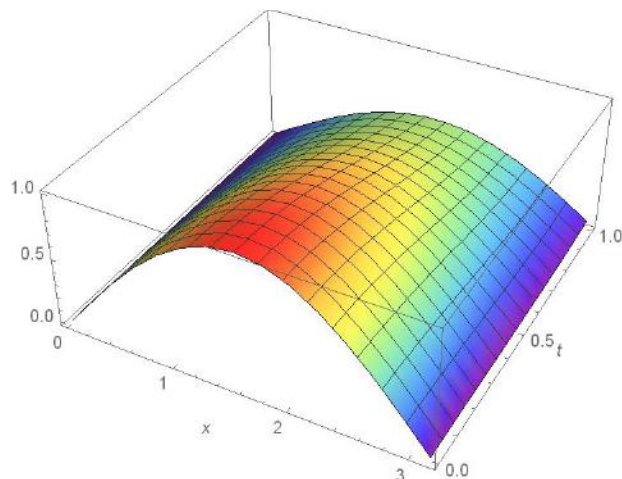


Fig. 1: Surface plot of the third order PIA solution.

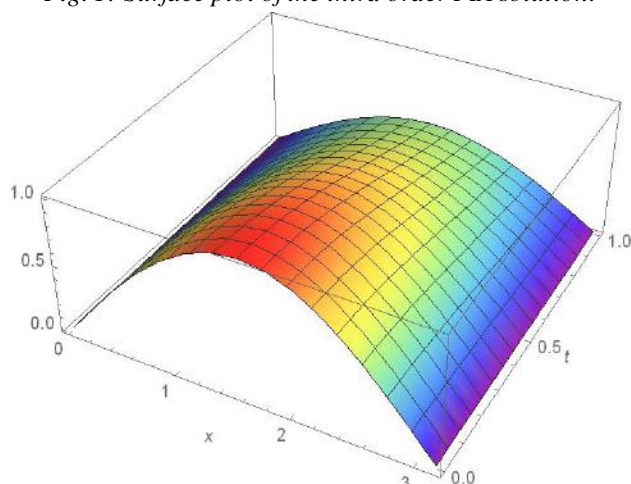


Fig. 2: Surface plot of the exact solution.

Table. 1: Comparison of the third order PIA absolute errors

Third order PIA Absolute Errors			
$x$	$t = 0.2$	$t = 0.4$	$t = 0.6$
$2\pi/10$	$3.26329E - 7$	$2.32795E - 5$	$2.85770E - 4$
$4\pi/10$	$3.23876E - 7$	$2.47931E - 5$	$3.24057E - 4$
$6\pi/10$	$1.78211E - 64$	$1.23072E - 4$	$1.48412E - 3$

Table. 2: Comparison of the first order difference scheme absolute errors

First Order Difference Scheme Absolute Errors			
$x$	$t = 0.2$	$t = 0.4$	$t = 0.6$
$2\pi/10$	$2.66413E - 4$	$4.85849E - 4$	$6.71907E - 4$
$4\pi/10$	$4.33106E - 4$	$8.00497E - 4$	$1.12590E - 3$
$6\pi/10$	$4.35134E - 4$	$8.14527E - 4$	$1.16251E - 3$

Table. 3: Comparison of the second order difference scheme absolute errors.

Second Order Difference Scheme			
$x$	$t = 0.2$	$t = 0.4$	$t = 0.6$
$2\pi/10$	$6.50953E - 8$	$1.19193E - 7$	$4.00733E - 8$
$4\pi/10$	$1.11504E - 7$	$2.51531E - 7$	$1.43050E - 7$
$6\pi/10$	$1.71319E - 7$	$5.05788E - 7$	$7.22128E - 7$

As shown in Table 1 and 3, the second order difference scheme is approximately  $10^{-3}$  times better than the first order difference scheme. On the other hand, the results obtained by PIA are better than the first-order difference method but they are not as satisfactory as the results obtained second-order difference method.

For more steps of PIA, various partial differential equation scan be studied and solved and the results are compared with each other as future problems

## V. CONCLUSION

In this paper the approximate solution of a wave partial differential equation is obtained by previously developed efficient method, perturbation-iteration algorithm. The method gives highly approximate solutions after a few iterations. The results are compared with the exact solution via absolute error and finite difference method. For this purpose first and second order difference schemes are applied. Also some surface plots and tables are presented to show the reliability of the method. This confirms that the method is ready to apply for wider class of partial differential equations.

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# An Evaluation of Periodic Performance of an Improved Solar Box Cooker

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**Abstract**— The study outlined how the solar box cooker is constructed; taking in mind all those conditions that enhances optimum heat gains in the cooker and avoiding those that will bring heat lost into it. Some selected instruments were used in taking major measurements while the cooker is at work. The results found revealed that at about 1400 on the selected day the cooker receives maximum solar insolation. Some other parameters like temperature of the solar plates, the ambient temperature in the cooker seem to be higher at that hour, more importantly, the experimental efficiency recorded higher value at that period, and the result of the experimental value of efficiency is in agreement with the theoretical value calculated.

**Keywords**— Solar Box Cooker, Thermocouple, Anemometer.

## I. INTRODUCTION

Energy has always been an essential input to all aspect of the modern age; moreover, energy is the live wire for industrial production, transportation as well as other conventional power generation. For most developing countries, wood is the most readily available and most important energy source for domestic application. This

means that more than two billion people depend largely on various forms of biomass to meet their energy needs mainly for cooking. (Dunn, 1986).. However, the major problem with the use of solar energy is that, it is very dilute and fluctuates with time and weather condition. The economic feasibility of solar energy utilization depends upon efficient collection, conversion and storage. The efficient utilization of solar energy for heating, application requires the use of flat plate or focusing collector system which first captured as much as possible, incoming radiation and then deliver a high fraction of the captured energy to the user. The availability of solar energy depends on the time of the day, the day of the year, and other meteorological parameters, such as clouds, rains and other atmospheric condition. The time variation of solar radiation is generally out of phase with the demand, thus solar energy is viable only when thermal storage is integrated into the system.

## II. MATERIALS USED

The data collected in this work was based on the performance of the box cooker when exposed to the solar insolation. Below is the list of equipment/ instruments used in recording measurements made during the experiment with their label of accuracy

S/N	PARAMETER MEASURED	INSTRUMENT	TYPE/MAKE	LEAST COUNT	ACCURACY
1.	Solar insolation	Pyranometer	PSP 24319 F – 3	1.0W/m <sup>2</sup>	0.5%
2.	Cooker plate temp.	Thermocouple	Copper-Constantan	0.1 <sup>0</sup> c	0.5%
3.	Ambient and water temp.	Thermometer	Pt-100	0.1 <sup>0</sup> c	0.2%
4.	Wind Speed	Anemometer	CPO Box 1618 Japan	0.1m/s	0.5%
5.	Dim. of the cooker	Measuring tape/ Scale	Kristeel-Shinwa 401E10	0.001m	0.2%



### III. METHOD OF CONSTRUCTION THE COOKER

Most previous cookers (Mohammad et al, 1998; Suharta et al, 2001 and Arouna, 2004) used a single reflector for their cookers; foam as an insulator and larger in sizes. These tend to reduce the cookers efficiency and a bit expensive, hence beyond the reach of most rural people. To overcome these short comings, a double mirror are used as reflectors, sawdust as an insulator and the size of the box cooker reduced.

The box cooker is made up of a thick wood of dimensions 64cm by 41cm by 28cm in a rectangular shape. An aluminum sheet of same rectangular shape, and dimensions 54cm by 31cm by 22cm was used in lining up all the inner surfaces of the cooker. The aluminum plate was painted dull- black, to enhance the heat capacity of the cooker for efficient cooking. It is important to note that since the dimensions of the aluminum is less than that of the cooker, the curved aluminum sheet was slotted into the box allowing some spaces in all the four walls of the box. Another space was left at the bottom of the box. The reasons why spaces were left in all the walls and the bottom of the cooker is to put adequate insulators in all the spaces to curtailed heat losses from the surrounding. Adhesive glue was later used to fill up the top surfaces of the box including any crack created as a result of construction imperfection.

The glass cover is made up of a transparent glass and even plastics may be used. Glass is used here, since according to Aalfs (1992), glass traps radiant heat better than plastics, and glass is difficult to surpass because it is a relatively low-cost material, easy to get and replaced. More so, when a glass gets hot it does not become distorted as many plastics do, more importantly, glass is

widely available in developing countries and therefore by far the most common material used. The light energy is absorbed by the dark absorber plate which is converted into longer wavelength heat energy, and radiates from the interior materials. Most wavelengths cannot pass back out through the glass and is therefore trapped within the enclosed space.

The double reflectors used in this construction help bounce additional sunlight through the glass into the solar box. This additional input of solar energy results in higher cooker temperatures. It is however important to note that the choice of double mirror in this project offers the following advantages:

- It generates higher temperature and can efficiently be used for a variety of cooking applications.
- The mirrors need not to be adjusted once they are set, by this all the incident solar radiations impinging on the mirrors are reflected onto the base absorber of the box of the cooker and this will enhanced the heat capacity of a cooker.

Figure below illustrate the optics geometry used for the design of the glass cover. The glass cover is employing two non – tracking plane mirrors fixed in an east-west configuration with the lateral sides of the box of the cooker. The solar concentration is accomplished in such a way that the reflectors positioned on a plane making an angle equal to the latitude of the site with the plane of the solar energy on the absorber plate of the box of the cooker. It could be seen from the figure that, the ray reflected from the mirror placed on the left side will meet the edge R and that reflected from the mirror placed on the right side will meet the edge Q of the absorber. This multiple reflections received by the absorber will enhance accumulation of higher temperature in the cooker.

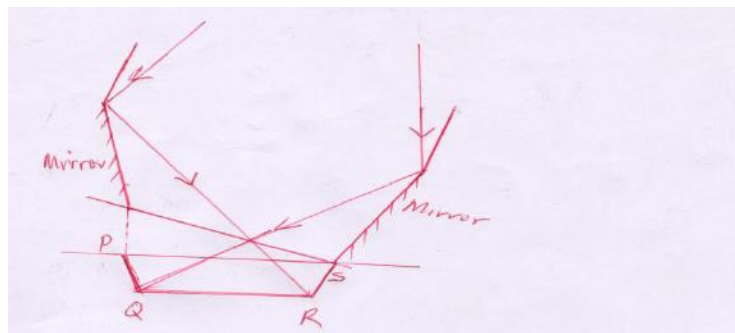


Fig. 1

#### ASSEMBLY OF THE SOLAR BOX COOKER

The various components constructed separately were put together and the desired solar cooker was formed. The frame work of the cooker was supported with hinges fixed on the southern wall of the box, the box is also provided

with another hinge having an elevation tracking arrangement to set the concentrator for its seasonal tilt arrangement. Based on this, the cooker receives solar radiations on the east-west configuration as shown in the figure below:



*Fig. 2*



*Fig. 3*

## DATA COLLECTION PROCEDURE

A completed solar box cooker at work is shown in figure above. The two mirrors were placed in an east-west configuration in order to ensure maximum collection of solar radiations in the cooking chamber. An aluminum pot of mass 0.5kg painted black containing 1kg mass of water was inserted into the cooker. The initial temperature of the water was noted and recorded and the following measurements were subsequently made;

- I. solar radiation on the collector plate
- II. the collector plate temperature
- III. the ambient temperature
- IV. water temperature and
- V. wind speed

These parameters were measured at an hour interval, from 9:00 am to 6:00 pm on the 20/10/2017. Copper constantan thermocouple positioned inside the cooker was used to record the inside air and the absorber plate temperatures. Solar insolation was recorded using pyranometer, initial and final temperature of water was measured using a sensitive thermometer (pt-100 type).

The measured values were used to calculate the instantaneous efficiency of the collectors.

## EVALUATION OF THE DAILY EFFICIENCY USING THE DATA OBTAINED

The measured values can be used to calculate the instantaneous efficiency of the cooker as follows;

Mass of water = 1kg

Specific heat capacity of water = 4200J/kg K

Mass of the vessel and its lid = 0.5kg

Specific heat capacity of aluminum = 800J/kg K

Initial water temperature ( $T_{wi}$ ) = 20°C = 293K

Final water temperature = 39°C = 312K at 9:00 am

Therefore,

$(T_{wf} - T_{wi}) = 19K$  at 9:00 am

A the collector area = 0.1674m<sup>2</sup>

I the solar insolation = 667.5W/m<sup>2</sup> at 9:00 am

The magnitude of the efficiency at 9:00 am can be found using equation;

$$h = \frac{E_o}{E_i} = \frac{M_w c_w + M_{al} c_{al} (T_{wf} - T_{wi})}{A I t}$$

But from the assumptions made,

$$U = u$$

$$\text{And } u = \frac{1}{R} \text{ from equation (3.28)}$$

$$\text{Hence, } u = \frac{\text{conductivity}}{\text{thickness}}$$

Thermal conductivity of wood = 0.1 and its thickness as measured is 0.023m.

$$\text{So, } u = \frac{0.1}{0.023}$$

The theoretical value of the efficiency can be found using the equation,

$$\eta = \frac{M_w c_w + M_v c_v (T_{wf} - T_{wi})}{A I t} + \frac{u (T - T_a)}{I}$$

$$= \frac{(1 \times 4200 + 0.5 \times 800)(312 - 293)}{0.1674 \times 667.5 \times 3600} + \frac{4.35 (312 - 303)}{667.5}$$

$$= 0.217 + 0.169$$

$$= 0.386$$

$$@39\%$$

Table.2: Showing data recorded on 20/10/2017

Hours	$T_p/^{\circ}C$	$T_a/^{\circ}C$	$T_w/^{\circ}C$	$I/\text{Wm}^{-2}$	$v/\text{ms}^{-1}$	$h$
8-9	56	30	39	667.5	0.35	0.22
9-10	85.5	34	52	890.0	1.15	0.27
10-11	114.5	37.5	65	1042.5	0.50	0.33
11-12	117.5	38	84	1210.5	0.45	0.40
12-13	126.0	40.7	92	1280.5	1.10	0.43
13-14	142.0	40.5	96	1286.5	0.20	0.45
14-15	136.0	40.3	92.5	1293.3	0.43	0.43
15-16	121.0	40	82.5	1210.3	2.4	0.39
16-17	109	38	70.0	923.3	2.1	0.41
17-18	85.5	36	55.5	477.0	0.35	0.57

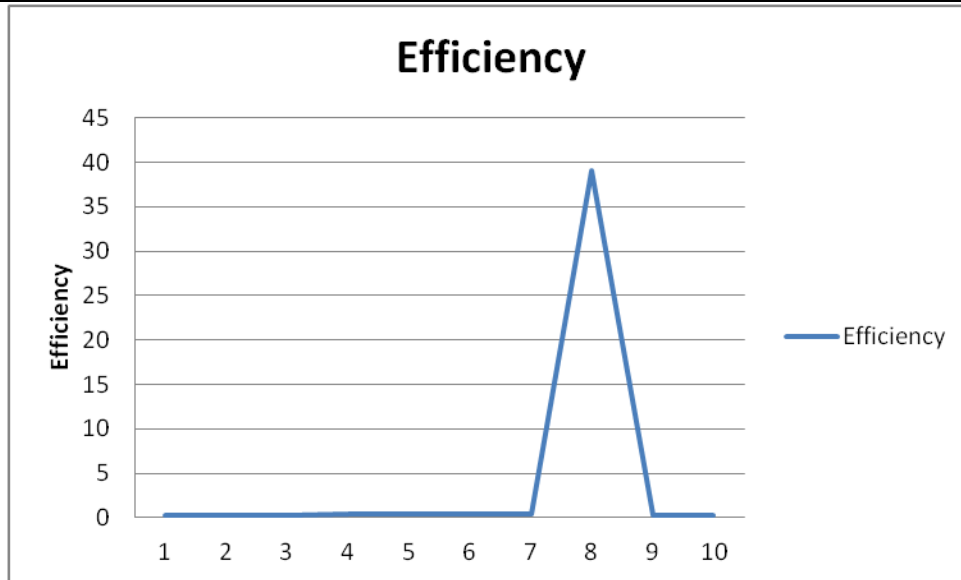


Fig 4

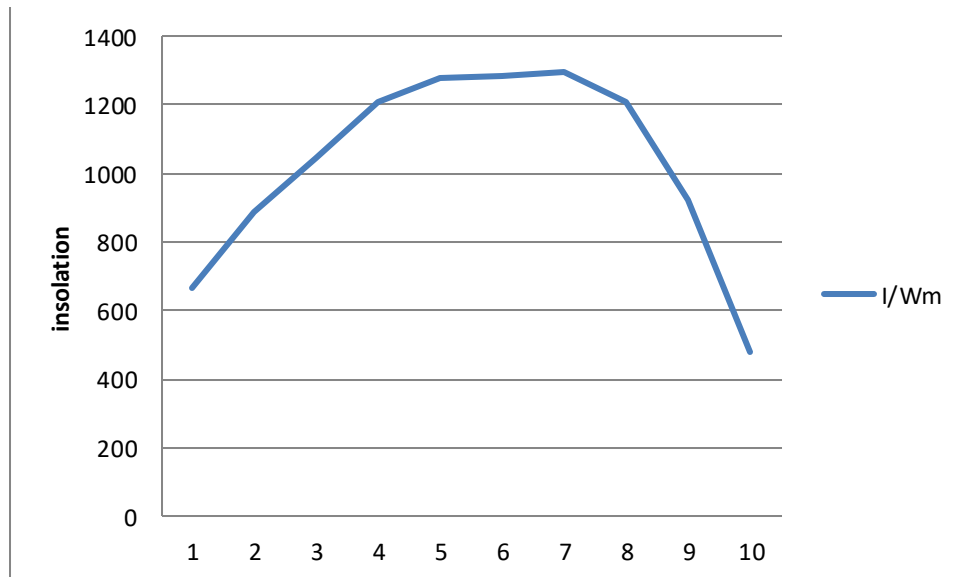


Fig.5

## VI. DISCUSSION

Figs 4 above show the variation of the cooker efficiency at different time. It is clear from the figure that the efficiency of the cooker is high at 14.00. Moreover the experimental value is in good agreement with the theoretical value which is approximately 40%.

Fig 5 above shows the variation of solar insolation on the selected day. It is clear from the figure that the cooker receives enough solar radiation at around 14.00. Hence, the thermal performance of the cooker is better at that period.

## CONCLUSION

We have been able to construct a cooker that is used to determine at what period of the day is its efficiency maximum. More so, the experimental efficiency found is in good agreement with the theoretical value as calculated in the work.

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# Development of a Wireless Data Acquisition System for Application in Real-Time Closed-Loop Control Systems

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**Abstract**—This paper presents the development of a wireless data acquisition system (WDAS) of incremental encoder sensors, for application in the real-time closed-loop control systems. The wireless technologies evaluated for the system were 433 MHz radio frequency (RF) and Bluetooth 2.0. The developed system was applied to the angular velocity control of a permanent magnet direct current (PMDC) motor, as a way of evaluating its development and also the time of communication with the different wireless technologies. The WDAS with the 433 MHz RF wireless module presented a satisfactory result, while the WDAS with the Bluetooth 2.0 wireless module was not adequate to this real-time closed-loop control system.

**Keywords**—Wireless Data Acquisition, Real-Time, Control Systems.

## I. INTRODUCTION

A fundamental part in the development of control systems is the data acquisition system, which allows the acquisition of information from a plant through the reading of sensors [1]. The conventional way of operating these systems is by means of the wired monitoring of the plant, due to its reliability in data transmission [2]. However, there are systems where wired acquisition is inconvenient, e.g. in a modified Ball and Beam [3] and in photovoltaic systems [2]. In the first, the wired acquisition of the cart position causes the limitation of its movement [3]. In the second, the use of cables increases the cost of installation and maintenance [2].

Acquisition systems applied in control have the desired characteristic of operating in real-time, being essential in critical control applications [1, 4]. In the case of wireless data acquisition systems (WDAS), the time delay between

sampling and application of the control signal, as a result of the data transmission time, may limit the sampling rate of the system. In addition, time delays in reading sensors can lead to system instability and poor control performance, when not taken into account in the controller design [4].

In this context, the work develops a hardware and firmware for a WDAS of a position sensor, i.e. a wireless sensor, the structure of which is typically composed of a sensor, a processing unit, memory and a wireless radio [4]. The processing unit used was the microcontroller PIC18F2331, which has enough memory for the developed application. The position sensor is a quadrature encoder type, which is read using the quadrature encoder interface (QEI) of the PIC18F2331 microcontroller. The technologies of the wireless radios used are 433 MHz radio frequency (RF) and Bluetooth 2.0, respectively, the Canton-Electronics' HYTRP-RS232 and DFRobot's DF-Bluetooth V3.

The purpose of the developed system is the application in real-time closed-loop control systems, therefore its performance was evaluated in the angular velocity control of a permanent magnetic direct current (PMDC) motor, through wired, radio frequency and Bluetooth 2.0 data acquisition. The paper is organized as follows. Section II presents related works. In Section III it is presented the methodology and the materials used in the system development. Section IV presents the validation of the WDAS. Section V presents the obtained results. Section VI presents the conclusions of the study.

## II. RELATED WORK

The work [4] presents the development of a real-time wireless data acquisition board and its software, for

application in the monitoring of structural health in civil engineering. The work is focused on the study of the latency introduced in the control loop by the data acquisition hardware, a low latency hardware solution was developed.

In the work [5], an architecture for the wireless data acquisition applied in the continuous monitoring of ambient radioactivity is presented. Since this monitoring occurs in large, inaccessible and risky areas, the use of wireless sensors is interesting, but the energy consumption of the equipment represents a limitation in its use. The objective of the work was to develop an accurate acquisition system, with self-sustainability and efficiency in energy consumption.

The work [6] proposes an intelligent wireless sensor, which uses the Arduino platform, able to acquire in real time the transverse displacement of railroad bridges under workload. The objective of the work is that the proposed platform is efficient and low cost. The authors validated

the platform in the laboratory proving that the system is able to acquire the transverse displacement and transmit it in real-time wirelessly.

In the work [7], an industrial synchronous wireless data acquisition system using the IEEE 802.11n protocol to implement a high-speed transmission is presented. The purpose of the work was to develop a solution capable of synchronously acquiring the data and allowing the transmission of a larger amount of data with limited bandwidth. Through experiments, the authors concluded that the system can be used in synchronous data acquisition and real-time analysis for applications such as power electronics analysis and bridge health monitoring.

### III. DEVELOPMENT

This section elucidates the materials and methodology applied in the development of the system.

#### 3.1 Wireless Data Acquisition System Overview

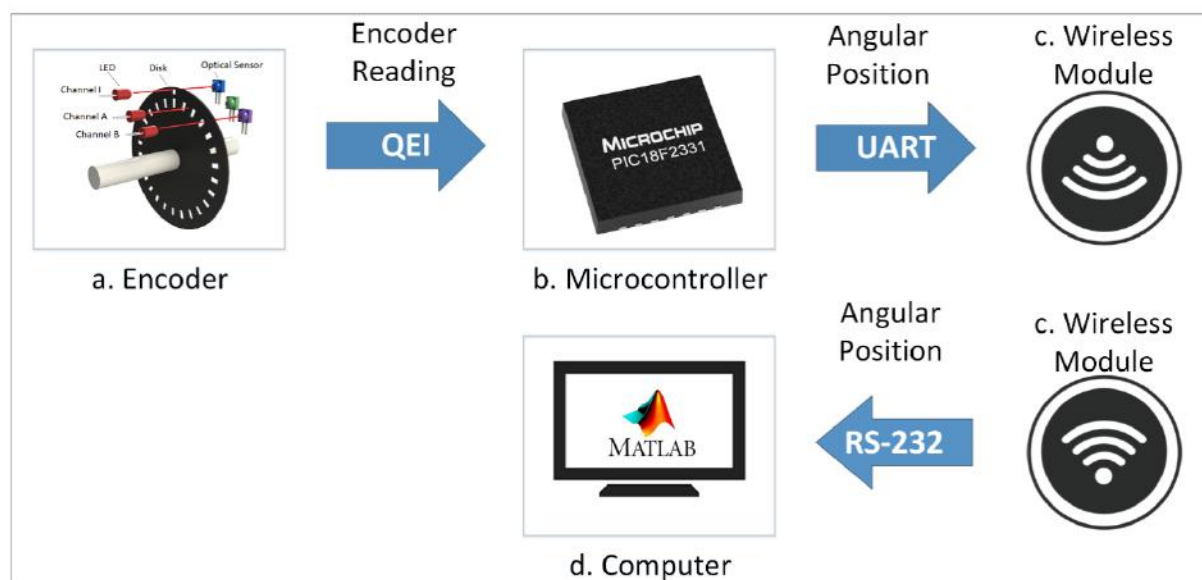


Fig.1: Wireless data acquisition system overview.

Fig. 1 presents the overview of the developed WDAS for reading the position of a quadrature encoder. The processing unit is Microchip's PIC18F2331 microcontroller (Fig. 1b), responsible to read the encoder position, through the QEI module, and send this information through the UART serial communication to the module (Fig. 1c) responsible for the wireless transmission. The other module performs the wireless reception of the encoder position, and transmits to the interface developed in MATLAB/Simulink (Fig. 1d) via RS232 communication.

The wireless modules used in this project were two Canton-Eletronics' HYTRP-RS232 and two DFRobot's DF-Bluetooth V3, both configured with a baud rate of 57,600 bits per second (bps), for communication with the

microcontroller (Fig. 1b) and the computer (Fig. 1d). In this scenario, the wireless modules were evaluated, in relation to the total data transmission time, in order to verify the best technology for data acquisition in real-time. Section V presents the results that aided in the choice of the wireless technology for the WDAS.

#### 3.2 Development of the Wireless Data Acquisition

##### Hardware

The WDAS for encoder reading was made on a printed circuit board (PCB) comprising connectors for any type of incremental encoder of 5V or 3.3V, in addition to the microcontroller PIC18F2331 and a connector for the wireless module.

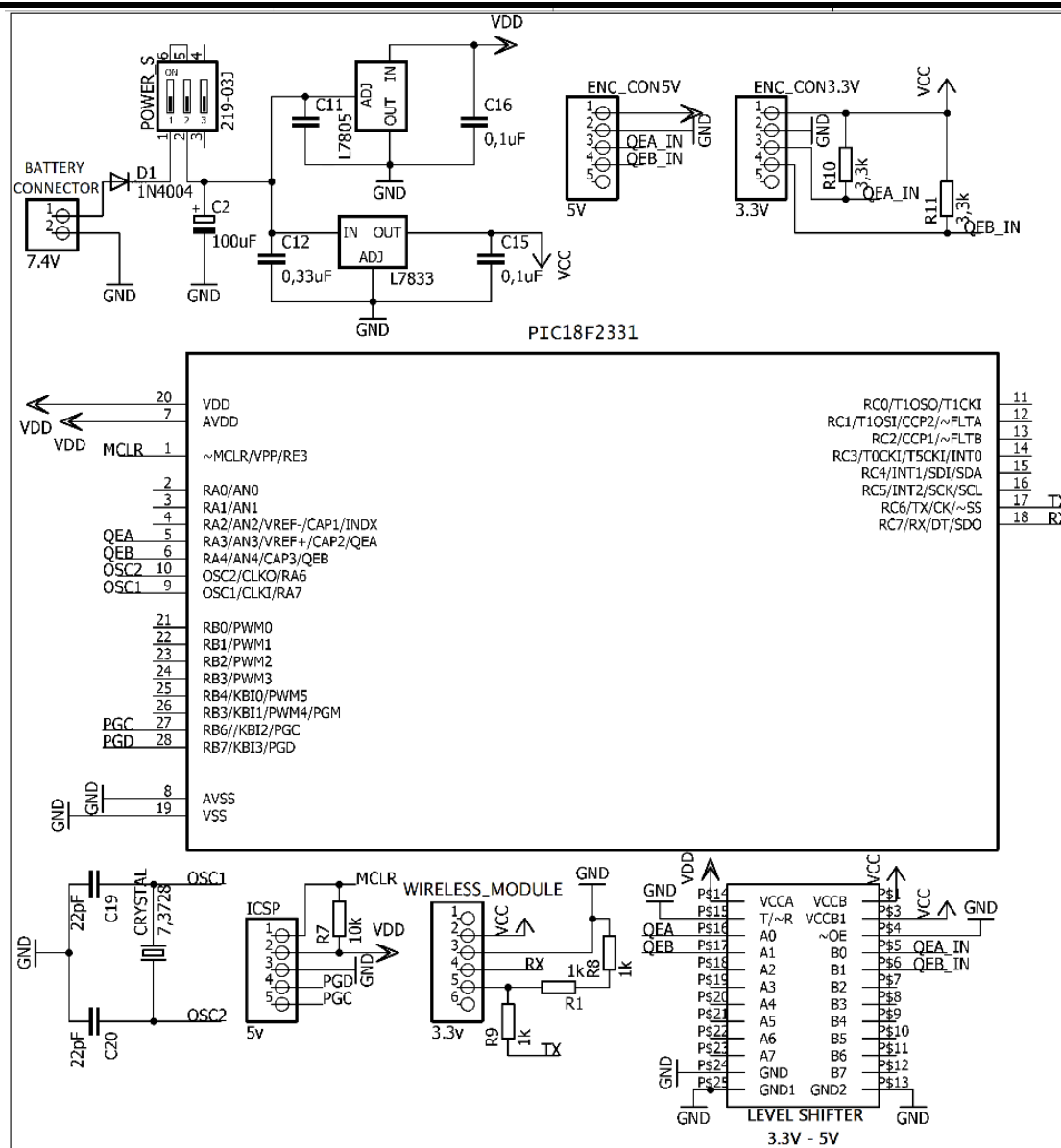


Fig.2: Presents the complete schematic of the PCB.

### 3.3 Development of the Wireless Data Acquisition Firmware

The firmware, built in C language, embedded in the microcontroller has its execution flow described in Fig. 3. In general, the peripherals and interruptions settings step configures the microcontroller's QEI module for X4 encoding and free counting mode, wherein the counter is automatically reset when the maximum count value is reached. In addition to configuring the UART transmission module with a baud rate of 57,600 bps.

The system works with requests initiated by sending the specific command of the implemented functionality. The waiting for the requests, through the serial read interrupt, occurs in step 2 of Fig. 3. If the received command matches the "request sample" command, the system reads the 32-bit encoder count variable and sends it within a response protocol to the computer via wireless transmission. After sending, the system returns to step 2.

The system has only one response protocol that contains a header byte (HB), the encoder reading data bytes (DB), and an end of transmission byte (EB). Table 1 shows the bytes that make up the HB and EB, besides the commands of the implemented functionalities.

Table 1: Commands and protocol bytes used in serial communication.

Byte (Decimal)	Description
40	Protocol Header Byte
41	End of Transmission Byte
123	Request Sample Command
67	Reset Encoder Counting Command

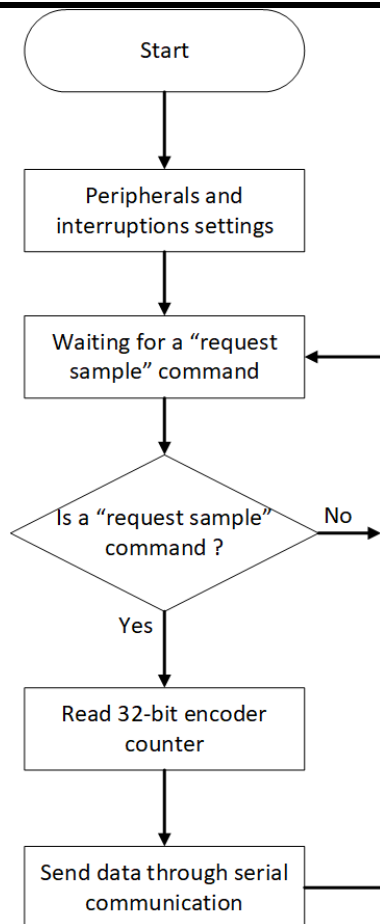


Fig.3: Firmware flowchart.

### 3.4 Development of the MATLAB/Simulink Interface

The interface for sending the commands and acquiring the encoder position can be developed in any program or

programming language capable of manipulating the serial ports of the computer. However, since the objective is to use the WDAS in real-time closed-loop control systems, the interface was developed in MATLAB/Simulink 2012a software.

To do so, the Real-Time Windows Target toolbox was used, which provides a kernel for running real-time models in the Windows operating system [8]. In addition to presenting libraries for handling Input/Output (I/O) devices of the computer, e.g. the serial ports [8].

Fig. 4 illustrates the Simulink block diagram for reading the encoder position through the developed WDAS. The diagram shows the sending of the "request sample" command and the reception of the response protocol with the encoder position, which is converted to angular position in radians (rad). The Simulink block diagram model operates in discrete mode with fixed fundamental sample time ( $\Delta t$ ). When executing the interface, at each  $\Delta t$  is sent the request command and received the response protocol.

The encoder position is a 32-bit variable whose count ranges from 0 to 4,294,967,295. The relation in (1) converts the encoder position to angular position (rad).

$$R = \frac{C \cdot 2\pi}{X \cdot PPR} \dots \dots \dots (1)$$

where,  $PPR$  is the encoder's number of pulses per revolution,  $X$  is the quadrature mode of the sensor reading, being 4 for the quadrature encoder in X4 mode, and  $C$  is the encoder pulses counting. For the calculation of the angular velocity in radians per second (rad/s), it is necessary to perform the numerical derivation of the signal or to apply a derivative filter, as illustrated in Section IV.

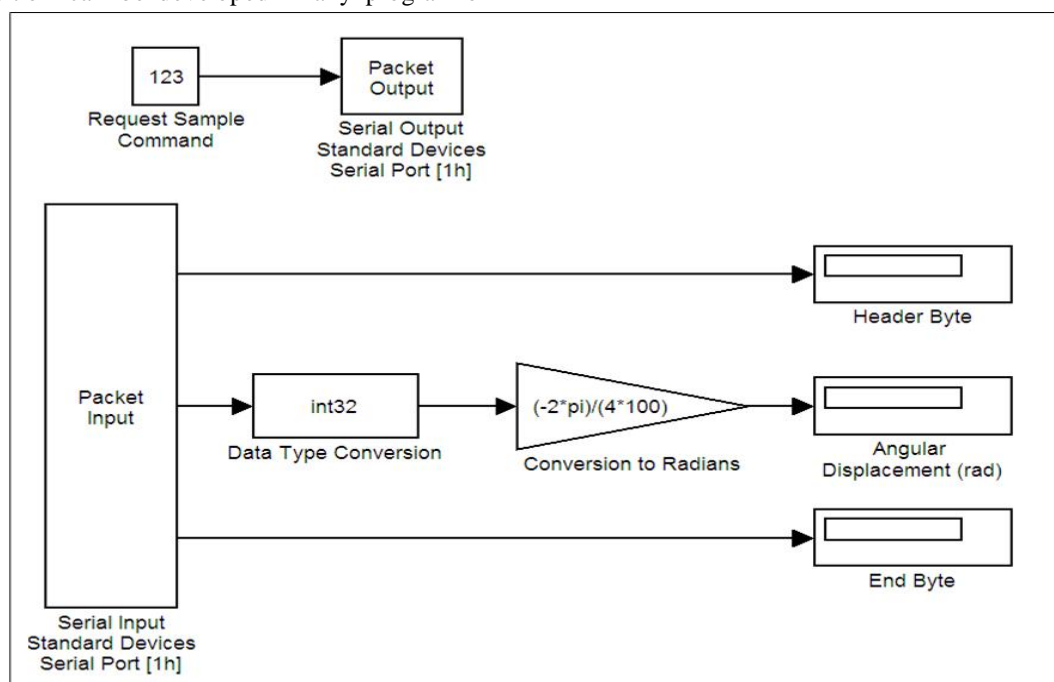


Fig. 4: Real-time data acquisition in MATLAB/Simulink.

#### IV. VALIDATION OF THE WIRELESS DATA

##### ACQUISITION SYSTEM

The validation of the WDAS for reading the encoder position was made through the angular velocity control of the PMDC motor F2140 from Maxon. The linear state-space model of the PMDC motor was extracted from [9]. Its representation is given in (2) and (3).

$$\frac{d}{dt} \begin{bmatrix} \omega_m \\ I_a \end{bmatrix} = \begin{bmatrix} -b/J & K_t/J \\ -K_e/L_a & -R_a/L_a \end{bmatrix} \begin{bmatrix} \omega_m \\ I_a \end{bmatrix} + \begin{bmatrix} 0 \\ 1/L_a \end{bmatrix} V_a \dots (2)$$

$$y = [1 \ 0] \begin{bmatrix} \omega_m \\ I_a \end{bmatrix} \dots \dots \dots (3)$$

Table 2 describes the parameters in (2) and (3) and presents their respective values identified in the work [10].

Table 2: PMDC motor parameters.

Parameter	Units	Description
$b = 2.33 \times 10^{-6}$	$\frac{Nm \cdot s}{rad}$	Viscous Friction Constant
$J = 2.32 \times 10^{-6}$	$Kg \cdot m^2$	Moment of Inertia
$K_e = 0.027439$	$\frac{V \cdot s}{rad}$	Electromotive Force Constant
$K_t = 0.027439$	$\frac{Nm}{A}$	Motor Torque Constant
$L_a = 0.0015168$	$H$	Armature Inductance
$R_a = 10.223$	$\Omega$	Armature Resistance
$V_a$	$V$	Supply Voltage
$I_a$	$A$	Direct Current
$\omega_m$	$\frac{rad}{s}$	Angular Velocity

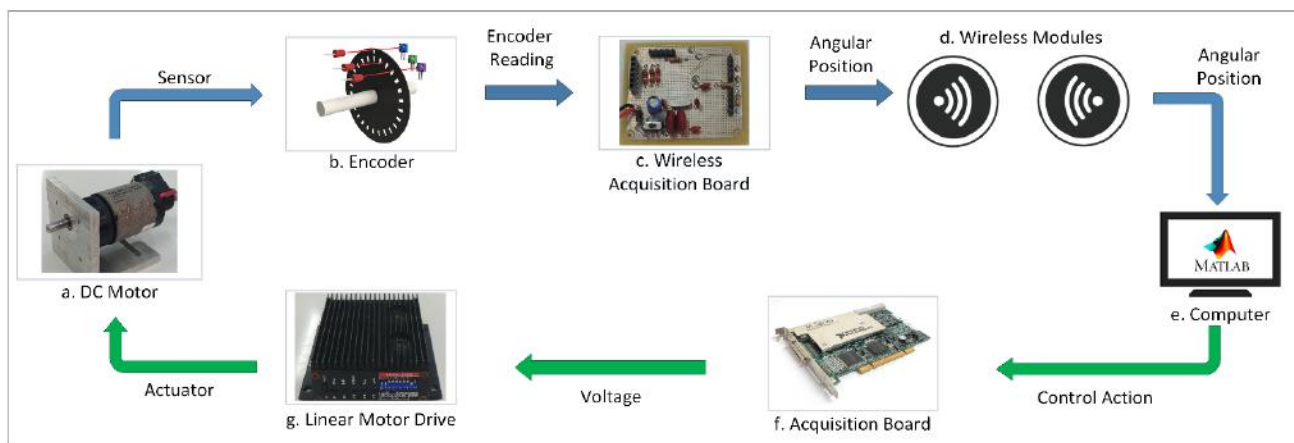


Fig. 5: PMDC motor angular velocity control system.

Fig. 5 shows the angular velocity control system of the F2140 motor (Fig. 5a), which has a quadrature encoder (Fig. 5b), with a resolution of 100 pulses per revolution, coupled to its shaft. The WDAS, which comprises the components in Fig. 5c and Fig. 5d, performs the reading and wireless transmission of the encoder position to the computer (Fig. 5e). In this was developed the real-time closed-loop control.

The angular velocity control of the motor was made in the MATLAB/Simulink. From the encoder position, received via WDAS, the angular velocity (rad/s) is calculated. This is used to obtain the error applied to the controller to determine the control action in Volts (V). The National Instruments PCI-6251 acquisition board (Fig. 5f) applies the control action on the Maxon LSC 30-2 linear drive (Fig. 5g) which actuates the F2140 motor in its voltage operation range, closing the control loop.

The controller implemented to stabilize the motor angular velocity is the PID controller. According to [11], this type of controller is composed of three terms: Proportional, Integral and Derivative. Each of them performs mathematical operations on the error function  $e(t)$ , the sum of these operations results in the control action  $u(t)$  applied to the system. In (4) is denoted the content of the error function.

$$e(t) = r(t) - y(t) \dots \dots \dots (4)$$

where  $r(t)$  is the reference angular velocity and  $y(t)$  is the angular velocity response of the PMDC motor. In (5) is presented the PID control law.

$$u(t) = K_p e(t) + K_i \int_0^t e(t) dt + K_d \frac{de(t)}{dt} \dots \dots \dots (5)$$

Where  $K_p$ ,  $K_i$  and  $K_d$  are the proportional, integral and derivative gains, respectively.



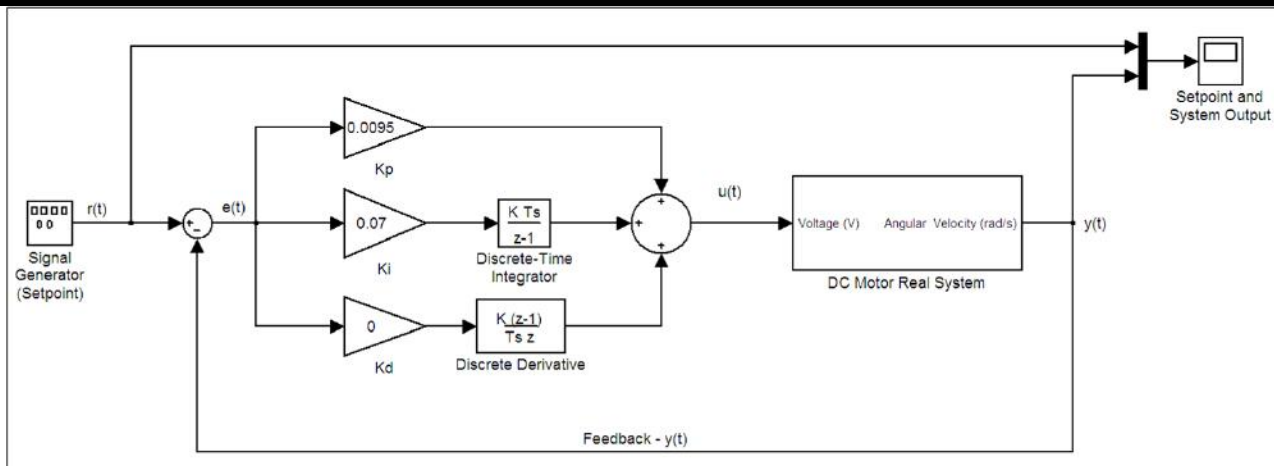


Fig. 6: DC motor angular velocity controller in MATLAB/Simulink.

Based on the state-space model of the motor in (2) and (3), in the motor parameters in Table 2 and in the control law in (5), the real-time closed-loop control was built in the MATLAB/Simulink software, as shown in Fig. 6. The block diagram in Fig. 6 is discretized for its application in the real PMDC motor control system. In this

context, the integral and derivative terms of the control law are calculated numerically as indicated in the Fig. 6. The diagram shows a subsystem that indicates the PMDC motor to be controlled, which is explained in Fig. 7.

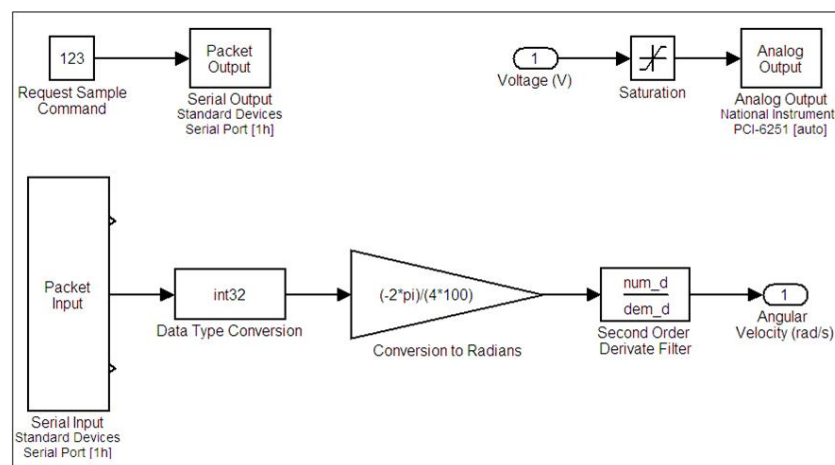


Fig. 7: DC motor subsystem block in MATLAB/Simulink.

In Fig. 7, the voltage (V) applied to the motor drive is limited by a saturator in the range of - 10V to 10V, that is the range on which the PCI-6251 analog output works. In addition, to achieve the operating voltage of the 12V motor, an internal gain was set in the linear drive. The negative voltage present in the operating range is applied to the motor to reverse its direction of rotation.

With respect to the calculation of the angular velocity (rad/s), the position of the encoder is converted to angular position (rad), according to (1), and after, with the aid of a second-order derivative filter, is converted to angular velocity (rad/s). In (6), the transfer function of the second order derivative filter is illustrated.

$$TF = \frac{\omega_{cf}^2 s}{s^2 + 2\zeta \omega_{cf} s + \omega_{cf}^2} \dots\dots\dots (6)$$

where  $\zeta$  is the filter damping ratio and  $\omega_{cf}$  is the filter cutting frequency, defined in (7).

$$\omega_{cf} = 2\pi f \dots\dots\dots (7)$$

where  $f$  is the cut-off frequency in Hertz (Hz).

## V. RESULTS

The real-time closed-loop control of the PMDC motor angular velocity was evaluated for the wired data acquisition and for the WDAS, with the RF and Bluetooth 2.0 modules. For this, the response of the real control for all forms of acquisition was compared to the response of the simulated control by the model in (2) and (3). In addition, the communication time of all forms of acquisition was evaluated. Table 3 presents the PID controller gains, damping ratio and cutting frequency of the derivative filter, all obtained empirically.

The comparison of real and simulated control responses are shown in Figs. 8 and 9. Fig. 8 shows the control for a square wave set point and Fig. 9 for a sinusoidal

wavesetpoint, both with amplitude of 200 rad/s and frequency of 0.1 Hz.

Table 3: General settings.

Parameter	Value	Description
$K_p$	0.0095	Proportional Gain
$K_i$	0.07	Integral Gain
$K_d$	0.0	Derivative Gain
$\zeta$	1.6	Filter Damping Ratio
$f$	15 Hz	Filter Cutting Frequency
$\Delta t$	0.02s	Sample Time

In Figs. 8 and 9, dashed lines in blue illustrate the set point. The solid line in red indicates the control response of the simulated model. The solid lines in green, pink and black colors indicate the real motor control responses for WDAS with Bluetooth 2.0, wired, and WDAS with RF acquisitions, respectively.

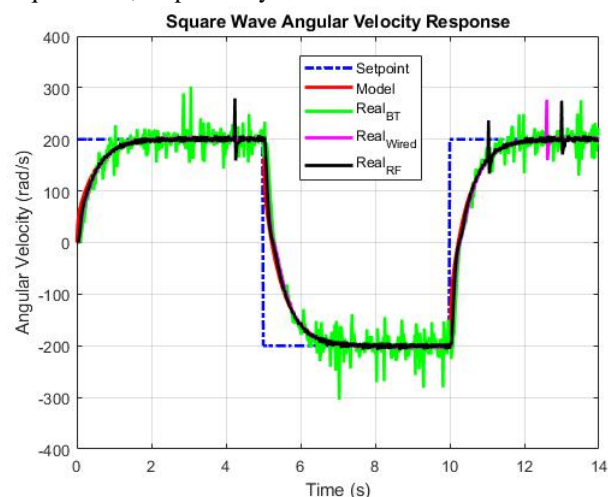


Fig. 8: PMDC motor angular velocity control response (square wave).

Fig. 8 shows that the system reaches the desired setpoint around two seconds for all motor control responses. In addition, the real control responses are in accordance to the simulated control response. This can be verified through the Normalized Root Mean Square Error (NRMSE), in Table 4, which evaluates how accurate is the fit between the response of the real controls and the response of the simulated control.

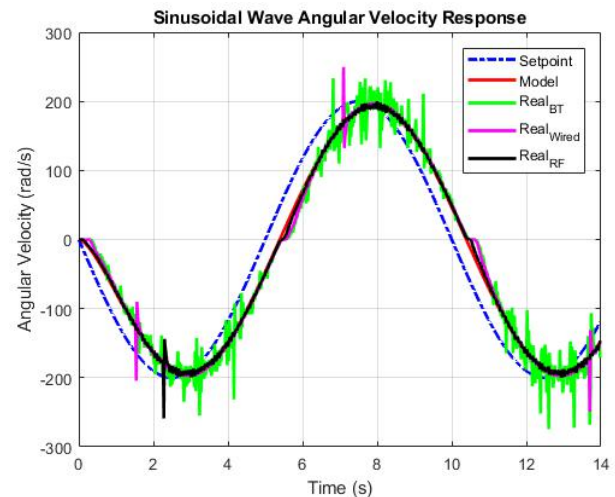


Fig. 9: PMDC motor angular velocity control response (sinusoidal wave).

As seen in Fig. 9, the real control responses are in accordance with the simulated control response. In addition to maintaining the characteristics of the setpoint, even with a delay around 0.4s. Table 4 presents the NRMSE calculation for the control responses with the square and sinusoidal wave set point. A result of 100% indicates that the responses are identical.

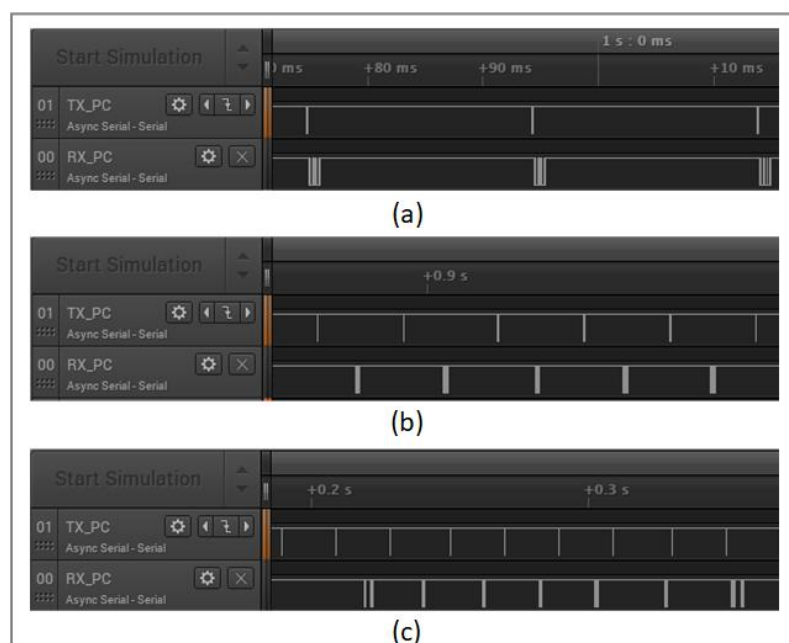


Fig. 10: Serial transmission/reception responses: (a) Wired; (b) Radio frequency; (c) Bluetooth 2.0.

Table 4: NRMSE between the simulated control response and the real control responses, for all modes of acquisition.

Wave	NRMSE Wired (%)	NRMSE Radio Frequency (%)	NRMSE Bluetooth (%)
Square	91.75	92.57	83.70
Sinusoidal	92.95	95.89	85.98

The evaluation of the communication time was performed using the Logic Pro 16 logic analyzer from Saleae. This, connected to the serial port of the computer, observes the sending of the command “request sample” and the reception of the response protocol. Respectively, through the transmission (TX) and receive (RX) channels of the computer serial port. The communication time is calculated in (8).

$t_c = t_{ERP} - t_{IRST}$ ..... (8)  
where  $t_c$  is the communication time,  $t_{ERP}$  is the time at the end of the response protocol reception and  $t_{IRST}$  is the initial time of the command “request sample” transmission.

Fig. 10 illustrates part of the data transmission/reception between the computer and all forms of acquisition, respectively, the wired communication (Fig. 10a), the WDAS with the RF modules (Fig. 10b) and the WDAS with the Bluetooth 2.0 modules (Fig. 10c).

Table 5 shows the average communication time for all forms of acquisition, considering 180 samples. In addition to the standard deviation with 95% confidence interval, according to the student's t-distribution.

Table 5: Data acquisition communication time.

Data Acquisition	Sample delay Time (ms)
Wired	$1.2418 \pm 0.0100$
WDAS + Radio Frequency	$10.1279 \pm 0.7728$
WDAS + Bluetooth 2.0	$41.3627 \pm 17.3689$

## VI CONCLUSIONS

This work presented the development of a WDAS of encoder type sensors, for the application in real-time closed-loop control of systems. For this, its performance was evaluated in the angular velocity control of a PMDC motor, for the wired, radio frequency and Bluetooth 2.0 data transmission. In addition, the communication time of the wireless transmission modules was studied to define the best technology to be incorporated into the WDAS.

In the PMDC motor control for square and sinusoidal setpoint signals, the responses obtained by the wired acquisition and WDAS, with RF and Bluetooth 2.0, followed the behavior of the simulated control, as shown

in Figs. 8 and 9. However, it is possible to note the presence of noise in the response signals. This can occur due to the low resolution of the encoder attached to the motor, which is 100 pulses per revolution. All the signals may eventually present some noise, such as the response signal from the wired acquisition and the WDAS with RF. However, the noise present in the entire response signal of the WDAS with Bluetooth 2.0 is also due to the operating characteristic of the wireless module.

In the analysis of the communication time of the data acquisition, it was possible to estimate the time to acquire the position of the encoder. In the context of real-time closed-loop control, it is necessary that the communication time is shorter than the sampling time, in addition to presenting small variation, so that one can consider that there is a determinism of time in the data acquisition.

As shown in Table 5, the RF was the best wireless technology evaluated, since the communication time was shorter than the sampling time used, in this case of 20 ms, besides presenting a standard deviation of less than 1 ms, for the confidence interval of 95%. In the case of Bluetooth 2.0, the communication time was more than two times greater than the sampling time, besides presenting a standard deviation slightly less than the sampling time. Therefore, the delay and variation of time in the acquisition of the encoder position with the Bluetooth 2.0 module, led to a control signal noisier than that of the other forms of acquisition, as shown in Figs. 8 and 9.

Finally, the results obtained in this work are valid only for the Canton-Electronics' HYTRP-RS232 and the DFRobot's DF-Bluetooth V3 modules, in addition to considering transmission of one byte and the reception of six bytes. If this set changes, the response times will also change and a new study of the communication time will be necessary.

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# Immunizations of Children from 0 to 2 Years: Knowledge of Caregivers and Actions of the Nurse in Family Health Strategy

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**Abstract— Objective:** To identify the main actions developed by nurses in the immunization process, the existence of the practice of care and education in health and describe the caregiver's knowledge about immunization of children under two years. **Methods:** Field research with prospective approach, descriptive objective, qualitative-quantitative approach and phenomenological epistemological assumption held with senior professional nurses and caregivers of children aged 0 to 2 years, two Health Units Family. He began collecting data after approval by the Ethics and Research Committee. Data collection was carried out between February and April 2016, lasting 65 days. We used two types of questionnaires, one for nurses, with open and closed questions, and another destined to caregivers, with closed questions. **Results:** Caregivers of children are mostly female. The age range is between those who had reached adulthood. There is a plurality of children within

most families. The level of education is low, but with a tendency to growth. Study involving nurses: mostly female, 7 (87,5%), predominantly aged between 30 and 40 years, 5 (62,5%), 10 to 15 years of professional experience, 4 (50%), and at least two employments, corresponding to 6 (75%) of the screened sample. **Conclusions:** There are aspects that need to be studied and thought throughout our society, opening banks to have more studies aimed at preventive practices with host and to improve the lives of nurses, helping them with findings that improve their health actions.

**Keywords—** Children. Caregiver. Nurse. Immunization. Knowledge.

## I. INTRODUCTION

The world population has a preventive resource of extreme importance to health, which is vaccination, as it provides protection against serious diseases, reducing the



circulation of infectious agents, acting as a shield for the community. Children are individuals who, from an immunological point of view, are more prone to acquire diseases, so their first five years should be met with immunization measures against immunopreventable pathologies (OLIVEIRA et al., 2010).

Santos et al. (2011) state that activities in the vaccination room should be carried out by trained persons. In addition, it is important to pass on the knowledge and guidance necessary for caregivers to realize the importance of immunization as a prophylactic measure of disease. The caregiver needs to feel informed and welcomed to develop the essential minimum of quality of life care for their children (TERTULIANO & STEIN, 2011).

The importance of a study aimed at education in immunization with the host is necessary to: guide caregivers, minimize vaccine shortages and distancing the caregiver with the health team, give subsidies to the educational actions in health and guide the nurse on the reception in his work process in the vaccine room. Therefore, the following questions are asked: what are the knowledge of caregivers and what are the main actions developed by the nurse and in this process?

This study aimed to identify the knowledge of the caregiver regarding the immunization of children under two years and the main actions developed by the nurse in the vaccination process, with detection of the practice of health care and education in two Family Health Units (FHU).

## II. METHODOLOGY

The present study is a field research, with a prospective focus, a descriptive objective, a qualitative approach and a phenomenological epistemological assumption, as a theoretical reference tool which was performed with caregivers of children aged 0 to 2 years and with professional nurses, graduates of two Family Health Units - FHU of the municipality of Porto Velho-RO, being: FHU Agenor de Carvalho and FHU Socialista.

The research was developed in order to ensure compliance with Resolution 466/12, referring to research involving human beings, started with the authorization of the Municipal Immunization Secretariat, approval of the CEP, by the Research Ethics Committee of the Federal University of Rondônia - UNIR, under the number of opinion 1,128,565, on June 1, 2015, signing the Term of Free and Informed Consent (TFIC) by the respondents and then the instruments for data collection were applied. Data collection started on February 22, 2016 and ended on April 27, 2016, with a duration of 65 days. All

questionnaires were retrieved and there was no sample loss.

The definition of the sample was based on the non-probabilistic form, which included 60 caregivers, selected from 0 to 2 years old children, 30 from FHU Agenor de Carvalho and 30 from FHU Socialista, who accepted to participate in the study and 8 nurses, 4 from FHU Agenor de Carvalho and 4 from the FHU Socialist, invited to participate in the research, acting and / or responsible for each of the vaccination rooms of the FHU researched.

During the research, researchers were informed about the purpose of the study and the free right to choose to participate, as well as the need to sign the informed consent form.

After the signing of the TFIC, the instruments of data collection were distributed to caregivers and nurses. The questionnaire of the caregivers contained 13 closed questions and the subjects surveyed responded when they took the children for vaccination. The nurses' questionnaire, with 11 argumentative questions, 4 closed and 11 open, were delivered at the beginning of the files and collected at the end.

The quantitative data were tabulated in Microsoft Excel 2010 and exposed through tables and graphs along with their arguments. For the content analysis of the open questions we used the content analysis method proposed by Martin Heidegger, the results were exposed, guaranteeing the confidentiality, by pseudonyms represented by names of plants of the Amazonian biodiversity and confronted with the pertinent scientific literature.

## III. RESULTS

### 3.1 Characterization of Caregivers in Socio-demographic Aspects

Regarding gender, it was observed that 58 (96.7%) female caregivers and 2 (3.3) male caregivers. In the age group, 28 (46.6%) aged 20 to 29 years, 17 (28.3%) between 30 and 39 years, 14 (23.3%) under 20 years, 1 (1.6%) between 40 to 49 years and 0 (0%) and over 50 years. Twenty-one (36.6%) were single, 20 (33.3%) were in a stable union, 16 (26.6%) married, 1 (1.6%) in legal separation and 1 (1.6%) widowed. We have 25 (41.6%) caregivers who have a child, 23 (38.3%) have two children, 7 (11.6%) have three children and 5 (8.3%) have four or more children. 35 (58.3%) had completed or incomplete high school, 17 (28.3%) reported having studied elementary or incomplete elementary education, 7 (11.6%) attended either complete or incomplete higher education and 1 (1.6%) have some type of postgraduate, master's and/or doctorate degree.

Table.1 - Sociodemographic characterization of caregivers attending FHU Agenor de Carvalho and FHU Socialista. Period from February to April 2016.

DATOS	VARIABLES	FHU AGENOR DE CARVALHO		FHU SOCIALISTA		TOTAL	
		Nº	%	Nº	%	Nº	%
GENRE	Male	1	1,6	1	1,6	2	3,3
	Female	29	48,3	23	48,3	58	96,7
AGE GROUP	Under 20 years old	7	11,6	7	11,6	14	23,3
	20 a 29 years old	10	16,6	18	30	28	46,6
	30 a 39 years old	12	20	5	8,3	17	28,3
	40 a 50 years old	1	1,6	0	0	1	1,6
	Over 50 years	0	0	0	0	0	0
MARITAL STATUS	Not married	10	16,6	12	20	22	36,7
	Married	8	13,3	8	13,3	16	26,6
	Stable union	11	18,3	9	15	20	33,3
	Legal Separation	0	0	1	1,6	1	1,6
	Widower	1	1,6	0	0	1	1,6
NUMBER OF CHILDREN	A son	8	13,3	17	28,3	25	41,6
	Two sons	17	28,3	6	10	23	32,3
	Three sons	3	5	4	6,6	7	11,6
	Four sons or more	2	3,3	3	5	5	8,3
EDUCATION	No schooling	0	0	0	0	0	0
	Element. School Completed or incomplete	9	15	8	13,3	17	28,3
	High School Completed or incomplete	17	28,3	18	30	35	58,3
	Higher Education Completed or incomplete	4	6,6	3	5	7	11,6
	Postgraduate, Master and Doctorate	0	0	1	1,6	1	1,6

Source: Araújo et al, 2016.

Legend: FHU = Family Health Unit

It was evidenced that there is predominance of the female sex, being 96.7% among the caregivers.

Increasing studies on infant vaccination are based on female samples, with statements from mothers, who predominantly participate in this process. The participation of the men-parents in the vaccination of their children is little found and their understanding of the issue is also scarce (BARBIERI, 2014; GUTIERREZ & MINAYO, 2010).

Regarding the caregiver's age, there were predominance of those who had reached the adult stage, with 28 (46.6%)

caregivers between 20 and 29 years old and 17 (28.3%) caregivers between 30 and 39 years old and 1 (1.6%) caregiver was between 40 and 50 years old.

Cavalcanti & Nascimento (2015) report that mothers who are of age are better able to develop the process of childhood vaccination due to the maturity they have already acquired, and that they are more likely to seek knowledge about prevention and health promotion measures, as is the case of childhood vaccination.

The extreme ages of the caregivers, such as younger age, and elderly people over 60 years of age are considered

risk factors for current vaccination, since several studies show that in these phases there is the highest level of forgetfulness (Cava- cal et al. 2015).

In relation to the marital status, 20 (33.3%) stated stable union and 16 (26.6%) were married, making a total of 36 (60%) caregivers, more than half of them researched, committed to their spouses and involved in family commitments.

This result is in line with other studies that also have a predominance of caregivers with partners in their sample, such as the authors Cavalcante et al. (2015), who obtained 74.62% of married caregivers, of the authors Yococura et al. (2013), which quantified 81.8% with colleagues.

Sixty-three caregivers, the largest portion of the sample, were 60 children, and 23 caregivers with two children (32.3%), 7 caregivers with three children (11, 6%), 5 caregivers with four or more children (8.3%), showing that the greater number of caregivers have already acquired some experience regarding the immunization of children under two years of age.

Carneiro et al. (2013) in analyzes of the results of their study, related the higher numbers of children to risk factors for vaccine delay. Another author says that associated with the greater number of children, there must be some unfavorable internal or external condition for the vaccine to be disregarded, otherwise it would not be a hindrance (CAVALCANTE et al., 2015).

The education level of the population studied is more concentrated between high school and elementary school. A total of 35 (58.3%) of those surveyed reached high school and 17 (28.3%), caregivers who only had complete

or incomplete elementary education, culminating in a low level of education.

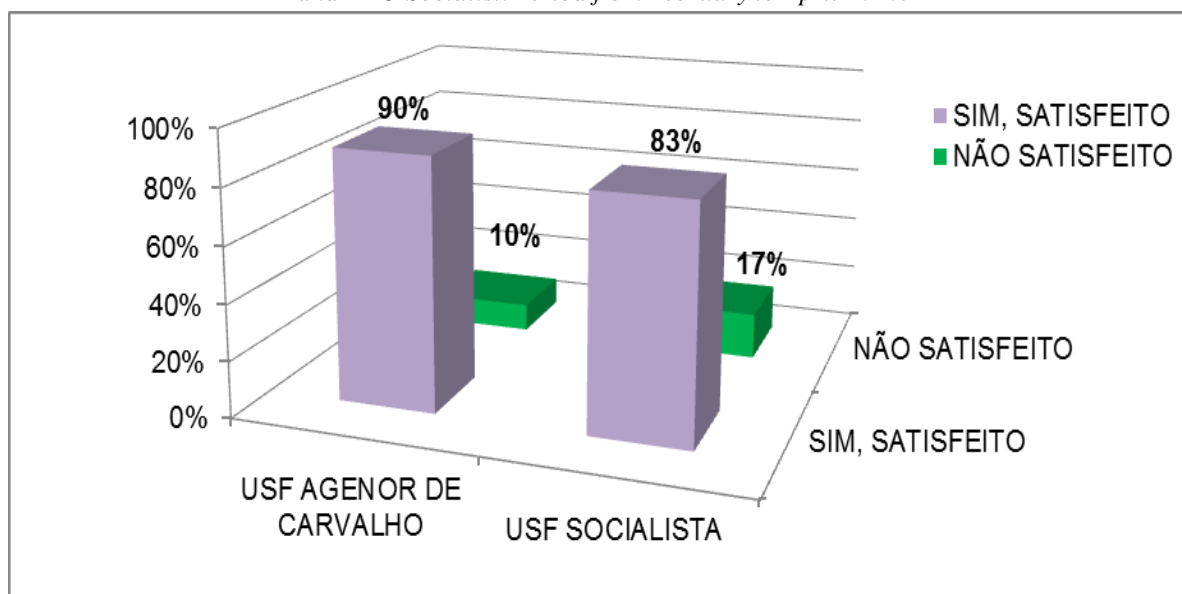
According to Silva & Borges (2011), the mothers' education influences how they receive information about their children's health and their time of study is of paramount importance in research that deals with the health of the child. knowledge will influence how they develop care for their children. In case of low schooling, there is no correct understanding of past information.

It is concluded in this research that female caregivers are the ones who are most involved in the life of these children. The risks of the caregivers' age range are diminished in the studied population, since they are not in the extreme ages, as in the case of adolescence and the elderly. The plurality of children found is a point to be considered positive or negative for the acquisition of knowledge in the vaccination process, but it depends very much on the personal situation and stimulus of each individual. Low schooling has shown that the population may have difficulty understanding past information, but they are beginning to diversify their intellects.

### 3.2 Satisfaction with the Service, Difficulties Generating Vaccine Delays and Facing the Vaccine Reactions

The 60 respondents were asked if they were satisfied with the FHU in which they vaccinated their children in order to know their feelings about the services offered. At FHU Agenor de Carvalho 27 (90%) are satisfied and 3 (10%) are dissatisfied. In the FHU Socialista, 25 (83%) are satisfied and 5 (17%) are dissatisfied, as shown below, in figure 01.

Graph 01 - Caregiver satisfaction with the Family Health Unit in which your child is vaccinated. FHU Agenor de Carvalho and FHU Socialista. Period from February to April 2016.



Source: Araújo et al, 2016.

Legend: USF = FHU and SATISTEITO = PLEASED

The results show that in both units the majority of caregivers are satisfied with the immunization services offered.

Massuia, Mendes & Cecílio (2010) stated that this concern is necessary due to the urgency to highlight the quality and efficiency of the public service provided, the host practice, because in unsatisfactory cases there is a probability of resurgence of cases of immunopreventable diseases, the satisfaction of the user would indicate ways of working to have the optimization of management in immunization services.

Of the 30 respondents from each FHU, 20 (67%) confirmed delaying the vaccines and 10 (33%) never delayed them, we found that, in total, 40 (67%) caregivers face some hindrances that lead to delays.

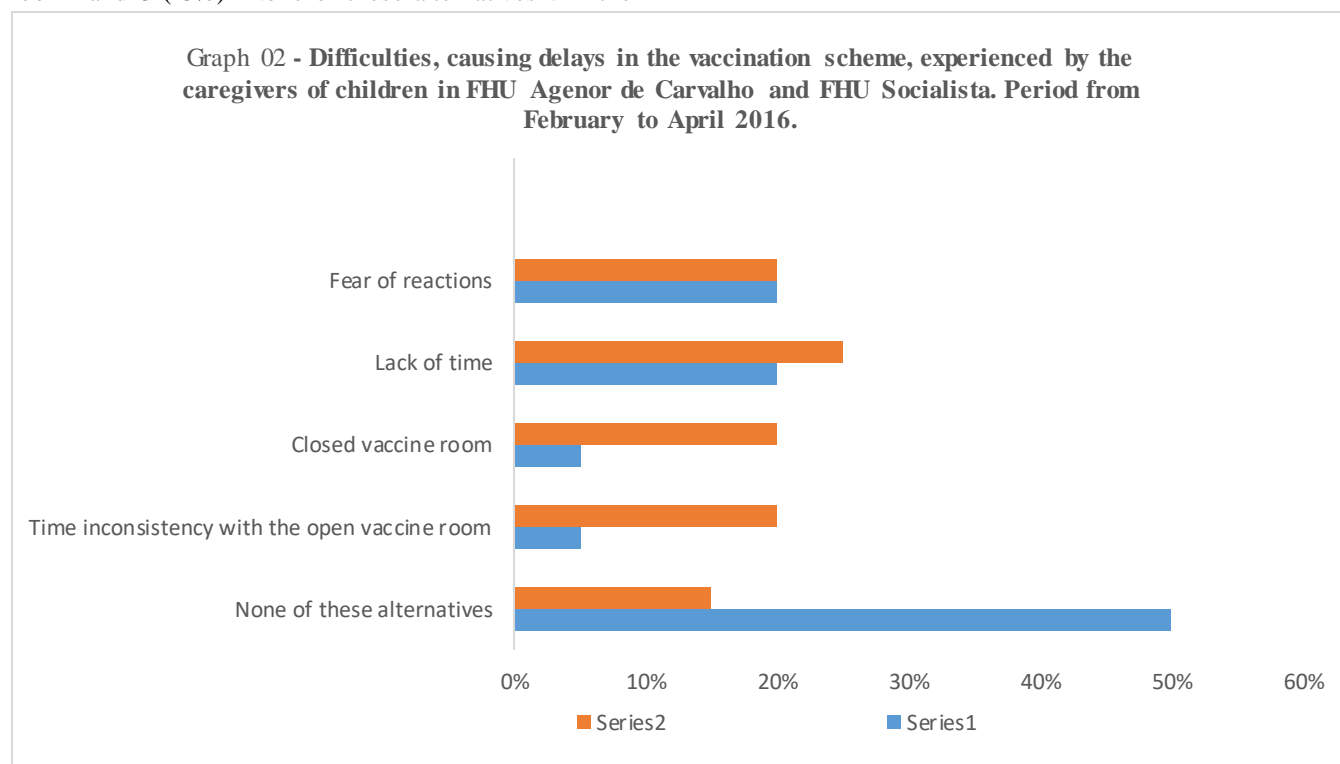
Of the difficulties that the caregivers face to vaccinate their children we have the quantification: in FHU Agenor de Carvalho 5 (25%) chose the "lack of time", 4 (20%) the "Fear of reactions", 4 (20%) a "Closed vaccine room", 4 (20%) "Time inconsistency with the open vaccine room" and 3 (15%) "None of these alternatives". In the

Socialist FHU 10 (50%) chose the option "None of the alternatives", 4 (20%) the "Fear of reactions", 4 (20%) "Lack of time", 1 (5%) closed vaccine "and 1 (5%) the" Incompatibility of time with the open vaccine room". (See Graph 02).

In the analysis of the data presented above we have: the lack of time with 5 (25%) surveyed at FHU Agenor de Carvalho and 4 (20%) surveyed were left with this option at FHU Socialista.

This result is in agreement with the study that reaffirms that the various commitments assumed by the parents are the detrimental factor of the memories of the doses scheduled in the child's vaccination schedule, citing the work day as one of the obstacles in vaccination (ANDRADE, LORENZINI & SILVA, 2013).

Vale et al. (2014) indicates that the difficulty in being away for a considerable time from their personal activities, or often domestic activities, is a factor that leads to the desistence of vaccination in a few days and the vaccine loss



Source: Araújo et al, 2016.

Legend: Série 2 = FHU Socialista.

Série 1 = FHU Agenor de Carvalho

The fear of the vaccine reactions obtained 4 (20%) choices in each FHU researched, being this a considerable percentage, since it totalizes 8 caregivers, out of 60 researched ones, who declare this reality. Despite this fear, 93% in the FHU Agenor de Carvalho and 90% in the FHU Socialist, declared to be knowledgeable of the post-vaccinal adverse events, with, which denotes an educational work on this subject. Fever was reported by 14 (47%) and 13 (43%) and pain by 4 (13%) and 6 (13%)

of the most frightening reactions in FHU Agenor de Carvalho and FHU Socialista.

Concern and fear about vaccine risks interfere with parents' vaccination decision (FIGUEIREDO et al., 2011). The presence of adverse reactions, which are greater than expected, are one of the causes of vaccine delays and abandonment of the vaccination program, so these problems can not be under complete occlusion from the perspective of health services so that strategies can be

created to combat the breaks for this reason (SILVA, 2014).

The frightening fame of the vaccines stems from its initial history of implantation, since these caused risks and required courage to be taken. Today, however, the vaccine is among the safest biological products and any adverse event occurring must be systematically reported in the National Post-Vaccine Adverse Event Surveillance System, to undergo investigations and clarifications, ensuring the population a service of quality (BRASIL, 2014; PIACENTINI & CONTRERA-MORENO, 2011).

This information needs to be passed on to mothers so that they become more reliable in immunization services. 3.3 Expectativas e Saberes dos Cuidadores para com a Vacinação

Caregivers were questioned about the importance of vaccination, most of the population surveyed, FHU Agenor de Carvalho and FHU Socialista, respectively (93% and 90%), acknowledged the importance of immunization for the health of their children.

In the studies of Cavalcante et al. (2015), a result compatible with current research was found, where 98.46% considered the vaccine to be important and about 1.54% did not consider it relevant. The researchers considered this outcome beneficial to prevent illness and death of the child.

Vaccination is currently considered of great importance for the individual and collective protection of children against immunoprevalent diseases, as it acts to interrupt the transmission and results in its control or even its eradication (SOUZA, VIGO & PALMEIRA, 2012).

This result is favorable since vaccination is seen by caregivers as a strategy of real importance for the health

of the children, so this will allow a better adhesion of the population to the vaccination scheme of children under two years.

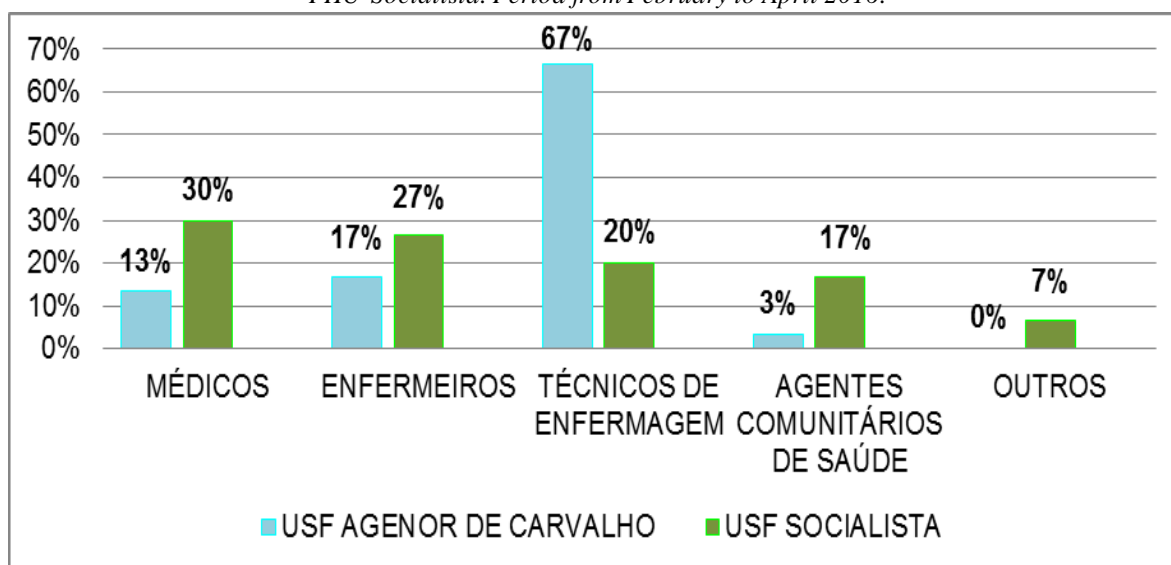
Caregivers were asked whether they were knowledgeable about the purpose of the vaccines administered to children. In FHU Agenor de Carvalho 28 (93%) and in the FHU Socialista, 20 (67%) surveyed know what the child immunization is for.

The results of a study have shown that a large proportion of the participants recognize the usefulness of immunization and label it as a strategy to protect children against various diseases, whose goal is focused on prevention and that lack of vaccination could make infants vulnerable to diseases (ANDRADE, LORENZINI & SILVA, 2013).

To this end, 25 (83%) caregivers received and in the FHU Socialista, 22 (73%) received guidance in the vaccine room, at FHU Agenor de Carvalho. It is well known that effective communication between mothers and health professionals promotes greater certainty that there is correct compliance with the childhood immunization schedule (ANDRADE, LORENZINI & SILVA, 2013).

Regarding which professional provides the most clarification to caregivers, we have the opinion of FHU Agenor de Carvalho, the nursing technicians with 67% of caregivers, nurses with 17%, physicians with 13%, Community Health Agents (ACS) with 3% and other professionals with 0%; in the FHU Socialist doctors were chosen by 30% of the sample, the nurses by 27%, the nursing technicians by 20%, the Community Health Agents - ACS by 17% and other professionals by 7% of the sample.

Graph 3 - Professional who provides more information about immunization to caregivers in FHU Agenor de Carvalho and FHU Socialista. Period from February to April 2016.



Source: Araújo et al., 2016.



It was noticed that the population studied is guided by several professionals, but there is still a greater prominence in the participation of the Technician in Nursing, with 67%, as the one that guides the population more.

Carvalho et al. (2015) argues that information pertaining to vaccination should be provided by the nurse and her team during the practice of vaccination and the visit of the puerpera to the health system. For this reason the team needs to be trained and prepared to teach, with health education methods, and clarify doubts, not forgetting to reinforce the importance of compliance with the vaccination schedule.

The nursing professional, as a vaccinator, is given another opportunity to develop as an educator while practicing his / her work activities, advising on the prevention of diseases and the importance of immunization in these cases to the diseases (ANDRADE, LORENZINI & SILVA, 2013).

### 3.4 Characterization of the Profile of Nurses that Work in Basic Health Units

Of the nurses studied, 7 (87.5%) are female and 1 (12.5%) are male; 5 (62.5%) aged 30 to 39 years, 2 (25%) between 40 and 50 years, 1 (12.5%) are over 50 years old and there are no professionals in the age group between 20 and 29 years ; 4 (50%) have 10 to 15 years of profession, 2 (25%) with 5 to 10 years, 1 (12.5%) with 15 to 25 years, 1 (12.5%) with more than 25 years and no participant has been active for less than 5 years; 6 (75%) have two jobs, 1 (12.5%) have three jobs, 1 (12.5%) have an employment relationship and there were no responses to the elective more than three jobs.

The nurse profile is mostly female, 7 (87.5%), with a predominant age group between 30 and 40 years, 5 (62.5%), 10 to 15 years of **professional experience, 4 (50%)**, and with at least two employment links, corresponding to 6 (75%) surveyed in the sample.

The study conducted by the Oswaldo Cruz Foundation (Fiocruz), on the initiative of the Federal Nursing Council - COFEN (2015) on the profile of nurses, shows that the nursing teams are formed by the female sex, **being composed of 84.6% women**. However, the study suggests that nursing is establishing an availability to masculinization, even though the present study still brings the predominance of women in the profession.

About the time of profession, according to Ramos et al. (2009), the higher the time spent in Family Health Nursing (ESF), there is a great possibility of acquiring experiences in the profession and forming links between the team and the user.

According to the present study in Rocha & Zeitoune (2007) on the profile of nurses of the Family Health Program - PSF in Florianópolis (PI), the predominant age

group of nurses was 31 to 40 years old and they pointed out that they have this reality because they are not adequately remunerated with their training and competence, they also affirm that the reality of working in more than one place is determined by the inadequate salary conditions of the professional and not by their spontaneous will.

Medeiros et al. (2010) found that although the accumulation of jobs leads to a wage increase, stress increases almost in the same proportion and this unfavorable condition interferes with the care provided and the health of the worker himself.

### 3.5 Effectiveness of Nursing Practice Guidelines in FHU and the Nursing Practice in the Immunization Process

The professional nurse is responsible for the supervision and monitoring of the immunization work, in addition to having the permanent education of the immunization team, this professional must guide and assist the population in safe conditions (BRASIL, 2014; TERTULIANO & STEIN, 2011).

The following nurses' reports reveal the importance of guiding immunizations:

"It will allow the user to recognize the importance of the vaccine [...] besides giving quality of life [...]. Orienting, reduces consultations due to illness" (Palmeirinha).

"Ensure that everyone is vaccinated, preferably in the correct age range. Since this practice decreases the rate of infant mortality and hospitalization" (Caapeba).

Much of this care that must be undertaken prior to and after vaccination can be done with clear, objective, succinct guidelines that contain the appropriate information to be truly understood (SANTOS et al., 2011).

Another important guideline on immunization is to:

"[...] demystify certain fears" (Castanheira).

By demystifying fears and erroneous empirical knowledge, the professional can not destroy the autonomy that users have to build their own health. However, he must listen attentively, acknowledge the other's knowledge, perceive his form of expression, welcome him and care for him with his attention focused on him (VASCONCELOS, GRILO & SOARES, 2009).

We questioned what educational strategies would work to keep caregivers oriented on the immunization process of children.

"Wheels of conversations and in the daily visits of the ACS" (Rubber tree).

Vasconcelos, Grilo & Soares, (2009) explains that in the wheels of conversation all the assembled members are invited to sit in a circle, then interaction dynamics are

developed, such as the presentation of each member, and activities on a particular theme they wish to teach to the target audience.

Another option of educational strategy would be an appeal to visual learning as reported below:

"The main strategy: to offer pupils and training to the ACS to explain the importance of vaccination, to train nurses and doctors of the changes in the schemes and more educational campaigns on TV and the internet" (Palmeirinha).

The ACS was incorporated into the Basic Health Team since the creation of the Family Health Program in 1994. This professional makes it possible to know the reality of the territory under his responsibility, therefore, the reality of the families (VASCONCELOS, GRILO & SOARES, 2009). taking advantage of this function of ACS would be a good educational strategy to incorporate activities that guide immunization, as pointed out by the researcher.

Regarding the nurse's response indicating the means of communication to inform, Araújo's study (2010) reports that there is a wide relationship between Communication and Health and that it is growing more and more each day, since communication has been used for the promotion of health, because in a mediated world, to use these means is fundamental plan and can be a good strategy of information to the Health Service.

The research pointed out that nurses think about the creation of educational strategies to keep caregivers informed, among which the ideas pointed out were: communication media and community health agents.

We question nurses about what immunization-related health education activities their staff performs within the FHU and / or campaigns:

"The main activity is during childcare consultations with evaluation of the vaccine booklet to assess delays in doses and activities performed by the ACS in the area. Discovery area does not exist many actions" (Palmeirinha).

Vasconcelos et al. (2012) points out that the moment of this consultation is an opportunity for the mother or caregiver to take her doubts, expose her difficulty of the day to day care of the baby, besides it is a great ally in the promotion of health and prevention of diseases.

Another strategy is groups as an educational medium that nurses claim to already utilize in the reality of their service.

"Groups of children, lecture on vaccination, supervision of CHAs in the area, as well as verification of the vaccination books" (Caapeba).

Campos et al. (2011) says that nursing consultations, medical consultations and groups are health services that favor the performance of all child care teams, in an

interim or joint manner, favoring the expansion and integrality of the service. We question nurses about what they understand immunization and if they practice it, they reported:

"It is measures and practices that must be developed with the population, aiming at adherence the vaccines advocated by MS. With actions of orientation empathy and mainly to develop in the user the responsibility and commitment [...]. Yes" (Palmeirinha).

"Immunization is a very important factor because it is through this action that a relationship of trust and commitment is built between the user and the healthcare team, that is where we have the opportunity to provide guidance on immunizations. Yes" (Vitória-Régia).

Nurses' reports on the host refer very much to the proper immunization guidelines. The study of Pereira & Barbosa (2007), whose theme is: nursing care in immunization: myths and truths; points out the nursing committed to all the actions of NIP implementation, being responsible, guiding and providing assistance with safety, responsibility and respect.

It was noticed, with most of the reports, that the nurses have the science that they must carry out the reception in the vaccine room, with the appropriate guidelines to their clients.

### **3.6 Motivation for the Development of Educational Strategies in Immunization**

Through the reports below we can see if nurses feel motivated or not to develop educational strategies in immunizations:

"Yes, always carrying out activities by the team to keep the children's vaccination updated" (Vitória-Régia).

The above speech shows that the reason the nurse is motivated is the very commitment required by his profession, which is to keep the vaccination of the children up to date, making him develop activities together with his team in this regard. For Robbins (2008), motivation is related to the existence of an interaction between some situation and the individual. Therefore, each person has a different reason to motivate himself.

"Motivated not, but we always have an obligation to encourage the parents to carry out the vaccination of the children and to guide the importance" (Babaçu-do-Amazonas).

"Service not motivated. I am motivated by the principles and responsibility I have with the children who consult with me" (Palmeirinha).

The professional dissatisfaction can reflect in their services, with apathy, indifference, lack of commitment,

irresponsibility, dehumanized relation with the clientele and lack of creativity (HORBACH & STEFANO, 2008).

It is generally concluded that nurses are dissatisfied with their work, but most perform their function in respect to the profession and the child.

### 3.7 Vaccine Delay and Its Determinants in Nurses' Perspective

Here are the reasons, in the opinion of the nurses for the vaccine delay.

"[...] ignorance, myths about the possibility of a vaccine to do harm," (Palmeirinha).

"Because they do not trust the vaccines and choose to postpone them or even eliminate them ... pure ignorance" (Buriti).

Meeting the nurses' statements, the research by Tertuliano & Stein (2011) mentions the unstable family situation and the low level of schooling of the parents as a factor that can interfere in the vaccine delay in up to 25% of the cases.

A study carried out by França et al. (2009: 262) in campina grande-PB, says that: "the resistance of the parents was pointed out as the main barrier to the reach of vaccination coverage, which may be the result of beliefs, culture of the elderly and even the fear of vaccine reaction."

With the nursing professionals' science, observed in this study, about the factors that cause the vaccine delays, there is a greater chance to work the awareness of the caregivers regarding the correct fulfillment of the vaccination schedules and to plan strategies to take advantage of the vaccine opportunity.

## IV. FINAL CONSIDERATIONS

With regard to the development of immunization in the units surveyed, there was a growing progress in this area of preventive health, a satisfied population, knowledgeable about the process and the good it provides for its children, despite the delays and difficulties they face day to day. It was also noticed that the professional nurse is a subject who is trying to improve his health practices every day, because despite the dissatisfaction of the profession, they are more focused on giving their best thinking about the well-being of others. This study made clear some aspects that need to be studied and thought by the whole society of Porto Velho, opening up margins so that there are more studies that aim at preventive practices with reception and that improve the life of the nursing professionals, helping them with findings that would improve health actions.

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# Application of Reverse Logistics in Hospital Material Processes: Case Study

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**Abstract**— One of the major current concerns of society is the environmental issue, precisely because this is a prerogative of great importance for the populations in terms of quality of life. International organizations have sought to develop symposiums, seminars, and global meetings that involve discussions on environmental issues. Since the 1992 ECO-Rio-92 world summit, Brazil has sought to develop a normative framework to foster mechanisms of environmental policies, an element that is already part of the 1988 Constitution of the Federative Republic of Brazil. Thus, this article addresses the Reverse Logistics of Health Services Waste in a public hospital in the city of Manaus-Amazonas, with the general objective of analyzing the reverse logistics process in the recycling of medicine and hospital material in a public hospital in the city of Manaus – Getúlio Vargas University Hospital (HUGV) based on the formation of an inventory of environmental/hospital interests, as well as specifically identifying the main characteristics of reverse logistics; verifying if there is flexibility in the application of the reverse logistics process in the recycling of medicines and hospital material; demonstrating a proposal for the application of reverse logistics to reduce the environmental impact caused by solid waste; understanding how the reverse logistics process can contribute to softening the impact of the environmental degradation caused by the incorrect disposal of medicine and hospital material in a public hospital in Manaus; and, demonstrating its environmental benefits to the city of Manaus. The methodology used included integrative review research, as well as documentary research and direct observation. It is concluded that reverse logistics is a way of obtaining environmental management within the legal parameters determined by the Brazilian legal system but cannot be

applied in its entirety in the public hospitals of Manaus, which can make nosocomial disposal dangerous.

**Keywords**— *Urban solid waste; National Policy on Solid Waste; Reverse logistics.*

## I. INTRODUCTION

Reverse logistics is a very old stock control procedure, although it was not named as such in the beginning. Its origin dates back to a cost cutting measure taken by American soft drink producers regarding container collection in the nineteenth century [1].

As the production of glass containers was costly for the soft drink industries, it was much cheaper to collect them directly from sales outlets after use, than to dispose them in city waste storage sites. This practice has been going on for many, many years, regardless of its nomenclature [2]. In the 1950s, quality programs emerged in industry alongside post World War II environmental concerns. The quality programs, embodied in ISO 9000, incorporated environmental quality programs through ISO 14,000 [3]. But the idea of environmental preservation has existed and has already been deeply rooted into society since the Industrial Revolution, as a simple supplier of raw material for the production of goods and of energy sources for the functioning of these goods. However by the twentieth century, and especially after World War II, with the expansion of industrialization as well as the improvement in living standards for consumer societies in underdeveloped countries, the ability to alter natural systems has reached global proportions to the point that it has quickly overcome nature's ability to recuperate itself. It should be noted that some damage to natural ecosystems has been considered irreversible [4].

There have always been concerns linked to sustainability issues based on the relationship between society, nature and the harm caused by mankind to the

natural environment. But these concerns were isolated. Only after World War II, and especially the 1960s, were the environmental problems seen as being extremely serious. It was observed that the Earth was no longer withstanding the intensity of aggression that it has been receiving [5].

The ISO 14,000 was introduced in the early 1990s in order to establish standards for the following environmental treatment processes carried out by companies: environmental management systems; audits in the area of the environment; environmental labeling; environmental performance (performance); life-cycle analysis; definitions and concepts; integrating environmental aspects into product design and development; environmental communication; and climate change. Within this context, environmental management norms have received the nomenclature of ISO 14,001 [6].

The ISO 14001 is an internationally accepted standard that defines the requirements to establish and operate an Environmental Management System. The standard recognizes that organizations may be concerned with both their profitability and environmental impact management [6].

Environmental Responsibility is a concept that institutions have adhered to in order to understand themselves and seek new courses of action. Among the various forms of conceptualization of environmental responsibility, all have the same vector - civil society - that values the actions of institutions, conscious of the duty of preserving the environment [7].

In this manner, environmental management adds another dimension to the way of operating a company, not something that can be controlled, except by the company itself. Thus, a better expression for environmental management of this would be institutions with a focus on society. Thus, environmental management would be a series of actions that interact with each other to create value. [8].

Based on these premises, Brazil issued Law No. 12,305, of August 2, 2010, instituting the National Policy on Solid Waste; amending Law No. 9,605 of February 12, 1998; and making other provisions. Its objective was [9]: Chapter I – Object and scope:

Art. 1 This Law institutes the National Policy on Solid Waste, its principles, objectives and instruments, and sets forth guidelines in relation to integrated management and solid waste management (including hazardous ones), generators' responsibilities and applicable economic instruments.

§ 1o This Law shall apply to all individuals and legal entities, ruled by Private or Public Law, which are either directly or indirectly responsible for the generation

of solid waste, and develop actions related to integrated management or solid waste management.

§ 2o This Law does not apply to radioactive waste, which shall be regulated by specific legislation.

Art. 2 In addition to the provisions outlined herein, provisions of Laws No. 11,445, of 5 January 2007, 9,974, of 6 June 2000, and 9,966, of 28 April 2000, and the norms established by bodies of the National Environment System (hereinafter referred to as SISNAMA), the National Sanitary Surveillance System (hereinafter referred to as SNVS), the Unified System of Animal and Plant Health (hereinafter referred to as SUASA) and the National System of Metrology, Standardization and Industrial Quality (hereinafter referred to as SINMETRO) also apply to solid waste. [10].

Law No. 12,305 has a hierarchy of ordinary law that regulates the validity, application, interpretation and repeal of norms in Brazilian law regarding the National Solid Waste Policy. Thus, it is a "law on the law". [10].

According to Resolution 275/01 of the National Environmental Council - Conama, the types of waste produced in this kind of generating unit include [11]:

- Domestic/Organic: Food Remains, Fruit and Vegetable Skins, Grass, Small Branches etc. [11];
- Industrial/Waste: Toilet Paper, Sanitary Napkins, Toothpicks, Cigarette Filters, Contaminated Paper, Contaminated Plastic, Labels etc. [11];
- Industrial/Hazardous: Ink cans (empty), Contaminated cloth and towels, PPE, Cans with contaminated alcohol, Fluorescent lamps, Air conditioner filters, Batteries, solder pads, plates and components, general scrap etc. [11];
- Office / Recyclable: Paper, Cardboard, Clean plastics in general [11];
- Recyclable: Styrofoam, Metal etc. [11];
- Domestic/ Organic - Whatever is deposited in standardly identified Brown 100 liter garbage collectors, following resolution 275/01 of CONAMA [11];
- Industrial/Waste - Whatever is deposited in standardly identified Gray 10.5m<sup>3</sup> rooms, following resolution 275/01 of CONAMA [11];
- Industrial/Hazardous Rejects - Whatever is deposited in standardly identified orange 21m<sup>3</sup> rooms, following resolution 275/01 of CONAMA [11];
- Office/Recyclable - Whatever is deposited in standardly identified Blue/Yellow/Red rooms, following resolution 275/01 of CONAMA [11].

## II. APPLIED METHODOLOGY

Bibliographical research was carried out reading from the main knowledge bases (LILACS, MEDLINE, PUBMED, SCIELO, BIREME, among others) and on websites for official organs such as PAHO/WHO (Pan

American Health Organization and World Health Organization) and FAO (United Nations Food and Agriculture Organization), as well as books in print highlighting the words solid waste; Environment; Reverse Logistics [12].

Research on documentation was carried out between November 2017 and January 2018, in the city of Manaus - Amazonas, on technical documents from the Getúlio Vargas University Hospital (HUGV), which belongs to the Federal University of Amazonas (UFAM). The approach to planning the solid waste disposal process was initiated referring to the main question: Why discard? How to measure something that seems so abstract that is procedures widely used in diagnostic studies. In this sense, the observation must be precise. That is, one should note behavior during observation. Three (3) direct observation technical visits were made. [12].

essentially environmental in scope? These instruments aim to analyze the internal environment from needs assessments. They aim at mapping or portraying the critical aspects that shape the moment. At the document analysis stage, the documents pertinent to the theme were sought for; their importance and representativeness were evaluated. These documents concerned only issues related to the waste disposal program. [13].

Direct observation is a technique of collecting data obtaining information and using one's senses in obtaining certain aspects of reality. It is not merely seeing and hearing, but also examining facts or phenomena that one wishes to study. Observation is recording that includes

For the integrative review, scientific articles and books dealing with the theme were used, specifically those dealing with the issue of garbage, solid waste, the environment and reverse logistics [12]. Table 1 presents the operational capacity of the HUGV.

*Table.1: The operational capacity of the hospital.*

<b>Total Number of Employees</b>		<b>1.075</b>
Number of outsourced employees		125
Total number of insourced employees		950
<b>Number of registered beds in service</b>		<b>159</b>
Number of actively used beds		159
Total admissions 2016		3.429
Total surgeries 2016		2.589
Total operating rooms		11
<b>Units Services</b>	<b>Installed beds</b>	<b>Beds in use</b>
Neurosurgery	27	-
Surgery	52	-
ICU	09	-
Nephrology	10	-
CV. orthopedic	26	-
C. Medical	26	-
<b>Services rooms</b>		-
Laboratory	06	-
Transfusional	01	-
Administrative	23	-
Nutrition	06	-
Pharmacy	10	-
Surgical Center	11	-

Source: [14].

*Table.1: Classification of solid waste according to ANVISA Resolution No. 306 of December 7, 2004, and CONAMA Resolution No. 358 of April 29, 2005.*

<b>Group</b>	<b>Composition</b>	<b>Examples</b>
Group A	Components with the possible presence of biological agents that, due to their characteristics of greater virulence or concentration, may present a risk of infection.	Laboratory plates and laminae, carcasses, anatomical parts (limbs), tissues, transfusion bags containing blood, among others.

Group B	Chemicals that may pose a risk to public health or the environment, depending on their flammability, corrosivity, reactivity and toxicity characteristics.	Confiscated medication, laboratory reagents, metal-containing wastes among others.
Group C	Any material resulting from human activities containing radionuclides in amounts exceeding the elimination limits specified in the standards of the National Commission for Nuclear Energy – CNEN	Nuclear Medicine and radiotherapy, etc.
Group D	Those posing no biological, chemical or radiological risk to health or the environment, can be considered as household waste.	Eg: food leftovers and leftovers from the preparation of food, waste from administrative areas, etc.
Group E	Sharpening or scarifying materials.	Shaving blades, needles, glass ampoules, diamond tips, scalpel blades, lancets, spatulas, etc.

Source: [14].

The next item in the document is the definition of the PGRSS, which describes in detail the strategies, goals and targets established in the plan that pose challenges, as they entailed changes in the environment and internal processes of HUGV. The main challenge is to change people's attitudes, as well as the nature and quality of their working relationships. This implies changes in the unit's organizational culture and climate. It is understood that, in parallel with the Solid Waste Management Plan process, there will also be a need to plan internal changes, taking as a reference solid knowledge of the organizational culture and climate aspects of the hospital.

Then, the classification of solid waste by group and subgroup generated in the hospital is presented; waste management; segregation and packaging; identification of solid waste in which each group is divided into subgroups of solid waste. This division is extremely important because it allows a much more detailed view of each type of waste.

Afterwards, these informative details are transformed and applicability seeking to detail each step that must be followed in the plan for the introduction of new practices into the organizational culture of the organ.

### III. RESULTS AND DISCUSSIONS

The Getúlio Vargas University Hospital created an Environmental Management Committee in 2015, which produced the document 'Internal Regulation', forecasting all Environmental Management actions in this institution, which as a whole has the purpose of taking corrective and preventive action within the assumptions of ISO 14001 following the following model [14]:

1 - Purpose. Corrective and preventive action should be planned and documented. Corrective and preventive action focuses on the elimination of symptoms and the root causes of problems [14];

2 - Research and analysis. Nonconformities, imperfections or deficiencies are prioritized and the most important ones are analyzed and eliminated first. Some of

the analysis tools used are cost of quality, SPC, user complaints and inspection results [14];

3 - Prevention and control actions. The goal of corrective action is to prevent recurrences. Corrective action results are investigated to ensure that the problem is not repeated [14]; and,

4 - Documentation and registration. Corrective action is adequately documented from the beginning to its outcome [14].

This committee also produced the Health Services Waste Management Plan of the new HUGV – PGRSS [14].

This plan contains the waste classification process that must be analyzed along with the Integrated Management System - SGI, because although the hospital is already certified, a reassessment of these will always be necessary in order to guarantee the effectiveness of the system. And for correct selective collection to take place, the characteristics and the places where the waste must be deposited must be pointed out.

Recyclable waste (eg paper, plastic, metals) is destined for recycling and converted into raw material for new products while non-recycled waste go to landfills, incineration and / or decontamination.

Transportation - After collection, waste is transported by carts or manually to the existing waste storage location in this generating unit <sup>14</sup>.

Packaging - Packaging is done in the Storage Area, which is in the outer area, taking into consideration the following physical characteristics: roofed rooms of volume 21m<sup>3</sup> each (for Styrofoam, cardboard, plastic, waste and dangerous materials) and for organic waste, a roofed area near the cafeteria, where plastic bags collected and previously selected will be deposited in specific areas [14].

Disposal - the waste is internally deposited in specific collectors and later goes to temporary storage and awaits collection by to its appropriate destination. [14].

The process of raising awareness with the company's 407 employees took place during the monthly

meeting held on September 10, 2014 in which the importance of disposal and selective collection of waste generated by the company was presented. [14].

After the employees are made aware of the classification of the waste generated in the organization, compliance with the actions set forth in the Waste Management Plan is ensured [14].

The Waste Management Plan has two phases [14]:

a) Collection and removal of waste to the area for temporary storage: waste is collected from the sites where it is generated, handled and stored in the temporary waste area [14];

b) Final disposal of waste: the waste is transported to its final destination of disposal.

Compliance with the Waste Management Plan is linked to other environmental actions of the Organization, such as selective waste collection and internal audits of the Environmental Management System [14].

For the final disposal of the waste, service providers duly authorized by the Environmental Agency are selected to transport the waste to its final destination of disposal, respecting legal requirements and other applicable environmental requirements. The choice of environmental service providers complies with the criteria of IT.08.001 - the Matrix of Prior Qualification of Suppliers of Services (Legal Environmental and Quality Requirements). Waste may be removed from the Organization by SGI authorization and follow-up with appropriate documentation.

When the waste is sent for treatment, processing or any other form of final disposal to the environment, suppliers of such services should send a "Final Destination Certificate" to the Organization, describing the characteristics of the waste, quantity, final disposal methods and final results of the disposal as shown in Table 2.

*Table.2: Stages for waste management ANVISA and Conama standards compared to what is carried out in HUGV.*

Conditional qualities	Concept	HUGV
Segregation	Separation of waste at the time and place of its generation, according to its physical, chemical, biological characteristics, physical state and the risks involved.	Yes
Packaging	Packaging of waste in bags or containers that resist rupturing and leaking.	Yes
Identification	Recognition of waste contained in the bags and containers.	Yes
Internal Transport	Internal transport of waste carried out according to a previously defined route which should be done separately according to the group of waste and in specific containers for each group of waste.	Yes
Temporary storage	Temporary storage of the containers containing the waste in a place near the generation points.	Yes
Treatment	Modifying the characteristics of the risks inherent in the waste, reducing or eliminating the risk of contamination by applying appropriate methods, techniques or processes.	Yes
Collection and transportation	Removal of the RSS to the treatment unit or final disposal, respecting the conditions of packaging.	Yes
Final disposal	Disposal of waste in soil appropriately prepared to receive it.	Yes

In this study, documents from the Getúlio Vargas Hospital which deal with the reverse logistics process were researched. In this way, it is extremely important for the environment that this institution uses the terms of reverse logistics, within the parameters of the ISO 9000 standards of product quality and ISO 14000 standards of environmental responsibility.

In addition to these quality programs, the Getúlio Vargas Hospital is in line with the Public Sector Quality Program - Gespública, which is the result of the necessary

compilation that was essential for the quality programs of Brazilian public governance to be brought together into a single program. This came into fruition in 2005 under the government of Luiz Inácio Lula da Silva through Decree No. 3778 of February 23, 2005. It is a program focused solely on the public sector and established within the parameters of the governance of the Brazilian public sector based on excellence that follows the dictates that can be observed in the figure 1:



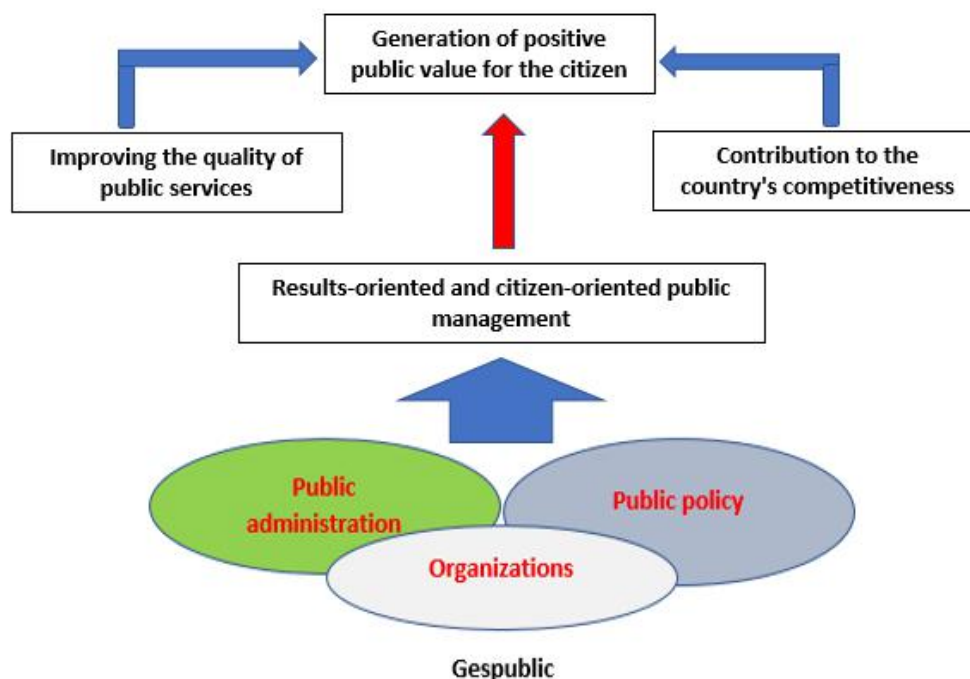


Fig.1: Performance of Gespública.

Source: Adapted from [8].

In the case of HUGV, there is a need to plan its reverse logistics, since the unit already has a solid Management Plan for Solid Residues that has been applied within the daily routine of the hospital. Thus, the very specific work of doing an analysis of the conditions

of application of reverse logistics was taken into consideration, described in Table 3, where compliance means existing and non-compliance means not yet implemented [15].

Table.3: Compliance or non-compliance to implement reverse logistics.

Solid Waste Management Plan	Compliance	Non-compliance
Description of project or activity.		
Diagnosis of solid waste generated or managed.		
Definition of operational procedures.		
Identification of the solutions shared with other generators.		
Preventive and corrective actions in situations of incorrect management or accidents.		
Goals and procedures related to the minimization of solid waste generation.		
Existence of actions regarding shared responsibility for the product life cycle.		
Sanitation measures of environmental liabilities related to solid waste.		
Periodicity of review.		

Source: Adapted from [15].

As can be seen, HUGV complies with all the conditions for the implementation of reverse logistics. And for this the following are needed:

- 1) Formatting of the Reverse Logistics application manual;
- 2) Survey of suppliers;
- 3) Analysis of suppliers;

- 4) Analysis of environmental management documentation;
- 5) Suppliers sign a participation agreement with Management to ensure compliance to Reverse Logistics;
- 6) Selected Delivery Points that adhere to the System with Management;
- 7) Selected recycled waste transport companies that sign the service agreement after applications for transparent objective proposals.
- 8) Implementation of the pilot project
  - 8.1 - Screening of disposable waste through the conceptual orientations of bibliographic references;
  - 8.2 - Separation of waste:
    - 8.2.1 - Waste for reverse logistics;
    - 8.2.2 - Waste for disposal;
  - 8.3 - Waste transportation company collects waste and transports it to the Suppliers of the environmentally appropriate final destination units;
  - 8.4 - Suppliers pass waste to recycling companies that promote environmentally adequate final disposal;
- 9) Suppliers sign a participation agreement with Management to ensure compliance with Reverse Logistics.

However, through the analysis that the HUGV has been seeking solutions from decentralization models of local environmental management, from the selective collection of solid waste. But there have been many difficulties since the implementation of the Solid Waste Management Plan in the hospital, due to the lack of support from both the university and the federal government,

The case study pointed out that there is a need to meet some requirements, so that the project encompasses the entire unit, since, according to data taken from the study, even though it has a Solid Waste Management Plan, there is still no reverse logistics. There is a need to place collector containers in all hospital settings.

Therefore the requirements are as follow:

- 1) Action focused on the disclosure of information for the improvement of environmental management in HUGV;
- 2) Cost of investments in technical assistance aiming at the equipping of the unit, decentralized reverse logistics project management.
- 3) Direct investments in the reverse logistics program as a goal for global improvement;
- 4) Preparation of studies necessary for the development of new financial or material resources;
- 5) Provide specific financial support for the community to maintain the continuity of services

With the existence of the Solid Waste Management Plan in HUGV, there is a need to determine four (4) essential

points of view: *why, what, how* and *who* after the application of a Pilot Project in the surgical center. [16].

Previous studies have argued that the following types of characteristics are relevant to characterize reverse logistics such as [16].

- Why things are returned: reviewing the driving forces behind companies and institutions becoming active in Reverse Logistics, Conveyors (receiver) and the reasons for flow reversal (reasons for return), i.e why reverse logistics is being done. In the specific case of HUGV, why it is directly associated with the existence of the Solid Waste Management Plan with reverse logistics being the final step.
- What is being returned: characteristics of the product should be described that make recovery attractive or obligatory and examples given based on actual cases (products and materials) that in the case of HUGV, in the pilot project to be applied, only serum bottles will be used of the surgical center (FLEISCHMANN ET AL, 2017) [16].
- How reverse logistics works in practice: the reverse logistics system must be applied from a very well defined process / system that begins with the formation of partnerships; from the correct collection of material, delivered to the carrier; returning to the supplier that sends it for recycling and returns it to the productive system [16].
- Who is performing reverse logistics activities: In this case, only the surgical center is used as the basis in the HUGV Solid Waste Management Plan [16].

Factors such as economics, environmental laws and environmental awareness of consumers. Generally, it can be said that companies get involved with Reverse Logistics through which they can reduce costs with application [17].

In this sense, HUGV's reverse logistics program will gain directly by reducing the use of raw materials, adding value to recovery or reducing disposal costs. Independent of any other gain, financial opportunities are offered in the dispersal of superfluous or discarded goods and materials.

Thus the HUGV reverse logistics network requires a collection network that is already determined by the Solid Management Plan. The starting point will be the surgical center where serum bottles are discarded into specific collectors. Thus, the first process will be to determine the HUGV area in which the products (surgical center serum bottles) will be disposed of in accordance with the Solid Management Plan. Then, after choosing the location and collecting and storing the material correctly, it will be delivered to the contracted carrier and to the supplier and / or suppliers [16]. Table 4 shows the benefits of using reverse logistics.

Table.4: The benefits of using reverse logistics.

ISSUES	SUPPORTING EXISTENCE IN COMPANY DOCUMENTS	
	YES	NO
Environmental policy	X	-
Decreased pollution	X	-
Service Improvement	X	-
Decrease in waste	X	-
Attitudes	X	-
Suggestions	-	X
Information on product acquisition	X	-
Pre-certification Changes	-	X

Source: Authors, (2018).

#### IV. CONCLUSION

Generalizing from the reflections made throughout the study, three (3) important conclusions emerge about the application of a reverse logistics project in HUGV:

1. The successful implementation of an institutional strategy that will involve leadership and management factors. The 1988 Federal Constitution determined the principle of efficiency as a fundamental for the public service to assume responsibility for the enunciation of objectives and the negotiation of terms of responsibility before its area of competence. The efficiency principle has come as a determining factor for the necessary improvement in public activities, which in some specific cases are visible, but in most cases they are completely insufficient, creating negative public value to civil society, which was not evident in HUGV, whose implementation of reverse logistics may add public value to the institution's activities.

2. Activities in HUGV need to be attuned to the amount of pressure it imposes on the institution, as challenges are followed by credits; criticism, praise; demands, new resources. The first opposition and defections are considered incidents of course, but the environmental management of the hospital knows that in order to fulfill its goals and objectives, everyone will have to recruit partners inside and outside of the institution creating, especially public value.

3. Environmental management committed to the principle of efficiency, as determined by the Federal Constitution, art. 37, caput, influences the performance of other related institutions or not using only part of the manipulation of administrative systems. When this prerogative is used in institutions, the visibility of their performance is not guided by abstract notions of what constitutes integrity, perfection or modernity of systems; rather, they are guided by sound assessments of what will help them focus effort on civil society, creating value.

This research presents its conclusions regarding the specific objectives and the general objective established for the study:

1 - The HUGV Solid Waste Management Plan model reverts from the Satisfaction Philosophy, that is, the organ seeks only to achieve a satisfactory level of environmental performance, without the pretension of optimizing its environmental indicators. In addition, the plan gathers the prescribed normative elements. The organizational diagnosis made through specific instruments visualizes future scenarios.

2. The results of the implementation of the Solid Waste Management Plan are promising, which points to the next step - the application of reverse logistics - but that will depend on the maturation time and the commitment of the teams to executing it.

With regard to the specific objectives of the research it can be inferred that:

1) Identifying the main characteristics of reverse logistics was achieved when the entire reverse logistics process applied in some institutions was very clearly described;  
 2) Checking if there is flexibility in the application of the reverse logistics process in the recycling of medicine and hospital material; was successfully verified, since the institution already has a Solid Waste Management Plan;  
 3) Making a proposal for the application of reverse logistics to reduce the environmental impacts caused by solid waste; was demonstrated with the suggestion of applying the principles of GESPÚBLICA as a second step for the adoption of a Reverse Logistics Project, since the first one was already done so with the adoption of the Solid Waste Management Plan;

- To understand how the reverse logistics process can contribute to softening the impact of the environmental degradation caused by the incorrect disposal of medicine and hospital material in a public hospital in Manaus; this understanding was possible from the moment it was verified that although there is a Solid Waste Management Plan in the HUGV, the City Hall of Manaus is in charge of the disposal of the material, which dumps all these materials into the city landfill as common garbage;

- To demonstrate its environmental benefits to the city of Manaus; it was shown that a reverse logistics program

will infer prominent results to HUGV, as instead of discarding perfectly recyclable materials no longer dumped at landfills, creates bonds with suppliers and strengthens the production chain concept.

In conclusion, the HUGV Solid Waste Management Plan if fully implemented, can perfectly lead to the reverse logistics process. The execution of the plan directly affects structural and behavioral variables of its internal and external environment.

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# Assessment of pesticides handling Practices and Health and Environmental Impacts on Khat Growing Farmers: in Haro Maya Woreda, Eastern Ethiopia

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**Abstract**— Methods were designed to evaluate the handling practice and the effect of pesticides on environment and human health. The data were collected by participating mainly Khat growing farmers and further supported by interviewing health and agricultural professionals, field observation and focal group discussion with Khat chewers. 97.1 % of farmers used pesticides for pest control. The survey revealed that, 95.2% confirmed that they using DDT. The pesticide treated khat is harvested and consumed starting from the same day of treatment. Farmers were not taken measures while spraying whether children and other people are in the field or not. Majority of farmers i.e. 84.1% have no experience of taking bath, 42.85 % of farmers do not change clothes right after spraying; and 86.93% do not wash the contaminated clothe separately. Majority of farmers doesn't have knowledge about labelling, dosage and expiry date mentioned on pesticide container. Farmers used protective devices rarely, except 73.3% who used scarf to protect the uncomfortable smell of pesticides. Farmers store their pesticides where they sleep, where they eat, prepare their food, where the cattle feed, hut in the field. Majority of farmers experienced headache, dizziness, difficult to breathe and vomiting, itching or burning of different parts of body as the main symptom filling during application of pesticides. Liver case, kidney and stomach are the most common healthy problem realized; and significant number of farmers and health professionals are confident enough that, chewing of pesticides treated khat and unsafe use khat are the case. The care of for the environment is very low in that spray pesticides near water bodies like well water and ponds, disposing the leftover and empty pesticide containers in the field. Number of pollinating insects like, butterfly, and bee are decreasing. The care of livestock not to eat residue of Khat treated by pesticides and graze near treated was small.

**Keywords**— pesticides, khat forming, survey, health issues etc.

## I. INTRODUCTION

The term pesticide includes chemicals used as growth regulators, defoliants, desiccants, fruit thinning agents, or agents for preventing the premature fall of fruits, and substances applied to crops either before or after harvest to prevent deterioration during storage or transport [1]. Obviously productivity of agriculture sector largely depends on substantial inputs of chemical pesticides. As a result of this farmers use a wide range of pesticides to prevent crop losses from pest attack, to improve yield as well as quality of the agricultural products. Besides agricultural use, chemical pesticides are also being used in domestic, health and industrial sectors. These benefits of pesticides have led to their widespread use in controlling agricultural pests and disease vectors [2, 3].

The environmental pollution and poisoning due to the widespread use of pesticides in pest control may be detrimental to the health of handlers, non-target organisms and consumers. Environmental pollution by pesticides depends on several variables, including the type and quantity of the pesticides employed. Physical, chemical, biological properties and the capacity of pesticides degradation influence the transport of these compounds to surface waters [4]. Pesticides are poisons and can be dangerous when misused. Pesticides are a threat to the environment by losing from areas of application to non-target sites [5]. Many pesticides highly toxic to insects like honeybee, birds, aquatic organisms and fishes [6].

There are many routes of exposure to pesticides. However, people can be exposed to pesticides in three major ways: breathing (inhalation exposure), getting it into the mouth or digestive tract (oral exposure), and contact with the skin or eyes (dermal exposure). These



paths are frequently referred as routes of entry [7, 8]. Exposure to pesticides depends on the intensity, frequency and duration of contact between the body like mouth, nostrils or skin surface and any pesticides [9, 10]. Similarly the respiratory tract provides a very efficient surface for the absorption of substances, whether they are in the form of vapours, particles or droplets [11]. Exposure to pesticides can cause healthy problem in humans, ranging from irritation to severe illness or death [12 and 13].

The Ethiopian economy is supported by agricultural sector, which is a fundamental instrument for poverty alleviation, food security, and economic growth. Due to its high and stable market prices and its resistance against drought and frost, farmers in the study area have a more secure and higher income from khat than from other crops. As a result of these many farmers have abandoned other crops and started growing a more profitable crop, khat. In Ethiopia, the region of Hararghe particularly Haro Maya Woreda, where the international market of khat know as Awaday is found, international khat market, is considered to be the main area for cultivation and trade khat.

Khat is subject to a wide range of insect pests, diseases which results to destruction of the plant but mostly the damage is to the quality of the harvested material, which affects the economic gains from the crop. Lowering of pest damage is associated with increased yield and higher quality of product that improve the income of farmers. The rise in level cultivation of khat and the pest attack may develop into another unexpected problem in pesticide practice. Even though, pesticides are essential in agriculture and household pest controls, they are recognized as potential hazard to non-target organisms and the environment [5]. The efforts to increase food production and protection should be in a way that does not affect public health the environment adversely. This study, therefore, aimed at assessing the pesticide use practice and hazards in Hara Maya woreda, eastern part of the Ethiopia, focusing on khat growing rural communities.

## II. MATERIALS AND METHODS

### 2.1. Description of the study area

This study was conducted in Haro Maya Woreda, East Hararghe Zone, Oromia region of Ethiopia. Haro Maya Woreda is known for its extensive production of different varieties of *Khat*. Survey study indicates that farmers are using pest control chemicals to protect *Khat* plant from pest and to increase the yield of production. Recognizing all these facts Haro Maya woreda is selected as research site and high attention was given to these Awaday surrounding kebeles in this study.

### 2.2. Sampling methods

A questionnaire containing open and closed ended questions was designed and used to obtain data through face-to-face interviews with sampled farmers. Five months before the data collection, the questionnaires were pre-tested on 20 farmers and four other expertises of health and another four agricultural workers who were living and working in study area but not included in the main data collection area. In addition to the structured questionnaires the data collection was supported by semi-structured interviews and observation to validate the study.

Kebeles in the woreda were clustered into five mutually exclusive geographical zones to make data collection simple and economical. Depending on the size of clusters a total of seven kebeles were sampled from 33 kebeles of the werada for the data collection. After selection of kebeles by multistage sampling method an exhaustive list (sampling frame) of all members of *Khat* owning house hold was prepared by the help of kebele agricultural development office. After determination of sample size (the number of *Khat* producing house hold), sites and elevation factor (quotient between the size of the population and the size of the sample) the first unit was selected randomly. After selection of the first unit, systematic sampling method was applied to draw sample at regular interval from the list. Accordingly, two hundred and forty-five farmers were selected randomly from these kebeles. Representative number of agricultural workers and healthy professionals were made to participate in the interview to evaluate the training status of farmers on the safe use and handling, and alternative use of pesticides.

For the validation of the data from khat growing farmers different concerned bodies were participated. There are two to three agricultural workers per kebele to guide farmer in agricultural practice. In the same way there are 9 agronomists and one environmental protection worker at woreda level. All the agricultural workers in the sampled kebeles and all the agronomists were made to participate. In the same way, there are one hospital and six healthy centres in the woreda. Up on discussion with the woreda health office three health centres are selected depending on the geographical location to represent the whole health centres. Almost all the physicians in the hospital are participated. After selection of healthy centres data was collected by participation of all the health professionals. Focal group discussion also took place with khat chewer to see the health impact of chewing pesticides treated khat. Almost all the woreda health expertises were participated.

## III. RESULT

### 3.1. Socio-Demographic Characteristics of the Participants

The age of the farmers, participated in data collection covers the age between 21 and 61, a wide range of age. Analysis of educational levels also revealed that significant number of the respondents, 33.1% is at no schooling level that means they are illiterate. However, nearly to half of the respondents (48.97) % were at basic education (reading and writing local or national language), primary education, secondary education, and diploma level accounts about 10.3 and 6.2% and 2% respectively. But there is no participant at education level of first degree and above. Therefore; most of the farmers who participate in data collection are illiterate or at the level of basic education.

Almost all (96.7%) of the participant are married and head of the family. The number of members with in each family ranges from one to more than eleven, and near half of the participants have family member from six to ten. Majority of respondents 95.3 % of the respondents have lived in the study area for more than ten years; and about 93.20 % of the respondents have worked on *Khat* crop for more than six years having experience in *Khat* farming. This shows the duration of the stay in the study area is highly correlated with the number of years in participating *Khat* cultivation in the

study area. In the same manner the health professionals, agricultural workers are at different educational levels starting from diploma.

### 3.2. The Practice of Handling, and Environment and Healthy Impact of Pesticides

Some of the pests which are identified by this study area are commonly known as '*Bararo*' '*Hudhoo*', '*Mancaroo*' and '*takudhofu*' in local language. The study result is indicating that '*Bararo*' is the most common pest in attacking khat. Farmers were asked whether they used pesticides or not to protect khat from pest attacks. 97.1% of farmers confirmed that they used pesticides. Less than 10% of farmers indicated that they used alternative methods like smoking, using ash and pepper in addition to pesticides. About 95.1 % of farmers responded that they are using DDT. The table shows that malation, seven, '*Wuhagar*' (used for water treatment) are some of the pesticides used by farmers in addition to DDT.

From 21 respondents of agricultural workers only one person (4.8%) denied the use of pesticides on the Khat farm. Those who responded that pesticides were used on the Khat farm were made to respond on the types pesticides of used on the khat farm. About 91 %, 60%, 45%, 39 % of agricultural workers responded that farmers were using DDT malthion, sevin and wuhagar respectively. In the same way 70 % healthy professional agreed on the use of pesticides in the khat plant. The same trend responded on the type of pesticides. They responded as follows 70%; 86.6% DDT, 53.3% malthion, 33.3 % sevin and 20% wuhagar. More than 90% of the farmers indicated that they buy pesticides from the nearby markets. About 8% of farmers pointed out agricultural office and union are the source of these pesticides.

Table.1: Types of pesticides used and its collection by formers

No	Variable	frequency	%
1	How did you control these pests mainly		
	Apply pesticides	238	97.1
	Using traditional methods	19	8
2	What pesticides chemical are you using at present on khat ?		
	DDT	233	95.1
	Malathion	138	58
	Seven	119	50.2
	Wuhagar	42	17.2
	Others( Actellic, Thiroxin,)	39	15.91
3	Where do you purchase/collect pesticide(s)?		
	From local market	220	89.9
	From nearby agricultural office	20	8.1
	From local health bureau	-	-
	From illegal venders through smuggling	31	12.61

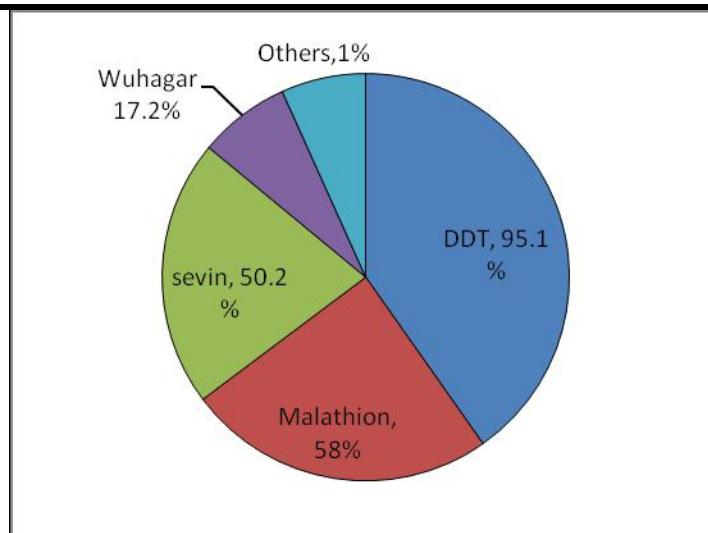


Fig.1: Type of pesticides using on khat

Table.2: Criterion of farmers to purchase pesticides

Criterion	Very important		Important		Not so important	
	Freq.	%	Freq.	%	Freq.	%
Prices of the pesticides	23	9.4	97	39	125	51
Efficiency of the pesticides	102	41.6	132	53.9	11	4.5
The easiness to manipulate	13	5.3	67	27.34	175	71.42
The quality of the explanation	7	2.9	25	10.1	213	86.93
The legality to use in Ethiopia	8	3.3	12	4.8	235	95.91

As can be seen from Table 2, almost all the farmers (95.5%) are efficient in the usage of pesticides to control pests as no criteria for purchasing. Very few farmers (4.05%) used the legality of pesticides in Ethiopia as a criteria for purchasing. These pests' incident is more common in rainy season particularly in autumn and spring months. Thus, application of pesticides to the *Khat* plant is more common and regular in these months.

Table 3 reveals that 8.8% farmers identified that they could harvest *Khat* treated with pesticides within the day of spraying. However, majority of the respondents had habit of harvesting *Khat* within 15-30 days (98.8%) or after 30 days (87.34%) after application of pesticides. In the same way, 96.32% of farmers accepted that children play in pesticides treated field. Significant number of farmers (35.41%) indicated that children were allowed to play in field while spraying. 68.57% of farmers never considered whether other people are chewing in the field or not while spraying. As Table 3 shows majority of the farmers practiced eating, smoking, and chewing in the treated field.

All the respondents accepted that they chewed pesticide treated *Khat*. Only 3.9% accepted that they used to chew *Khat* treated with pesticide in the same day. Even though chewing *Khat* treated with pesticides is increasing after the second day only about 7.75% respondents indicated that they used to wash *Khat* treated with pesticides. Almost all of the farmers said that they never ate while spraying however relatively small number of farmers indicated that they drink while spraying. As the Table shows 3 small number farmers indicated that they used to smoke or chew while spraying. Even though the degree is relatively different almost all the respondents responded that they used to eat, drink, smoke and chew in the field which is treated with pesticides chemical. Almost all of the farmers indicated the non-chewable left over commonly known as 'garaba' used as animals' food (93%) and 88.16% indicated that it is also used as fire wood. Goats were identified as highest consumer of *khat* leftover. This practice is observed during the survey study.

Table.3: Farmer's experience on application of pesticides, exposure and its usage of *khat*

	Variable	Frequency	%
1	How many days prior to harvest were the pesticides applied?		
	The same day	21	8.8
	1-7 days	72	29.4

	8-15 days	242	98.8
	16-30days	221	90.2
	Above 30 days	214	87.37
2	Do you chew Khat from farm land treated with pesticides?		
	Yes	245	100%
	No	-	-
3	When spraying happens, are workers or family members expected to work in the field?		
	Yes	230	93.87
	No	15	6.1
4	Are children allowed to play in areas treated with pesticides?		
	Yes	236	96.32
	No	9	3.6
5	If yes, how soon after the application?		
	While applying	87	36.87
	In the same day	221	93.64
	The next day	222	94.06
	Within 3-5 days	230	97.45
	Above 6 days	229	97.03
4	Do children help working in the fields?		
	Yes	32	13.06
	No	213	86.93
5	How soon after the application entry?		
	The same day	153	62.44
	2-15 days	195	79.59
	16-30days	219	89.38
	Above one month	221	90.20
6	Do you wash the pesticide treated khat before use		
	Yes	19	7.75
	No	226	92.24
7	In the field treated with pesticide do you:		
7.1	Eat?		
	Yes	229	93.45
	No	16	6.5
7.2	Smoke?		
	Yes	103	42.04
	No	42	17.14
7.3	Drink?		
	Yes	187	76.62
	No	58	23.67
7.4	Chew khat?		
	Yes	245	100
	No		

It was observed that farmers apply pesticides to the Khat crop in a solution form. 97.95 % farmers explained that they have spraying tank equipped with stick used for mixing. As Table 4 shows farmers sometimes (86.5%) faced excess or pesticides left over during mixing. About 77.1% of farmers indicated that they continue to use the leftover pesticide, which may result to over use of

pesticide. About 26.53 % of farmers said that they dispose in the yard or soil. In the same way, 51.42 % of the farmers indicated they throw the empty container into the bush, and 91.42 % said that they leave the empty container in the field and significant number of farmers 23.26 % also indicated that they wash and use domestically.

Table.4: The ways of disposal leftover pesticides and empty containers of pesticides by farmers

No	Variable	Freq.	%
1	How do you dispose of <i>Khat</i> residue?		
	Burn in field after drying	5	2
	Use as fuel	141	88.16
	Use as animal feed	245	100
2	Do you make more pesticide mixture than you need?		
	Always		
	Sometimes	212	86.5
	Rarely	63	25.7
3	What do you do with obsolete (expired) pesticides in your hand?		
	I continue use it	189	77.1
	I just store it	12	4.8
	I dispose of it in the soil	65	26.53
	I ask advise of DA		
4	What do you do with empty pesticide containers/bottles		
	Dispose into the disposal pit	11	4.4
	Wash and use domestically	57	23.26
	Left in the field	224	91.42
	Destroy and burn or bury it in the soil	-	-
	Throw in to the toilet	4	1.6
	Throw in to the Bush	126	51.42

Farmers also made to respond on the possibly of body contact to pesticides during pesticide handling. Majority of farmers' 94.28% indicated that there was high possibility of body contact while mixing pesticides. As indicated in Table 5 the majority of the farmers mentioned that they faced the spray leak on their body part while refilling the tank except 9.7% who indicated never faced. Almost all the farmers who faced the problem of leak on their body replied that nothing they did rather than continuing the task until finishing spraying. More than 90 % of farmers responded that they did not consider the direction of wind during spraying of pesticides. 90.04 of the agricultural workers also confirmed that farmers are not considering the direction of wind during spraying of pesticides.

Regarding to cleaning or laundry practice, Table 5 clearly showed that majority of farmers 84.1 % have no experience of taking bath right after spraying pesticides. 42.85 % of farmers responded that they do not immediately change their clothes after application of pesticides. Only 20.86 % of farmers indicated that they wash their clothes immediately after working with pesticides. Almost all the farmers 86.93% said that there is no experience of washing pesticide contaminated clothes separately. Even though the frequency of washing the spraying tank is very small the possibility washing near the well water and in the farm is identified to be high.

Table.5: The ways of contact of pesticides after spraying on *khat* by the farmers

No	Variables	Ferq.	%
1	When you mix/use the pesticide solution, does the liquid come into contact with any part of your body?		
	Yes	231	94.28
	No	14	5.7
2	Parts of body in contact		
	Hands	214	92.64
	Feet	161	69.69
	Other parts body	67	29
3	Do you take a bath right after spraying		
	Yes	19	7.7
	No	206	84.08
	Do pesticide contaminated clothes get washed		



4	immediately after spraying		
	Yes	51	20.86
	No	84	34.28
5	Does pesticide contaminated cloth get washed with the rest clothes		
	Yes	213	86.93
	No	32	13.06
6	Do you change clothes right after spraying		
	Yes	140	57.14
	No	105	42.85

As can be seen from Table 6 significant number farmers came across pesticides containers that do not have labelling. Majority of farmers 87.7% indicated that they will not give attention and attempt to read the instruction given on the containers. Only 4.9 % of the farmers indicated that they could understand the information written on the container. Almost none (6.5%) of the

respondents indicated that they would follow the instruction. It is also observed and indicated by farmers also that the information on the container is with foreign language which is difficult to understand by farmers. Large number of farmers 59.59% responded that they do not know whether the expiry date even available on the pesticides container.

*Table.6: The farmers knowledge on labelling of pesticides containers*

No	Variable	Freq	%
1	Do you usually read the labels on pesticide containers?		
	Yes	31	12.6
	No	214	87.7
2	Do you understand the instructions for use?		
	Yes	12	4.9
	No	234	95.1
3	Can you always accurately follow the instructions		
	Yes	16	6.5
	No	229	93.1
4	Have you ever used chemicals with instructions in a language you don't understand?		
	Yes	235	95.5
	No	10	4.1
5	When you buy pesticides, does it happen that the container(s) has no label		
	Often	70	28.6
	Sometimes	136	55.5
	Never	36	14.28
6	Is there an expiry date on the container of pesticides?		
	Yes	32	13.03
	No	67	27.34
	I do not Know	146	59.59

As can be seen from Table 7; 73.5% of the respondents responded they experienced filling of different thing while handling pesticides. These who felt different things asked to explain their filling. Headache, dizziness, difficult to breathe, vomiting, and itching or burning of different parts of body is the main symptom they fill during application of pesticides. About 40% of respondents responded that they are not sure whether these fillings are related to pesticides or not. Even though the degree of confidence is different significant numbers

of respondents about 59% are sure that symptom is are related pesticides handling. Nearly half of respondents said that they take some remedial action like taking milk, using lemon after spraying to prevent poisoning or make them feel better. Even though different diseases are observed in the region about 86% of health professionals identified stomach ache, liver case, respiratory diseases, kidney case and allergic as top five diseases in the region. 63 % of professionals traced the problem to the unsafe use of pesticides and chewing pesticides treated *Khat*.

Table.7: The ways of filling while handling pesticides

	Variable	Freq.	%
1	After applying/handling pesticides, or being near an application site, have you ever felt any "different?"		
	Yes	180	73.5
	No	20	8.2
	Do not know	45	18.4
2	How sure you that the symptoms you experienced were caused by exposure to pesticides		
	Not sure (0 – 20%)/ I don't know	107	59.4
	Little (20 – 40%)	31	17.2
	Rather (40 – 60%)	28	15.6
	Very (60 – 80%)	13	7.2
	Extremely (80 – 100%)	1	.6
3	Is there anything you can do before or after you spray to prevent poisoning or make you feel better?		
	Yes	129	52.7
	No	116	47.3

Farmers made to respond whether they experienced or heard of any pesticide poisoning incident happening in the community. About 11% of khat growing farmers said that they came across pesticide poisoning incidence in their community. As indicated by these farmers chewing of khat 68% is the main case. Even though farmers were coming across different health defects like stomach ache, liver case, kidney case, cancer, long-term respiratory problems, infertility, skin disorders, birth defects only 15% of farmers are confident enough that these health defects are related to pesticides poisoning. Majority of farmers 85% indicated that the main root of exposure to pesticides is chewing khat which was sprayed.

Majority khat farmers (94%, 79%) revealed that they spray pesticides near water bodies like Well water and ponds respectively. Almost all the farmers (98.5 %) responded that the number of pollinating insects likes butterfly, bee is decreasing. 58% of farmers said that the number birds are not changing, 31% responded the number is decreasing and another one third of respondent were responded that they did not observe the change in

number. Most of the farmers (84%) do not know what happen to the number of aquatic animals. Almost all the respondents responded that there was no care of livestock not to eat residue of *Khat* treated by pesticides. However 21% of the respondents indicated that they will not allow goats to the pesticides treated khat field for short time. Almost all the farmers indicated that there was no practice of protecting animal not to graze near treated khat field. 43% farmers said that they experienced or heard the pesticide poisoning incident happening in the community livestock particularly goats. In line with farmers' response the agricultural professionals responded that, pollution of environmental by pesticides ranges from being problem (95.23%) to a very serious problem (71.42 %), almost all ( 90.47 %) professionals responded extent of decreasing the population of insects like bee, butterfly is very serious problem. About 57.14% and 42.85 % of professionals responded that the extent of contamination of drinking water by pesticides is serious and very serious respectively.

Table.8: Health effects of pesticide application on khat

S.No.	Symptoms shown	Freq.	%
1	Head ache	223	91.02
2	Dizziness	211	86.11
3	Chest pain or difficult to breath	187	76.33
4	Eyes/face/skin irritation /burning sensation	237	96.73
5	Vomiting	102	41.63
6	Gastric and stomach inflammation	160	65.30
7	Coughing	178	72.65

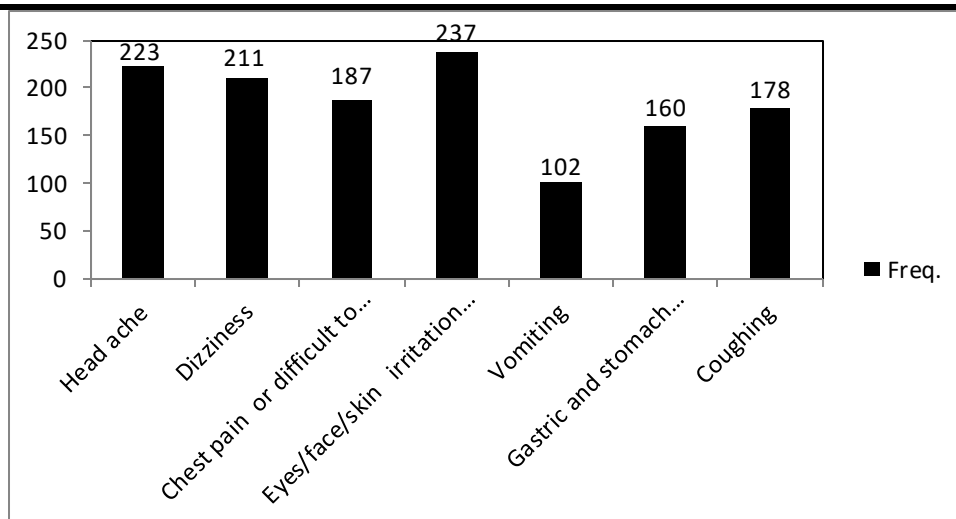


Fig. The frequency of different symptoms caused by pesticide application on khat

#### IV. DISCUSSIONS

Khat is by far the largest cultivated plant in the study area. Khat is exposed to different diseases and insects which create problem to Khat growers. Even though different pests and diseases are identified in the area, Barara" or „Matur" is very common in attacking khat. It is very small flying insects that migrate from one Khat plant to another. As this survey result revealed almost all the khat growers were using pesticides. The main chemical identified to be used are DDT, malathion, sevin, wuhagare. As reported by farmers and confirmed by different respondents (khat chewers, Agricultural workers and health professional) DDT was by far the most commonly used pesticides. Interviews result also indicating that khat which is treated with pesticides looks very attractive. In other way, some farmers indicated that khat which is attacked by these pests particularly barara looks beautiful appearance and costs high.

DDT is persistent, and its residues persist in the environment for long periods due to the fact that it is not readily degraded by the action of water, heat, sunlight, or microorganisms [14]. Ethiopia has signed the Stockholm Convention on Persistent Organic Pollutants. Similar to this survey study, different recent survey reports in some part of Ethiopia (rift valley and Butajira) also indicated that DDT was being used for protecting crops and animals against agricultural pests [3,15]. This study also identified some chemical like wuhagar which is supposed to be used for water treatment was used for treating khat pests. In other word farmers select to buy pesticides based on the effectiveness and being inexpensive however legality of pesticides in Ethiopia has been given a little attention.

Regularly, pesticides application takes place during summer and spring. Farmers revealed that May is the month when high incidence of barara occurs; and thus the most common month at which pesticide application is high. As khat plant is not seasonal crop application of

pesticides to the same plant or the same farm takes place regularly. Significant number of farmers indicated the amount of pesticides they use is increasing with the incidence and resistance of pests to pesticides. For farmers who use well water or irrigation the incidence and application occur any time in the year. Thus, they apply pesticides as the incidence take place. The regular application and the increasing usage of pesticides to the same plant and field may results into the accumulation pesticides, like DDT, and contamination of environment (water system and soil).

Different studies have showed, little attention to the instructions on how to use the pesticides, ignoring basic safety guidelines on the use of personal protective equipment and fundamental sanitation practices are the main elements that increases the human exposure to pesticides [16]. One of the elements of unsafe use of pesticides that have been identified by past researches was ignoring label instructions [17]. Similarly, in this study farmers in the study area confirmed that they sometimes come across pesticides containers that have no label; majority of farmers did not give attention to labelings, and no attempt to read the instruction given on the containers. The information on the container is with foreign language which is difficult to be understood by farmers. Almost all the farmers did not know whether the expiry date available on the pesticide's container or not. Even though, labels were identified as the most important source of information about pesticides safe use and precautions to be taken there was gap in using the instructions. This may lead khat growing farmers to high risk while using pesticides.

Farmers are believed as the most vulnerable group of people to pesticide exposure all over the world, because they are directly involved in mixing and spraying dangerous liquids [27,28]. This study result shows that headache, dizziness, difficult to breathe, vomiting, and

eyes/face irritation /burning sensation are the top five symptoms identified while handling or after handling pesticides. The study shows more than half of the respondents are not sure that the symptoms are related to the pesticides practice. Different study in different country also showed these symptoms are the common once. Different reports also showed that pesticide applicators tended to accept a certain level of illness as an expected and normal part of the work of farming and therefore do not report the symptoms in official health centres for formal medical assistance [12].

The result of this study indicated pesticide poisoning incident in the family during the last 3 years is not common. However, there were suicidal attempts in the past three years. The respondents also indicated the most common diseases in the study area were Liver disease, chronic stomach problems, and long-term respiratory adverse health problem in the study area. A pervious study conducted, in Yeman, on chewers of khat produced with more chemical pesticides cause acute adverse effects on the digestive system and chronic adverse effects such as body weakness and nasal problems which supports this study result [29]. As khat is a directly consumed leaves, the possibility that chewers catch with different diseases is high. A focal group discussion with khat chewers also indicated that they fill stomach irritation when chewing pesticides treated khat.

Environment might be strongly influenced by heavy agricultural reliance on synthetic chemical pesticides. Pesticides are a threat to the environment by losing from areas of application to non-target sites such as surface and ground water [5,30 and 31]. Pesticides can enter water via drift, surface runoff, soil erosion, leaching and, in some cases, deliberate or careless release of pesticide directly into the water. The result of this study shows farmers used pesticide like DDT, which can persistent in the environment. As the study result indicated the disposing practice leftover pesticides and empty container is poor that may cause environmental contamination. As indicated by farmers and agricultural experts the number of useful insects like honey bee is highly decreased as a result of pesticides poisoning.

OCP predominately accumulate in the lipid fractions of human food chain and hence animal fatty foods have become a major route of exposure for humans. Animals living in areas OCP contamination in the environment accumulate their residues when they eat contaminated feed and they inhale contaminated air [2,31]. It can be observed from this study result, the practice of protecting animal not to graze near treated khat field was less. Field observation and the interview result indicates that cattle particularly goats are highly exposed to pesticide that resulted to poisoning incidents into the community

livestock particularly goats. The residue of khat commonly known as 'garaba' is highly consumed by goats. Goats are used both as source meat and milk food in the study area. Thus, people who consumed the foods of these animals origin may be exposed to these persistent OCP such as DDT through food chain. Due to high solubility of DDT in fatty tissue, it can be readily absorbed through the skin into the fatty tissues of living organisms and can bio-magnify.

## V. CONCLUSION

This research result has shown that the pesticides, like DDT, are used by khat growing farmers. In addition of environmental contamination, massive use of DDT on khat farm poses a potential public health threat to the consumers of khat. The pesticide use practice of farmers is not knowledge based. Farmers are not using labels on the containers as their primary source of information. Since the khat growing farmers are not using protective clothes farmers and perhaps their family members, are directly or indirectly exposed to highly hazardous, restricted, and banned pesticides. Poor storing practice and improper handling of pesticides, starting from mixing to spraying, was identified in this research work. This can present a potential risk to khat growing farmers' health and the environmental consequences. Farmers suffer from discomforts ranging from headache, chronic diseases in handling these pesticides. The care for environmental contamination is also poor that may results to contamination of soil and water and poisoning of important insects.

## VI. RECOMMENDATIONS

Educational and training interventions on pesticide handling and safety precautions are recommended to change this situation. In addition, a governmental intervention is needed to restrict hazardous pesticides, monitoring of labels, and enforcement of good agricultural practices to decrease pesticide exposure of farmers. Government should discourage the use of pesticides that have been banned. Further study is also needed to analyse the extent of contamination of soil and water by pesticides in the study areas. In addition to this toxicology study is also recommended.

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# Antimicrobial and Antioxidant Activities of Four Selected Noncommercial Honeys

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**Abstract**—In this study; we investigated the antioxidant activities and antimicrobial effects of some honey samples (Honeydew, Eucalyptus, Petroselinum crispum M. and flower) from different regions of Hatay, Turkey. The antioxidant capacities were evaluated by using folin assay, free radical scavenging (DPPH) assay and  $\beta$ -carotene-linoleic acid emulsion method and the results compared against reference synthetic antioxidants (BHA, BHT). A 96 well minimum inhibitory concentration (MIC) spectrophotometric-based assay is used to assess antimicrobial activity against some gram positive bacteria and gram negative bacteria. Total phenolic content of the honey samples were determined according to the Folin-Ciocalteu procedure and found between 60,58–287,3 mg GAE/kg honey. The characteristic antioxidant activities showed a marked correlation with the total phenolic contents. The honey samples showed low MIC values against three gram (+) and three gram (-) bacteria. Honeydew honey found to be stronger than the other honeys in terms of both antioxidant and antimicrobial potential.

**Keywords**— Honey, DPPH, total phenolic content,  $\beta$ -carotene assay, MIC.

## I. INTRODUCTION

Natural food usually contains natural antioxidants, which are ubiquitous in fruits, teas, vegetables, cereals, honeys and medicinal plants, can scavenge free radicals. According to the literature natural antioxidants have received great attention and have been studied extensively. The use of natural antioxidants in foods is limited, however, on account of the lack of knowledge concerning their molecular composition, the content of active compounds in the raw material and the availability of relevant toxicological data [1]. Honey has been used since ancient times and has gained appreciation as the only concentrated form of sugar available worldwide [2] and it is known both as food and as a natural product with nutritional, therapeutic and social roles in different cultures. Ancient Egyptians and Greeks used honey as a

medicine to treat ailments. Honey has been reported to contain more than 150 substances (complex mixture of sugars and also small amounts of other constituents such as minerals, proteins, vitamins, organic acids, flavonoids, phenolic acids, enzymes and other phytochemicals) and is considered as an important part of traditional medicine [3] and to be effective in the treatment of burns, gastrointestinal disorders, asthma, infected wounds and skin ulcers [4,5]. Many researchers showed that honey serves as a source of natural antioxidants, which are effective in reducing the risk of cardiovascular disease, cancer [6]. These diseases are a consequence of oxidative damage and it seems that part of the therapeutic properties of honey is due to its antioxidant capacity. Because of its sweetness, color and flavor, honey is often used as a sugar substitute, an ingredient or a natural preservative in many of manufactured foods and can also prevent oxidation reaction in foods (e.g., lipid oxidation in meat) [7-9]. Honeys with dark color have a higher total phenolic content and consequently a higher antioxidant capacity [10]. Honey is generally classified by the floral source of the nectar from which it was made, and there are also divisions according to the packaging and processing used. Previous works have indicated that the antioxidant capacity of honey varies widely, depending on the floral source [11-13,4]. Monofloral honey is made from the nectar of one type of flower. In order to produce monofloral honey, beekeepers keep beehives in an area where the bees have access to only one type of flower. In practice, because of the difficulties in containing bees, a small proportion of any honey will be from additional nectar from other flower types. Some typical European examples include thyme, thistle, heather, acacia, dandelion, sunflower, honeysuckle, and varieties from lime and chestnut trees. In North Africa, such as Egypt, examples include clover, cotton, and citrus, mainly orange blossoms. The main aim of this study was to determine the total phenolic contents, antioxidant levels and antimicrobial activities of several monofloral

(Honeydew, *Eucalyptus*, *Petroselinum crispum* M. and flower) honey samples from Hatay, Turkey.

## II. MATERIALS AND METHODS

**Honey samples;** Four noncommercial honeys of different floral sources are provided in different areas of Hatay/Turkey. Honeydew honey (secretion honey) is supplied from Serinyol, *Eucalyptus* honey is supplied from Reyhanlı, *Petroselinum crispum* M. honey is supplied from Iskenderun and flower honey is supplied from Antakya/Hatay (Fig.1). All honey samples provided from beekeepers and stored at room temperature in dark until further analysis.

**Chemicals;** Butylated hydroxyanisole (BHA), Gallic acid, and Folin-Ciocalteu's phenol reagent were purchased from Fluka Chemical Co. (Buchs, Switzerland).  $\beta$ -carotene, butylated hydroxytoluene (BHT), linoleic acid, Tween 40, and 2,2-diphenyl-1-picrylhydrazyl (DPPH) were purchased from Sigma-Aldrich. Anhydrous sodium carbonate ( $\text{Na}_2\text{CO}_3$ ), di-Potassium hydrogen phosphate ( $\text{K}_2\text{HPO}_4$ ), Potassium dihydrogenphosphate ( $\text{KH}_2\text{PO}_4$ ), methanol and chloroform were purchased from Merck. All solvents and chemicals used in the experiments were of analytical grade.



Fig.1: Samples and collected regions

**Total phenolic content** The Folin–Ciocalteu method was used to determine the total phenolic content (TPC) as reported by Singleton et al. (1999) [14], with some modifications. Briefly each honey sample (1 g) dissolved in methanol (5ml) and filtered through Whatman No: 1. This solution was used (40  $\mu$ l) and mixed with 2.4 ml of distilled water and 200  $\mu$ l non-diluted Folin–Ciocalteu reagents for 3 min and then 0.6 ml of sodium carbonate was added (%20,  $\text{Na}_2\text{CO}_3$ ). After incubation in the dark at 25 °C for 2 h, the absorbance of the reaction mixture was measured at 760 nm against a methanol blank using a UV-VIS Spectrophotometer. All measurements were made in triplicate. Gallic acid (0–1000 mg/L) was used as

a standard to derive the calibration curve. Total phenolic content was expressed as mg gallic acid equivalents (GAE) per kg of honey.

### Determination of DPPH radical scavenging activity;

The DPPH radical scavenging activity of honey samples was determined as described by Brand-Williams et al.1995 [15]. Briefly each honey sample (1 g) dissolved in methanol (5ml) and filtered through Whatman No: 1. A 0.1 ml aliquot of each honey sample (12,5–200 mg/ml), BHT and BHA in methanol was added to 2.9 ml of  $6 \times 10^{-5}$  M methanolic solution of DPPH. The mixtures was shaken vigorously and left at 25 °C in the dark for 60 min. The absorbance of the solution was measured at 517 nm, using a Spectrophotometer, against a methanol blank. All measurements were made in triplicate. The radical scavenging activity was expressed as  $\text{IC}_{50}$  (the concentration of the sample (mg/ml) required to scavenge 50% of DPPH), calculated by a linear regression analysis.

**$\beta$ -carotene bleaching assay;** The antioxidant activity of methanolic honey solutions was evaluated by the  $\beta$ -carotene linoleate model system [1]. Briefly, a solution of  $\beta$ -carotene (0,2 mg/ml) was prepared in chloroform and two milliliters of this solution was pipetted into a small (100 ml) round-bottom flask. After removing the chloroform under vacuum at 40 °C; 20 mg of linoleic acid, 200 mg of Tween 40 and 50 ml of distilled water were added to the flask with vigorous shaking. Aliquots (4,8 ml) of the prepared emulsion were transferred to a series of tubes containing 0,2 ml of honey samples. After placing the test tubes in a water bath at 50 °C; the absorbance of each tube steadily was measured using a spectrophotometer at 470 nm by starting zero time absorbance ( $t=0$  min) and at 15-min intervals until the end ( $t=120$  min), of the experiment. BHA and BHT were used as standards. The  $\beta$ -carotene bleaching was calculated using the following equation:

$$\text{Rate of } \beta\text{-carotene bleaching} = \ln(A_0/A_t) \times 1/t$$

where  $A_0$  is the initial absorbance of the emulsion at time 0;  $A_t$  is the absorbance at 120 min; and  $t$  is the time in min. Absorbance of all the sample solutions were measured at 470 nm. The antioxidant activity was described as by the mean percent inhibition of  $\beta$ -carotene bleaching against using the equation:

$$[(R_{\text{control}}/R_{\text{sample}})/R_{\text{control}}] \times 100$$

where  $R_{\text{control}}$  and  $R_{\text{sample}}$  are the bleaching rates of  $\beta$ -carotene in the emulsion without antioxidant and with honey samples, respectively.

**Antimicrobial Activity Test**

**Honey Preparation;** Four different honey types from four different floral origin (Fig. 1) was used and the honey dilution preparations of 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, 5%, 2.5% vol/vol in nutrient broth were prepared and pipetted (100 µL) onto sterile 96-well microtiter plates by using Eppendorf multi channel pipette.

**Assay for antimicrobial activity;** The antimicrobial activity of the honey samples was studied spectrophotometrically by a modified dilution method for minimum inhibitory concentration (MIC) using three Gram-negative bacteria (*Escherichia coli* ATCC 25922, *Klebsiella pneumoniae* ATCC 700603, *Pseudomonas aeruginosa* ATCC 15442) and three Gram-positive bacteria (*Staphylococcus aureus* ATCC 6538, MRSA *Staphylococcus aureus* ATCC 43300, and *Bacillus cereus* ATCC 11778) [16-17]. The tests were performed in sterile 96-well microtiter plates with U – shaped wells. In brief all bacterial strains grown on nutrient agar at 37°C for 24 h and were suspended in Nutrient Broth at density adjusted to a turbidity of 0.5 McFarland standards. The final inoculums were 5x10<sup>5</sup> CFU/ml of bacterial colony. The wells were filled with 100 µL honey dilutions by using Eppendorf multi channel pipette. After that by using microplate dispenser each well was inoculated with 100 µL of 0.5 McFarland standard bacterial suspensions except the 12<sup>th</sup> serial of the 96-well microplates. The 11<sup>th</sup> well were selected as positive control containing medium and microorganisms and the last well were selected as negative control containing only medium. The absorbencies were measured in an ELISA microplate reader at 620 nm prior to incubation, T<sub>0</sub>. The plates were lid and incubated at 37 °C for 24 h. After 24 h, plates were again read in ELISA microplate reader at 620 nm, T<sub>24</sub>. KCjunier program is used to calculate MIC values which are defined by subtracting the absorbance of each well (T<sub>24</sub> - T<sub>0</sub>) on the value obtained were plotted against the concentrations of wells.

**III. RESULTS AND DISCUSSION**

The antioxidant properties of different non-commercial honey samples were evaluated using the honey samples and synthetic antioxidant compounds. Numerous antioxidant tests have been developed for food or some biological samples but none of them can be accepted as universal. Therefore generally these methods are modified just as in this study. Higher antioxidant capacity of honeys are depends on their chemical structure especially polyphenolic compounds and flavonoids. These compounds in honey are strongly impressed by their floral origin and climate characteristic of the locations. [18]. Polyphenolic content analyzed of honey samples are

introduced in Table 1. Clearly, total phenolic contents in the honey samples are determined as mg gallic acid equivalents (GAE) per kg of honey. According to these results, while honeydew honey sample (287,31 mg.GAE/kg honey) has a rich polyphenolic content than others and phenolic contents of *Eucalyptus* honey (60,58 mg.GAE/kg honey) showed the lowest. The concentration and type of polyphenolic substances in honey is variable and depends on the floral origin of honey [19]. DPPH is a radical and has been widely used to test the free radical scavenging activity of various samples. DPPH free radical gives a strong absorption maximum at 517 nm and is purple in color. Values of IC<sub>50</sub>, connected to the percent decolorization of DPPH radicals, are shown in Table 1.

Table.1: Antioxidant activity test results of honey samples

	Hh	Eh	Ph	Fh	BH A	BHT
Phenolic content (mg.GAE/kg honey)	287, 3	60,58	121,6	61,7 1	---	---
IC <sub>50</sub>	9,85	22,51	16,02	17,6 2	4,11	5,45
Inhib ition %	40,9	5,68	17,04	4,54	27,8 4	16,47

Hh; Honeydew honey, Eh; *Eucalyptus* Honey, *Petroselinum crispum* M.Honey, Fh; Flower Honey

IC<sub>50</sub> is defined as inhibitory concentration or scavenging effect. The IC<sub>50</sub> is the concentration of an antioxidant which 50% inhibition of free radical activity is observed. So the lower IC<sub>50</sub> number indicates higher antioxidant activity [20]. According to the DPPH test results; BHA and BHT are synthetic polyphenolic antioxidant compounds therefore BHA and BHT have lowest IC<sub>50</sub> value. (4,11 and 5,45 respectively) and this is extremely normal. Among the honey samples, honeydew honey is the lowest than others (IC<sub>50</sub>: 9,85). Their IC<sub>50</sub> values of *Petroselinum crispum* M, flower and *Eucalyptus* respectively 16,02, 17,62 and 22,51. The value of correlation coefficient is between -1 and +1. The + and – signs are used for positive linear correlations and negative linear correlations, respectively. The correlation between the free radical scavenging activity and total phenolic

content was highly statistically significant. The correlation coefficient was equal to (-0.9171) (Table 2).

Table.2: The correlation coefficient values of between antioxidant activity tests.

	Between Folin Method and DPPH assay	Between Folin Method and $\beta$ -carotene bleaching assay.
<b>Correlation coefficient</b>	- 0,9171	+ 0,9970

These results suggest that the antioxidant power of honey samples is especially due to phenolic compounds that are the major constituents having reducing power. For this reason, the coefficient is negative. The antioxidant activity of the honey samples as measured by the bleaching of  $\beta$ -carotene; positive control BHA, BHT, and all samples were able to inhibit the discoloration of  $\beta$ -carotene. The order was honeydew honey (40,90%) > BHA (27,84%) > *Petroselinum crispum M.* (17,04%) > BHT (16,47%) > *Eucalyptus* (5,68%) > Flower 4,54%) (Table 1). The correlation coefficient between the inhibition % and total phenolic content was equal to (+0.9970) (Table 2). The antioxidant test results are parallel to each other.

The MIC was determined by the mean of lowest concentration of honey solutions that exhibited the growth of the organisms in the wells by spectrophotometric reading accordingly to an Elisa Microplate Reader. Environmental and economical concerns have led analysts towards smaller sample sizes and reduction of the required solvents. However, more realizable results are obtained with larger sample sizes. The MIC results obtained using a broth microdilution method was presented in Table 3.

Table 3. MIC values of honey samples (mg/ml)

	Gram positive			Gram negative		
	S.A	BC	MRS A	KP	EC	PA
Hh	500	500	500	700	500	500
Eh	600	600	600	-	500	400
Fh	500	600	400	800	600	600
Ph	700	600	600	700	600	700

SA; *Staphylococcus aureus*, BC; *Bacillus cereus*, KP; *Klebsiella pneumoniae*  
EC; *Escherichia coli*, PA; *Pseudomonas aeruginosa*

Hh; Honeydew honey, Eh; *Eucalyptus* Honey, *Petroselinum crispum M.* Honey, Fh; Flower Honey

Honeydew honey found to be stronger than the others in terms of antioxidant power also effective to antimicrobial potential both gram positive and gram negative bacteria. The results showed that honey extracts generally have similar antimicrobial capacity inhibitory, with the exception of the *Klebsiella pneumoniae* microorganisms, but honeydew honey moderately sensitive to the antimicrobial activity. It seems that honey, most effective against *Pseudomonas aeruginosa* is *Eucalyptus* honey. Therewithal the least effective than the others against all bacteria is *Petroselinum crispum M.* honey. Generally all honey samples showed an antioxidant effect with the respect of some differences. These discrepancies could be attributed with the differences of botanical sources of honey and also to the presence of different antioxidant compounds such as some flavonoids, phenolics and phenolic acids [4]. These results show that honey is a natural product with antioxidant and antimicrobial properties. Regarding the antioxidant and antimicrobial properties especially honeydew honey is valuable and its inclusion in the diet may be recommended to complement other polyphenol sources.

These results show that honey is a natural product with antioxidant and antimicrobial properties. Regarding the antioxidant and antimicrobial properties especially honeydew honey is valuable and its inclusion in the diet may be recommended to complement other polyphenol sources.

#### ACKNOWLEDGEMENTS

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# Application of Model *Quantum Learning* *Teaching Techniques Crosswords* Premises *Puzzle* in Improving Results of Student Learning Outcomes in Integers

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**Abstract**— *Quantum Teaching is real life learning strategy with relevance social nuances. Quantum Teaching consists of four steps, namely Grow ( Motivate ), Natural ( Do ), Name ( Symbolize ), Demonstrate ( Demonstrate ), Repeat ( Repeat ) ( TANDUR, for short ). The research purpose is to analyze the student learning achievement and activities . The research design is Classroom Action Research ( CAR ). It Consist s of four stages . Plan , implementation , observation, and reflection. Research was done in two cycles . The result shows that t he percentage of student learning achievement and activities respectively increase is from cycle I to cycle II items, namely 75% to 83.33% and. 70 , 27 % to 83.5 5 %. I can conclude that the application of Quantum Teaching with Crosswords is a puzzle technique can effectively improve student learning achievement as well as their activities .*

**Keywords**— *Quantum Teaching , Student learning achievement t , and activities.*

## I. INTRODUCTION

Education is an element that cannot be separated from human beings, education is like a light that tries to guide humans in determining the direction, purpose, and meaning of life. Humans really need education through a process of awareness that seeks to explore and develop their potential through various ways that have been recognized by society. Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation and country.

School mathematics is a part of mathematics as a science chosen on the basis of the importance of developing students' thinking and personality abilities and

the interests of the development of science and technology, must be in line with the demands of students' interests to face the challenges and demands of future developments. Mathematics is one of the subjects that is considered difficult by some students because the objects learned in school mathematics are abstract objects.

*Quantum Teaching* is one learning model that can help students understand a material optimally. which in turn can significantly improve student learning achievement, this learning method can create a comfortable atmosphere during the learning process that can increase student learning motivation (DePorter, 2000: 5). To increase student learning motivation, active learning is needed which can create meaningful and enjoyable learning. The *puzzle* learning technique is a modification of the *mind mapping* method developed by Tony Buzan. This *puzzle* learning technique can increase the active role of students in the learning process because in *puzzle* techniques there are challenges to be solved by students in addition to *puzzle* techniques can reduce student tension during the learning process.

Interest d nature of this study is to u ntuk examine the application of learning models *Quantum Teaching* techniques *Crosswords puzzle* in improving student learning outcomes subject matrix of class X program accounting expertise SMK Negeri 1 Jember, u ntuk clicking examine activism f itas current students applied learning models *Quantum Teaching* with *Crosswords puzzle* techniques in improving student learning outcomes. The subject matter of class X matrix accounting skills program at SMK Negeri 1 Jember, to study *Quantum Teaching* learning models with *Crosswords puzzle* techniques can improve student learning outcomes. Jember.

## II. RESEARCH METHODS

This research subject is grade 3 students SDN Pakis 01 academic year 18/2019 . The class consists of 15 male students and 25 female students. Selection of grade 3 as the subject of research, because students experience learning difficulties . In addition, the learning methods used by subject matter teachers make students experience learning saturation, so a new learning experience is needed.

The type of research used in this study is class action research (CAR) in English term *Classroom Action Research* (CAR) . Penelitian class action is a form of scrutiny on an action learning activities, which deliberately raised and occur within a class together. The action is given by the teacher or by the direction of the teacher conducted by the student.

The researcher used the Kemmis and McTaggart model action procedures. There were several experts who suggested that the action research model with a chart was different, but in general there were four stages that were commonly passed, namely:

Planning ( *planning* ) , at the planning stage carried out is the initial observation of the state of the school, subject teachers and students. More specifically is setting standards and basic competencies that will be used for research, planning learning methods will be applied in teaching and learning, preparing learning resources, develop lesson plans, developed the Student Worksheet (LKS), develop relevant format evaluation, and develop formats field observation.

Implementation ( *Acting* ), Phase 2 of PTK include procedures and actions to be carried out according to the plan that has been made previously, as well as process improvements that will be done.

Observation ( *observing* ) , the third stage of the PTK includes procedures for recording data about the process and the results of the implementation of the actions taken.

Reflection ( *reflecting* ), describes the analysis of the results of the monitoring procedures and the reflection on the process and impact of corrective actions taken, as well as the criteria and action plans in the next cycle.

The spiral cycle of the stages of classroom action research can be seen in Figure 1.

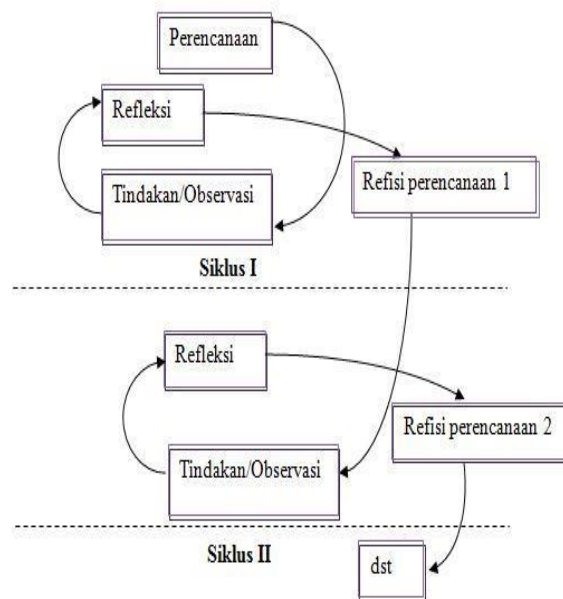


Fig.1: Classroom Action Research Cycle Model Kemmis and McTaggart (Pudjiono, 2008)

In this study, researchers plan to carry out classroom action research until the second cycle. If in the first cycle it has reached the desired target, the second cycle will still be carried out to strengthen the results of the study.

Data analysis was carried out after the data was collected while the references used in descriptive quantitative data analysis were final tests , Student Worksheets (LKS), and daily tests .

The data analyzed in this research are as follows :

1. Teacher and student activities during the application of *quantum* learning models. The percentage formula for the activity of teachers and students in learning is as follows:

$$a_i = \frac{Q}{R} \times 100\% ; i = 1, 2$$

Information:

$a_i$  = percentage of activity

**1** = teacher

**2** = students

**Q** = the number of scores achieved

**R** = maximum number of scores

From the formula above, the calculation results will be obtained in the form of percentages by matching the following categories:

Table.1: Activity Criteria

Percentage	Criteria
$73,3\% \leq a_i < 100\%$	Very active
$53,3\% \leq a_i < 73,3\%$	Active
$33,3\% \leq a_i < 53,3\%$	Less active
$a_i < 33,3\%$	Not active

Source: Ministry of National Education (2004)

2. The learning result, a analysis data from these test results are used to determine the value obtained by each student so that it can be determined which students were categorized as complete or incomplete with  $SKM \geq 75$ . Having in mind the number of students who completed or incomplete, so the new can be calculated percentage classical completeness with a target of 80% of students scored  $\geq 70$  in one class. Student learning completeness after learning takes place, sought by the formula:

$$P = \frac{n}{N} \times 100\%$$

Information:

$P$  : Percentage of learning completeness

$n$  = Number of students who complete study

$N$  = Total of all students

Ministry of National Education (in Zahro, 2012)

### 3. Performance indicators

A cycle PTK is said to have succeeded or has not been successfully measured from the achievement of a predetermined target, in the form of success criteria. If the achievement of results is the same as targeted, then cycle it has been successful, if it is not on target, the strategy must be revised to be used on the cycle next. So is on cycle second, and so on. The measure of success is measured by comparing the learning outcomes and activities that have been achieved with the targeted success criteria. The indicators of cycle success are measured by the criteria for active category activities ( $53,3\% \leq a_i < 73,3\%$ ) and classical completeness with the target  $\geq 80\%$  of students were declared complete in one class.

## III. RESULTS AND DISCUSSION

This research is a classroom action research (CAR) carried out using two cycles. This research is a classroom action research (PTK) which aims to find out the application of *Quantum teaching* with technique *Crosswords puzzle* to improve the learning outcomes and activities of students Sub-chapter of this study were grade 3 students of SDN Pakis 01, totaling 40 students.

In Quantum environmental teaching is a very important aspect. Environment is a teacher's way of

organizing classrooms. Figure 2 is a Class design designed for teaching and learning processes in this study.

Information:

1 - 5 : Affirmation posters

6 : Teacher's chair and bench

7-14 : Student chairs and benches

12, 13 : Sound system

14 : Doorprize box

15 : Whiteboard

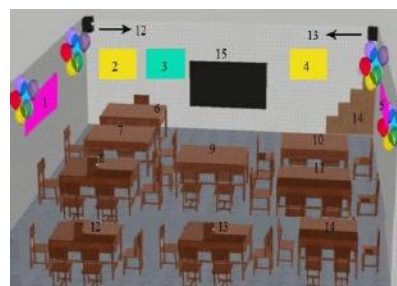


Fig.2: Design class

*Crosswords puzzle* is chosen because the type of puzzle is more familiar to the community. Usually the puzzle is often used in quiz questions in magazines and newspapers. These puzzles are also often used in TTS books (Crossword Puzzles). So that students can better understand how to solve the questions presented in the form of *Crosswords puzzle*. The way to fill in the blank columns in the *Crosswords puzzle* is to change the results in the form of numbers into letters. Wrong one Form *The crosswords puzzle* is presented in sheet work students could seen on Figure 3.

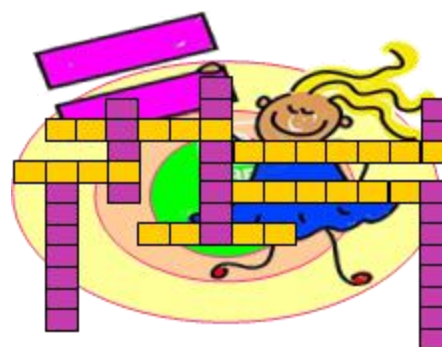


Fig.3: Form Crosswords puzzle

Application *Quantum teaching* composed on 6 frames design teaching shortened with acronym **TANDUR**, that is **T** umbuhkan, **A** lami, **N** Amai, **D** emonstrasikan, **U** langi, and **R** sieve. Stage grow it that is emancipating students to learn the material matrix to give a small gift to those who raised a hand sign to agree to follow a math lesson with a matrix material, as well as the teacher presents the objectives pembelajaran. Namely natural AHAP T m enceritakan some daily activities

related to the matrix material and provides examples of problems experienced by students to diesel esaikan with the concept of matrix. T AHAP frontage, m emberikan opportunities for students to read the material to be studied. After students read the material to be studied, the teacher gives questions related to the material students have read. T AHAP demonstrate that m embacakan clues to solve the problems in the student worksheet and provide an opportunity for the group that successfully complete the student worksheet prior to downloading explain the results of their discussion. T AHAP repeat, m engulangi material that has been conveyed by asking questions about the material that has been described to determine the extent of student understanding, and the last stage to celebrate ie, m emberikan praise, applause, to give an opportunity to students who have the best value to open the box *door prize* in front of the class that already contains a prize.

Teacher activity is all activities carried out during the learning process. The activity observed in the learning teacher's siklus I and II cycle of learning. Based on the results observations made by the observer obtained percentage data activity teacher as the following :

Table.2: Percentage of Teacher Activities

Teacher activities	CYCLE I	CYCLE I I
Grow it	16.67%	16.67%
Natural	11.11%	11.11%
Name it	16.67%	16.67%
Demonstrate	11.11%	16.67%
Repeat	11.11%	16.67%
Celebrate	16.67%	16.67%
Percentage teacher activity	83.3%	89.89%

The percentage of teacher activities in cycle I and cycle II will be presented in Figure 4 .

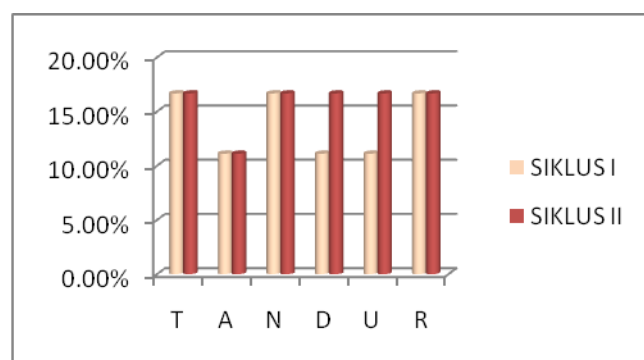


Fig.4: Graph of Teacher Activity Percentage

Information: T : Grow , A : Natural , N : Name , D : Demonstrate , U : Repeat , and R : Celebrate

Based on the results of observations of students on the implementation of learning with *Quantum teaching*

conducted by observers obtained data on student activities in the class at each meeting in the first cycle and second cycle, which is shown in Table 3 .

Table.3: Percentage of Student Activities

Student Activities	CYCLE I	CYCLE I I
Pay attention	78,37%	88,28%
Take notes	81,98%	82,88%
Asking	58,55%	81,98%
Express opinions	62,61%	81,08%
The average student activity each learning	70,27%	83,55%

Next, the results of the percentage of student activities in cycle I and cycle II will be presented in the form of tables,

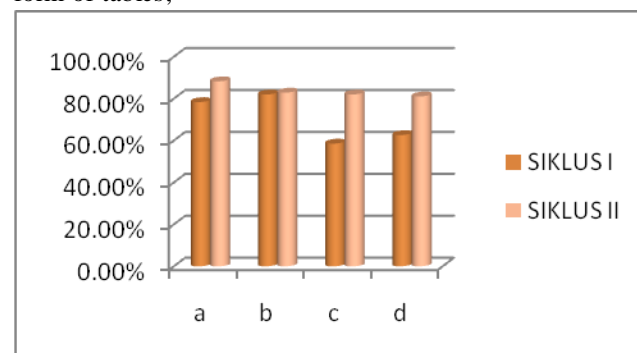


Fig.5: Graph of Percentage of Student Activities

Information: a : pay attention                      c : asking  
b : take notes                                      d : Express opinion

#### IV. CONCLUSION

Based on the results of the research and discussion that has been described, conclusions can be drawn as follows: (1) Application of *Quantum teaching* with *puzzle* techniques in improving student learning outcomes in grade 3 integers Pakis 01 Elementary School runs well and smoothly. ; (2) Activities students experience enhancement from 70.27% on the first cycle while in the second cycle the percentage of student activities was 83.55% ; (3) Results learn students experience enhancement in the first cycle the percentage of student learning outcomes was 75% while in the second cycle the percentage of student learning outcomes was 83.3% . The s aran to diberika n by researchers, namely: (1) Learning



mathematics with *Quantum teaching* techniques *Crosswords puzzle* can be used as an alternative learning in the classroom so that students do not get bored with the usual lesson, but keep in mind the selection of appropriate materials in order to learning can work well; (2) Management of the time when applying the learning method must be considered so that it does not exceed the predetermined time.

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# Management Plan for Solid Waste in Construction Sites

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**Abstract**— *The fast urbanization and densification processes in the cities have been causing serious environmental problems, like the disposal and management of solid waste generated during the construction, demolition and renovation of buildings. The present work develops a study on the Management of Solid Waste in Construction Site. This study investigates the method and procedures of waste planning at construction sites and the disposal of these same residues, with the objective to create conditions for the proper economy, standardization and increased safety in the construction sites and facilitation of waste disposal. A theoretical framework was created regarding the provisions of construction waste at construction sites. Based on the results, management actions are being proposed for greater sustainability, with benefits like the better use of the construction site with improvements in its operation and cleaning, as a direct consequence of good solid wastes management.*

**Keywords** — *Solid Waste, Civil Construction, Construction Site, Disposal.*

## I. INTRODUCTION DEVELOPMENT

In this article, we approach the study, classification and appropriate treatment of solid waste in the Civil Construction Industry through a Management Plan. This issue is not much discussed and is vital for the preservation of the environment, where it is primarily intended to prevent solid wastes generated in construction sites through initial construction, demolition, renovation and expansion, to be deposited in the nature, avoiding degradation.

The focus is to bring awareness to the readers for the importance of each type of waste, taking in consideration its classification and final treatment, as well as pointing

cheaper and practical ways to mitigate the waste of materials, diminishing the volume of the generated wastes.

The author Marques Neto (2005) states that it is estimated in Brazil that, for each ton of urban waste collected, two tons of rubble are collected from the civil construction area. According to the citation, it is possible to minimize the volume of waste generated by each construction company, so that they can reuse it in the construction sites when is possible, as well as reducing the waste of materials. Construction and demolition waste constitute a large proportion of solid waste. In Brazil, 59% of landfills are composed of materials from the construction industry (CARNEIRO, 2005, apud VIANA, 2009 p.16).

Taking as a reference basis the technology applied in the civil construction in Brazil, it is clear the lack of efficiency in the execution of the construction works. When comparing the volume of waste generated in new building constructions in Brazil to developed countries, it is evident that Brazil generates three times the number of wastes in comparison to the quantities generated in developed countries, 300 kg/m<sup>2</sup> built (MONTEIRO, 2001).

Finally, our purpose is to present in this study management actions with the intention to reach the economy, sustainability and correct destination of the (RSCD) Demolition and Construction Solid Wastes, significantly contributing with the environment.

One of the reasons for the decreasing in natural resources is the waste and misuse of raw materials. The exploration and inappropriate disposal are matters of concern and the reason to bring awareness for good daily practices in civil construction.

The construction waste has the property of its final volume being very large, so if the generation of waste is accelerated, it causes the fast filling of reserved spaces in sanitary landfills. Thus, in order to minimize the potential for generating economic, social and environmental impacts, we will use simple management and reuse tools at the construction site.

## II. DEVELOPMENT

The solid wastes of construction and demolition (RSCD) are those generated in construction sites, coming from constructions, reforms and demolitions, like bricks, ceramic blocs and concrete in general, etc. The RSCDs are the leftovers of the construction process (BLUMENSCHNIG, 2007).

According to Zordan (1997), all the activities performed in the civil construction area have huge potential to generate waste. As for the production, the main responsible for the RCD are the volumes of material lost. In the constructions, the demolition process does not relate the applied processes or quality of the area, but instead the permanent and invariable existence of each product of the process.

Among the negative impacts to the environment, we have the (RSCD), Demolition and Civil Construction Solid Wastes, originated through construction processes and also known as Civil Construction Wastes (RCC), being a strong polluting source inserted in the construction sites if not properly treated. In Brazil, the amount of losses in corporative construction materials (residential construction in buildings) has a variable between 20% and 30%, an index considered higher than the ones found in Developed countries (SCHNEIDER, 2003 apud PINTO, 2003)

“According to Law 12.305/10, the management of solid waste can be defined as a conjunct of direct and indirect actions during the steps of collect, transportation, transshipment, treatment and the environmental-friendly final destination of solid waste and rejects, according to the municipal plan of integrated management of solid waste or with the management plan of solid waste, demanded in the Law.” (BRASIL, 2010).

Due to the large volume of Solid Waste generated in the civil construction business, it was approved the Resolution nº 307, from 07/05/2002, by the National Environmental Council – CONAMA, which defined the responsibilities and duties and made mandatory in all the municipalities of the country and in the Federal District the implementation by the local government of Integrated Plans of Civil Construction Waste Management, to eliminate the environmental impact resulting from the activities related to the generation, transportation and destination of these materials. It also determines the

adoption, if possible, of measures capable of minimizing the generation of waste and its reuse or recycling, or, when inviable, that they are allocated in a segregated manner for posterior use.

On chapter VI, Art. 225, regarding the environment, the Constitution establishes that: “Everyone has the right to an eco-balanced environment, which is a right of common use of the people and essential to a healthy life quality, imposing to the government and the collectivity the duty to defend it and preserve it for the present and future generations.” (CONAMA, 2002).

The following chart (01) shows the responsible parties (agents) and the main responsibilities in the management of RSCD.

Chart 1 - Main responsibilities in the management of the RSCD.

Agent	Responsibilities
State	Introduction of means for direct and economic regulation to regulate the management of the collection process. Stablishing of monitoring standards and use of debris for grounding; Consolidation of recycling activities Stablishing of goals for the reduction of the use of sparse natural resources Incentives for the use of waste from construction and demolition Prohibition of sand and gravel extraction; Consolidation of the production of recycled aggregates Stablishing of legal areas for solid waste disposal.
Generators	Reduction of losses and waste generation through the adoption of constructive and rational methods. Management of solid waste during the construction process; Awareness of the necessity to use recycled materials, to consolidate recycling activities and to reassure the quality of the segregated waste. Investments in Research and Development.
Entrepreneur Clients, architects, engineers and consultants	Stablishing of specification criteria for the use of recycled materials and the adoption of sustainability principles; Demanding the adoption of a waste management system in construction sites; Definition of rationalization and standardization criteria in the definition of construction methods to produce flexible buildings of simple demolition

	capacities.
Transport Companies	Demanding the exercise of the transporting activity in a conscious and responsible manner, taking the waste to the areas designated by the city; Warning the drivers about the impacts caused by the illegally disposed waste; Contribution to the program of control and monitoring of the volume and characteristics of the produced waste.
Wastes Processors	Reassuring the quality of the recycling aggregates
Universities and Research Institutes	Implementation of labs, development of applied research, parliamentary consultancy, courses, consultation, integration of agents, among others.

Source: Adapted from Blumenschein, R., 2004. Extracted from: Technical Manual - Management of Solid Waste in Construction Sites (Blumenschein, 2007, p.8).

### 2.1. RSCD Generation

A civil construction site involves many different organizations, such as entrepreneurs, builders, planners, financiers, engineers, architects, labor, suppliers, among others. The lack of planning, coordination, monitoring, inefficient or incomplete information of technical documents and lack of communication between these areas results in delays, high costs and wastes that increase losses and generation of waste (BLUMENSCHIEIN, 2007, p. 9).

In figure (1) below we see characteristics of a linear, traditional, schematic production process. The phases work in a disintegrated fashion from each other, which does not allow the exchange of information to make compatible the technical information and the necessary corrections before beginning the construction, avoiding errors and reworking.

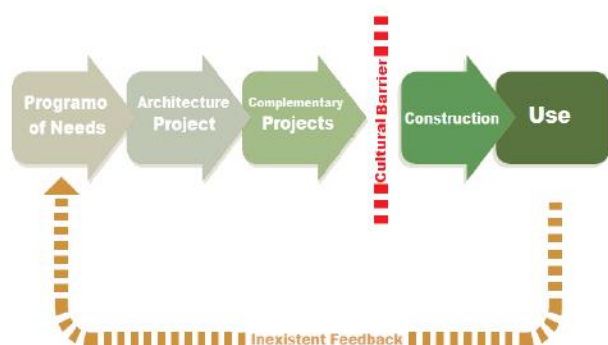


Fig.1: Traditional Construction Process

Source: Blumenschein, R., 2004. Extracted from: Technical Manual - Management of Solid Waste in Construction Sites (Blumenschein, 2007, p.9).

According to the Federal University of Bahia Publisher (EDUFBA, 2001, p.66, apud VIANA, 2009,

p.25), among the several factors that contribute to the generation of the rubble, it is worth mentioning:

- insufficient definition and detailing, in architectural projects, structure, forms, facilities, among others;
- lower quality of construction materials and components available on the market;
- unskilled labor;
- lack of operational procedures and enforcement and inspection control mechanisms.

Chart 2 shows the sources and causes of the occurrence of construction waste.

Chart 2 - Sources and Causes of Occurrence of Construction Waste.

SOURCE	CAUSE
Project	Errors in the contracts; Incomplete contracts; Project Modifications.
Intervention	Wrong orders, absence or excess of orders; Supply errors.
Material Handling	Damage during transport; Inappropriate stock.
Operation	Errors of the workers; Equipment malfunction; Inappropriate environment; Damage caused by previous and subsequent work; Uses of incorrect materials in substitution; Cutting remains; Waste from the application process.
Others	Vandalism and theft; Lack of material control and waste management.

Source: Pontes (2008, p.25). Excerpted from VIANA, (2009, P.26)

### 2.2. Management of RSCD In Construction Sites

For Kartam et al (2004) apud Tavaves (2007), the term management can be defined as the prudent use of means to achieve an end. Therefore, this term "management" has not been used correctly when applied in civil construction activities relating to solid waste generating activities, whose actions are reckless as a rule, and in most of the activities the ends are not achieved to the fullest.

The work of RCD management must begin well before the execution of the work, appearing already in the first planning stages, since the definition of the constructive technology to be used is crucial so that there is no waste at the construction site (SANTOS, 2012)

The resolution of CONAMA No. 307/02 calls attention to an aspect of high importance, which is the solution found for the abolition of the well-known "disposals" practices of the rubble of the civil construction. If there is no viability in establishing waste recycling from urban construction, the continuation of this highly polluting practice should be abolished (COSTA, 2005).

We cannot have in short-term high rates of RCD return to the productive cycle, but we can adopt practices that respect these materials as nonrenewable natural resources (PINTO, 2004).

In general, solid waste is one of the main determinants of environmental degradation, due to the volume of its treatment and its inadequate disposal. The main problems of its management must be solved by the government and municipal authorities (COSTA, 2003).

It is important to emphasize that no society can achieve sustainable development without the civil construction that supports it, undergoing through profound changes (FILHO, 2005 apud POLILLO, 2001).

### 2.3. Composition of Solid Waste

According to Silva and Fernandes (2012), the civil construction industry is one of the largest generators of solid waste today, and the waste originated during construction or demolition processes is of extreme importance in the total amount produced in urban centers.

According to Law No. 12.305/10, which establishes the National Solid Waste Policy, the objective is the prevention and reduction of solid waste generation, aiming at sustainable consumption, increased recycling and reuse of solid waste generated and its correct destination (BRAZIL, 2010).

#### Classification of Solid Wastes

ABNT NBR 10004/2004 classifies for standardization effects the waste in:

- a) Class I waste - Hazardous;
- b) Class II waste - Non-hazardous;
  - class II A waste - Not inert.
  - class II B waste - Inert.
- Class I waste - Hazardous:

Waste that present dangerousness and risk to public health, causing mortality, incidence of diseases or accentuation of their rates and risks to the environment when the waste is improperly managed. It may also present: flammability, corrosivity, reactivity, toxicity or pathogenicity.

- Class II Residues - Non-Hazardous:

Waste that do not fit into Class I.

- Class II A waste - Not inert.:

Waste that do not fit into the classifications of class I-Hazardous or class II B - Inert. Class II A - Non-inert

waste may have properties such as: biodegradability, combustibility or solubility in water.

- Class II B waste - Inert:

Any wastes that, when sampled in a representative manner, according to ABNT NBR 10007, and subjected to a dynamic and static contact with distilled or deionized water, at ambient temperature, according to ABNT NBR 10006, do not have any of their constituents solubilized at higher concentrations to water potability standards, except for appearance, color, turbidity, hardness and taste.

The classification of wastes as to their origin, chemical composition, presence of moisture and toxicity is presented by (LINS et al 2008, apud VIANA, 2009, p.21) as follows:

Regarding the origin:

- Residential – waste originated from the daily life of the residences.
- Commercial - waste coming from several commercial establishments and services
- Public - originated from the services of urban public cleaning (cleaning of public roads, beaches, galleries, streams and lands, remnants of pruning of trees, etc.), and cleaning of fairground areas.
- Of health services – they constitute the septic waste.
- From ports, airports, road and rail terminals – they constitute the septic wastes, which contain or may potentially contain pathogenic germs, brought to ports, airports, road and rail terminals.
- Industrial - those originated in the activities of the several branches of the metallurgical industry, chemical, petrochemical, paper, food, among others.
- Agricultural - solid waste from agricultural activities and livestock.
- Rubble - construction waste, such as demolitions and debris from works, excavation grounds, among others.

Regarding their Chemical Composition:

- Organic - paper, newspapers, magazines, plastics, packaging, rubber, tires, gloves, medicines, food scraps, crop residues, among others.
- Inorganic - metals, glass, ceramics, sand and stones.

Regarding the Presence of Humidity::

- Dry - apparently without humidity.
- Wet - visibly wet.

Regarding their Toxicity

- Class I - hazardous, which may be flammable, corrosive, reactive, toxic and pathogenic.
- Class II - non-hazardous, subdivided into:
  - Class II A- not inert. They pose no risk to public health or the environment and may be biodegradable, such as untreated and paintless wood, plaster, paper and others.
  - Class II B- inert. For instance, hardened concrete and mortars, masonry, ceramic and concrete components, tile, aluminum, glass, copper and plastic, among others.



According to the norm NBR 10004 (ABNT, 2004), the classification of class II b-inert, of civil construction, are defined as follows:

"Any wastes that, when sampled in a representative manner, subjected to a static or dynamic contact with distilled or deionized water at room temperature, according to the solubilization test, do not have any of their constituents solubilized in concentrations higher than water potability standards, except for the patterns of appearance, color, turbidity, and taste. As an example of these materials, we have rocks, bricks, glasses and certain plastics and rubbers which are not readily decomposed. " NBR 10004 (ABNT, 2004).]

Conama Resolution No. 307 defines classes according to their recyclable potential:

- Class A - reusable or recyclable wastes as aggregates, such as:
  - a) construction, demolition, alteration and repair of paving and other infrastructure works, including land from earthworks;
  - b) construction, demolition, renovation and repair of buildings: ceramic components (bricks, blocks, tiles, flooring boards etc.), mortar and concrete;
  - c) process of manufacture and/or demolition of precast concrete parts (blocks, tubes, bundles, etc.) produced at construction sites;
- Class B - recyclable wastes for other destinations, such as: plastics, paper/cardboard, metals, glass, wood and others;
- Class C - wastes for which no economically viable technologies or applications have been developed to enable their recycling/recovery, such as products made of plaster;
- Class D - hazardous wastes from the construction process, such as paints, solvents, oils and others, or those contaminated from demolition, remodeling and repair of radiological clinics, industrial installations and others (BRASIL, 2002).

#### 2.4. Environmental Impacts and Final Destination of RCD

One of the main sources of RCD generation considers the high loss rate of the construction process in the industry. Most of the researchers say that the causes of RCD generation are related to the losses. However, not every loss within the construction sites necessarily represents the generation of waste effectively. as the rubble responds to 50% of all wasted material (PINTO, 1989).

In most Brazilian cities, the RCDs adopted as a management model are of the corrective type. This type of model has been shown to be unsuccessful, marked by not including preventive, costly and periodic activities, where there are no expected positive effects. This makes it a practice without sustainability to the RCD. (EDUFBA, 2001 apud TAVARES, 2007).

For the employees who work in the field, the treatment, collection and improper disposition of solid wastes have high social and economic impacts. Therefore, the negative impacts generated are of wide knowledge, and the issue of wastes has been neglected for many times, reflecting these damages on future generations and potentiating the destructive occurrences (MENEZES and MENEZES, 1999).

A considerable number of professionals working in construction do not recognize the amount of RCD they generate, and by understanding the environmental pollution they are producing, they are usually not being guided by the conditions necessary to perform the correct dumping of the volumes generated, like making use of the reusable selection and being referred to external recycling process. These practices have a high contribution to the environment, where the reduction of environmental impacts caused by the sector is directly linked (MARINHO and SILVA, 2012).

Also, according to CONAMA's resolution, Article 10, construction waste should be disposed as described in Chart 3.

*Chart 3 - Destination of the RCD according to the CONAMA resolution n° 307/2002.*

Class	Destination
Class A	They must be reused or recycled in the form of aggregates, or sent to landfill sites of construction wastes, being arranged to allow their use or future recycling.
Class B	They must be reused, recycled or transported to temporary storage areas and disposed of in a way that allows them to be used or recycled in the future.
Class C	They must be stored, transported and destined in accordance with the specific technical standards.
Class D	They must be stored, transported, reused and destined in accordance with the specific technical standards.

Source: CONAMA Resolution No. 307/2002.

It is well known that the irregular dumping of the RCD culminates in larger issues faced by the

municipalities, with high costs for the environment and the community. This practice of illegal dumping results in the degradation of urban quality of life, with consequences like floods, visual pollution, transportation, proliferation of vectors of diseases, pollution of water beds and sedimentation, among other environmental issues (TAVARES, 2007).

It is necessary to reduce the generation of RCD in order to minimize the impacts into the environment. The civil construction industry has been working for implement this condition, but facing difficulties to do so, as stated by (CARELI, 2008).

### III. CONCLUSION

For a project to be considered sustainable, the work of the management of the RCD begins well before the execution of the work. It must point the impacts that will be generated and propose solutions that eradicate the waste in the construction sites. At the main stages of planning, it is important to create alternatives for the proper use of existing resources, such as the use of water resources and energy, as the definition of the constructive technology to be used is crucial to make a sustainable environment and minimize the potential of impact generators.

It is inevitable to generate wastes, as practically all the activities developed in the civil construction sector generate debris. The construction activities, mainly the urban ones, generate a significant volume of inert wastes, where they contribute to a low environmental quality, even more so in the occurrence of inadequate disposal.

The implementation is sustainable and economical in the construction sites, adopting programs and actions capable of reducing as much as possible the unsustainability that can be achieved through construction works. Solutions to treat inert waste, using appropriate techniques in accordance with current legislation.

Preventive and remedial actions must be introduced at the moment of the project, in order to successfully reach the proposed solutions. Prevention to minimize the generation of wastes, prioritizing non-generation, and secondarily, reduction, reuse, recycling and appropriate final disposal.

In view of this probable solution, it is necessary, in addition to raising awareness of the responsibilities of all participants in the construction processes, to implement a more efficient inspection system, not only ensuring an efficient reuse of solid wastes coming from civil construction, but also to supervise the disposal of the wastes that had its useful life expired.

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# Use of Clay Sludge Water Treatment Plant Sludge to Produce Ceramic Brick

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**Abstract** — In the search for solutions capable of minimizing the environmental impacts from waste water treatment plant (WWTP) and reduce costs related to the final destination of the waste generated, the present work aims to evaluate the potential use of WWTP sludge by incorporating clay slurry to the production of bricks, in order to present an alternative environmentally correct destination for this waste. Sludge and clay underwent chemical and mineralogical characterization, through granulometric distribution, X-ray fluorescence analysis, X-ray diffraction. The samples were homogenized in the proportions of 0%, 12%, 14% and 18% of sludge in red clay, pressed at 25 MPa, and later production of test specimens which were then burned to a temperature of 900°C. After sintering, physical and mechanical tests were performed to evaluate the quality of the final product, by means of analysis of the properties of fire loss, linear retraction, water absorption, apparent specific mass, apparent porosity, flexural rupture stress, moisture and plasticity. The results of the laboratory tests with the residue proportions incorporated in the clay mass demonstrate influence on the physical and mechanical properties of the ceramic material. The results presented show a similarity to that recommended and that despite the 18% (sludge) samples, in relation to the clay showed a variation in the chemical composition due to its high organic matter content, it was observed that both had SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub>. Comparing the results with the parameters established in NBR 15270-1, 2 and 3/2005, it was verified that the WWTP sludge can be incorporated in up to 18% in the clay mass for the manufacture of bricks.

**Keywords**— Waste water treatment plant, recycling, solid waste.

## I. INTRODUCTION

The environmental impacts caused by the high solid waste index are consequences of the necessary economic expansion and the technological advance, imposing to

society a consumerist rhythm. This consumption concept of modern society contributes to the various sources of waste generated, from the activities of industry, commerce, ore, fishing, water supply, residences, among others.

With the objectives of a cleaner production and commercial competitiveness, companies are increasingly concerned about the reduction and correct destination of waste generated in their production processes, and product life cycle. This concern is always aimed at minimizing the costs of solid waste treatment and the negative impacts on the environment.

The WWTP for public supply transform inadequate water for human consumption into sanitary safe water, in accordance with the drinking standard established in Brazil through decree n° 2,914 / 11 of the Ministry of Health [1].

The water supply industry, when using the complete or conventional treatment (coagulation, flocculation, decantation and filtration), carries out processes and operations such as the introduction of chemicals, which generate the residue [2].

This byproduct, generated from the addition of chemicals and water, is called sludge and is composed basically of soil particles, organic material drawn to raw water.

The sludge generated in the WWTP usually has an inadequate final destination, being exposed to the environment, contaminating it [3]. E a decomposição do solo e a contaminação de nascentes e lençóis são exemplos de danos ambientais causados pelo descarte inadequado de resíduos [4].

The fate of WWTP residue has long time been the water courses near the stations. However, current legislation is restricting and even prohibiting this practice. According to the National Policy on Solid Waste law 12.305/10 [5] e a NBR 10.004/871 [6], these sludges, classified as solid waste, should be minimized, reused and / or recycled, being prohibited in water bodies.

This material is a compound capable of causing

environmental pollution, containing chemicals which, if disposed of in the environment without proper treatment, can cause serious environmental damage to the soil and aquatic life.

Heavy metals such as copper, zinc, nickel, lead, cadmium, chromium, manganese and, in particular, aluminum and iron, present in the sludge, have toxic actions [7]. The toxicity is also due to reactions during the process, form and retention time, characteristics of the watercourse, composition and impurities and other chemicals used in the treatment of water [8].

For [9], the generation of WWTP residues increased due to the use of higher concentrations of chemicals, since the water quality of the rivers is poor and the demand for drinking water is higher.

The sludge is considered the biggest environmental liability in the sector, since the concern with its correct disposal, without damaging the environment, has been gaining increasing attention, due to its composition, with the presence of metals [10].

Due to the high costs and environmental restrictions, many countries are looking for economically and ecologically viable alternatives for final disposal of waste generated at a WWTP. Although most developed countries have already adapted their systems to treat sludge, underdeveloped countries still release this material directly into the waterways and few stations have been concerned with waste disposal treatment [11].

One of the residues that present potential to be recycled in red ceramics are the sludge generated in the WWTP [12]. The physical and chemical characteristics of WWTP sludge are often similar to that of materials used in the manufacture of bricks: clay [11].

The raw material used in the production of ceramic bricks, ie the clay is usually composed of different mineralogical species that are mixed during the formation process. The characteristics and constitution of the ceramic products depend on these minerals or chemical compounds qualitatively and quantitatively and on other parameters of the raw material such as granulometry, thermal behavior and behavior in the presence of water.

The Polo Oleiro of Iranduba / Manacapuru, metropolitan region of Manaus in Brazil, presents 32 industries, whose production distribution varies in: Up to 100,000 bricks/month: 4 companies; from 100 to 400,000 bricks/month: 7 companies; more than 400,000 bricks/month: 9 companies [13].

The production of pottery depends directly on natural resources, especially clay and wood. Exploitation of the Iranduba polo clay deposit on the right bank of the Negro River is considered negative due to the environmental impacts [14]. The impacts promoted by the activity oleira stand out ditch opening for extraction of clay, deforestation for removal of wood, the production of

smoke.

Both the extraction of clay and the generation of WWTP sludge cause serious environmental problems in water, soil and air. The problem of the disposal of the sludge would be solved if it successfully incorporated the clay sludge. In this case, the incorporation of sludge in the ceramic material, contributes to the reduction of pollution, and at the same time makes possible an alternative for the production of brick in the potteries [15].

The need to reduce the environmental impacts generated by the solid waste produced by the water treatment plants in the City of Manaus shows that it is necessary to develop techniques for adequate final disposal and treatment of sludge. In order to do so, it is believed that the WWTP should be adapted to solve solid waste problems, since it is necessary to review the production and consumption models, adopting laws that aim to recover the waste at source, seeking reuse or recycling. Therefore, it will be necessary to seek partnerships, especially with companies of the nearby ceramic pole.

It is in the search of answer to the questions that define the objectives of this work, because it seeks to understand the environmental impacts generated by solid waste in the water treatment processes in the City of Manaus, since the incorrect disposal of these residues threatens streams, rivers and groundwater, and even the municipal landfill. The research proposes as an alternative for an adequate final destination of the waste generated in the decanting process in water treatment plants in the city of Manaus. The present research will be based on a series of standards and legislation, with Law No. 12.305/2010 being the main frame, as it deals with the National Policy on Solid Waste.

## II. DEVELOPMENT

### 2.1 The Water Treatment

The water consumed by man is a source of well-being and health, requiring treatment for the removal of impurities that are in the form of suspended particles and particles in a colloidal state. Colloidal state is understood to mean particles with a diameter of less than 1  $\mu\text{m}$ , and those with a diameter of more than 1  $\mu\text{m}$  are known as slime. The removal of these particles is performed through the coagulation/flocculation process [16].

#### 2.1.1 Chemical Coagulation

It is important to have clarity of the terms "coagulation" and "flocculation" and that there is a difference between them that cannot be confused.

The term coagulation comes from the Latin "coagulare" which means to join. This process describes the effect produced by the addition of a chemical to a colloidal dispersion which results in destabilization of the particles by reducing the forces that tend to keep them apart. In this



case the particles begin to agglomerate allowing contact between them, forming particles of submicroscopic size.

Flocculation is characterized by the formation of sedimentable particles from destabilized particles of colloidal size. The term flocculation is also derived from the Latin "floculare" which means to form a flake similar to a very fibrous porous structure. Unlike coagulation where the primary forces are electrostatic in nature, flocculation occurs through a mechanism of formation of chemical bridges (Van der Waals forces). Macroscopically flocculation transforms coagulated particles of submicroscopic size into more visible ones facilitating the sedimentation by gravity that occurs in the process of cleaning the water [17].

We have news of water treatment for human consumption, including the use of chemical substances (aluminum salts), since the year 70 BC. According to the historian of the time, named Pliny, aluminum salts were known as the clay of Italy, which was already an important commodity of world trade, since it had the capacity to transform "bitter waters into drinking water" [17].

In general, water presents impurities from soil decomposition, mineral dissolution and vegetation decomposition, all dissolved in water. Furthermore, the need for coagulation is increasing steadily as a result of increased water pollution and accelerated population growth in the world [18].

The impurities contained in the waters of natural origin or man-made origin, are of organic or inorganic origin. The inorganic ones are responsible for the variation of the turbidity being that the taste and odor are caused by the organic substances dissolved.

The particles that produce turbidity are classified according to their size, the molecules have an average size of 50µm. The fraction of molecules with a diameter greater than 1µm are known as slime and settle easily when the water is at rest. On the other hand particles with a diameter smaller than 1 µm known as colloidal remain in suspension for long periods of time and therefore coagulation is necessary for its elimination [19].

Therefore, the need for coagulation is for the colloidal particles to form larger aggregates and thus increase their sedimentation rate. The formation of larger particles from smaller ones is important for a phase of cleaning the water known by filtration [20].

#### 2.1.1.1 Factors that influence coagulation

To achieve a suitable water coagulation pattern, a complex network of variables such as pH, turbidity, water chemical composition, type of coagulant, and physical factors such as temperature and mixing conditions must be taken into account. These interactions are so complex that it is theoretically impossible to determine an appropriate coagulant pattern for a given water sample, so

the amount of coagulant is determined empirically for each type of water [21].

#### 2.1.1.2 The Effects of pH

There is a pH scale for a given sample of water within which good coagulation/flocculation occurs in the shortest possible time. The variation of this scale is influenced by the type of coagulant that can be used, by the chemical composition of the water and the concentration of the coagulant [20].

The most commonly used coagulants are aluminum salts (aluminum sulfate) or iron salts (iron chloride) called metal coagulants. Os coagulantes de metais precipitam e coagulam mais rapidamente, e o pH deve estar entre 5.8 e 7.8. Depending on the turbidity and the presence of ions in the water this variation rises to 6 to 7.8 [22].

#### 2.1.2 Sludge generation in WWTP

Water treatment plants collect water from rivers, carry out adequate treatment and distribute it as drinking water to the centers for human consumption. The processes used in these stations are, as a rule, the following [23]:

- Oxidation
- Coagulation
- Flocculation
- Decanting
- Filtration
- Disinfection
- pH stabilization
- Fluoridation

In the oxidation, chlorine is injected into the raw water collected to oxidize the dissolved metals, especially iron and manganese. Coagulation adds lime to maintain the pH at the appropriate level and then after aluminum salts or iron salts as the primary coagulant to form the impurities flakes. In contact with water this coagulant reacts almost instantly, promoting a hydrolysis reaction, resulting in the formation of certain compounds that will be, together with the impurities present, constitute the flakes, which will be separated later in the settling and filtration units [17].

In flocculation, the water is mixed in tanks, with flakes of larger impurities beginning the decantation phase. After decantation, the water passes through filters with anthracite, sand, and gravel retaining the impurities that were not sedimented in the previous steps [23]. These impurities withdrawn from the water, mainly from the decanters and from the washing waters of the filters are called sludge from the WWTP sludge water treatment plant. The characteristics of these impurities depend on the conditions of the raw water withdrawn from the source, the dosages and chemical products used and the way of cleaning the decanter filters.

The sludge lagoon is the place of disposal of the sludge after its removal from the decanters and then it is sent to the drying beds where the free water is drained and can be

returned to the treatment system, depending on the treatment plant.

A maioria das estações de tratamento de água realiza limpezas periódicas, em média uma vez por mês, manualmente, isto é, esvaziando o decantador e lavando o fundo. Em seguida, temos a seguinte sequência de tratamento de água em uma WWTP: coagulação, floculação, sedimentação, filtração, remoção do lodo - fluoretação [24].

#### 2.1.2.1 Characteristics of WWTP sludge

Due to the addition of aluminum salts or iron salts to cause the coagulation of the existing residues in the raw water, the hydroxides of these salts become the main chemical components of the sludge and, in addition, organic and inorganic particles. In the absence of algae and other organic materials in the fountain, the organic fraction of the sludge becomes negligible and the sludge has chemical stability characteristics, being composed only of inorganic matter, such as fine sands, limes and clays [25].

#### 2.1.2.2 Water removal

The hydroxides formed due to the salts added during the coagulation process hinder the dehydration of the sludge during the drying phase making it gelatinous and bulky and of thixotropic viscosity. A widely used parameter for assessing the difficulty of removing water is "specific filtration resistance". The higher the value of this parameter, the more difficult it is to remove the sludge water by filtration [20]. Sludge produced in WWTP using aluminum salts or iron salts as coagulants presents specific resistance ranging from  $5 \times 10^{12}$  a  $50 \times 10^{12} \text{mg/kg}$ . Sludge with specific resistance greater than  $5 \times 10^{12} \text{mg/kg}$  are difficult to dehydrate and those with values less than  $1 \times 10^{12} \text{m/kg}$  are easy to dehydrate, so the sludge generated in the WWTP is difficult to dehydrate [26].

All sludge consists of a combination of a solid phase with a liquid phase. The different physical forms of water in the sludge exert a marked influence on the greater or lesser difficulty of separating the liquid phase from the solid [26]. The physical states of the water are defined, in order of increasing difficulty of dehydration, that is, they present greater free water withdrawal facilities followed by interstitial water, vicinal water and finally water of hydration because they have chemical bonds with the surface of the solid particles [26].

A better efficiency in the operations of reducing the amount of water in the sludge is through the addition of lime or solutions of synthetic polymers known as polyelectrolytes [26]. Synthetic polymers are classified into anionic polymers, cationic polymers, nonionic polymers, being related to the charges presented by their molecules in aqueous solution [20].

#### 2.1.3 Final disposition of WWTP sludge

The sludge treatment system involves techniques whose pertinence are influenced among other factors by the characteristics of the sludge, available area, local climate and environmental conditions of the region. Most treatment plants discharge it directly into the sewage system, without any kind of treatment, other than the presence of a tank for control and regularization of the discharge flow [26]. An alternative usually adopted is the use of ponds or drying beds, and after drying the sludge is sent to landfills in the treatment plant [20].

In temperate regions where sludge is difficult to dehydrate, sludge ponds are transformed into a drying bed, placing drains at the bottom of the ponds. After the drying period, both the ponds and the beds should be removed by dredging of the concentrated sludge at the bottom of the units for subsequent final disposal, which depending on a technical and environmental analysis may occur in several ways [26].

### 2.2 Solid wastes

The Brazilian standard NBR 10.004 (ABNT, 1987) defines solid waste as solid and semi-solid waste that results from community activities of industrial, domestic, hospital, commercial, agricultural, service and sweeping origin.

Included in this definition are sludges from water treatment systems, those generated in pollution control equipment and facilities, as well as certain liquids whose peculiarities make it unfeasible to be released into the public sewer or water bodies, or require for this technical and economically unviable solutions in the face of the best available technology. It is also verified that the commercial residues have composition according to the type of generating trade.

#### 2.2.1 Classification of Solid Residues

The Brazilian Association of Technical Standards - ABNT, through NBR 10004/04 [6], defines solid waste as follows: Solid and semi-solid waste, which results from activities of industrial, domestic, hospital, commercial, agricultural, public service, such as sweeping, pruning of trees, among others. Solid waste is also considered to be the sludge from water treatment systems, those generated in pollution control equipment and facilities, as well as certain liquids, whose particularities make it unfeasible to be introduced into the public sewage system or water body, or require technical and economically unviable solutions in the face of the best available technology Brazilian Technical Standards Agency (ABNT, 1987)[6]. For all these wastes there are several classifications, as waste class: I - Hazardous; Class II waste - Non-hazardous; Class II A waste - Not inert; Class II waste B - Inert, hazardous and non-hazardous, inert and non-inert (Fig. 1).

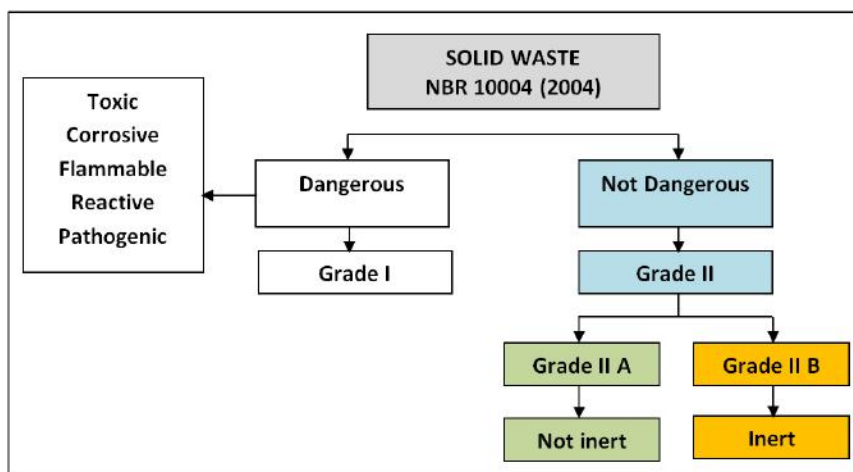


Fig. 1: Classification of solid waste.

Source: NBR, 10.004/2004(adapted from)[6].

Entre os resíduos de alto impacto ao meio ambiente, destacam-se os resíduos da estação de tratamento de água, o lodo WWTP. This waste is classified as Class I Hazardous Waste: where these can, in view of their flammability, corrosivity, reactivity, toxicity and pathogenicity characteristics, present risks to public health, causing or contributing to the increase in mortality or incidence of diseases or to present effects high impact on the environment when handled or disposed of improperly.

### III. MATERIAL AND METHODS

For the present study, two raw materials were used: waste from the water treatment plant for Manaus and clay pottery Cerâmica Montemar, from the municipality of Iranduba, State of Amazonas in Brazil.

#### 3.1 Preparation of samples

The clay was subjected to the drying process in an oven at 110°C for 24 hours and then milled in a ball mill for 30 minutes in order to reduce the clods of clay.

The solid residue was dried at 50 ° C for 48 hours. Then, ball milling was performed for 30 minutes. 15 grams of the residue was calcined at 900 ° C for 3 hours in an electric furnace Linn Elektro Therm LM 312.06, for further analysis.

The grinding of both the clay and the residue was carried out in a ball mill for the WORK INDEX test of the brand QUIMIS, series 005 and model MA 08/20. After grinding the raw materials were characterized.

#### 3.2 Characterization of raw materials

For the characterization of the raw materials (clay and residue), the chemical analyzes of the clay, the ground residue and the calcined residue were carried out by X-ray fluorescence, and for the analysis of the structure and identification of the mineralogical composition of the clay was used an X-ray diffraction apparatus.

The granulometric analyzes of the clay and the residue were done by wet sieving, using the opening sieves, according to ABNT: # 16, #30, #40, #50, #100, #200.

#### 3.3 Preparation of test specimens

For the preparation of the ceramic masses, were first measured the humidity of the clay and the residue, which were 4% and 7%, respectively, to make the correct corrections in the mixtures. Using an Adventurer OHUS brand analytical balance, model AR 3130 Class II, the raw materials were weighed by varying the residue concentrations by 0%, 12%, 16% and 18%. Then, water was added to the formulations in 10% of the mass, to facilitate the conformation of the proof bodies. Each mixture was subjected to a homogenization process for 1 hour in a ball mill.

Afterwards, the masses were subjected to the pressing process using a steel mold in the form of prismatic blades with dimensions of 100x50mm and taken to a hydraulic press, brand MARCONI, series 011639, with a maximum capacity up to 20 tons, using pressure of 2 (two) tons. 48 (forty-eight) test specimens were made, of which 12 (twelve) for each formulation, with dimensions on the order of 72,03 x 31, 67 x 7,77 mm.

After pressing, we measured the masses of the prepared test specimens, with analytical balance Adventurer OHUS, model AR 3130 Class II, being denominated wet mass ( $W_m$ ) and length value ( $L_0$ ), with a digital analog caliper 200mm / 8 precision, ZAAS Precision brand, Stainless Hanoi model, 1/129 "0.05" mm graduation, accuracy of  $\pm 0,05$ , before going through the drying process.

The molded samples were placed in a model MA033 oven of MARCONI brand, with temperature around 110°C, for 24h. After drying, the masses of the test specimens, with analytical balance Adventurer OHUS,

model AR 3130 Class II, denominated dry mass (Dm), were measured.

The process of burning of the test specimens was carried out in an oven micro processed muffle furnace, QUIMIS brand, at a temperature of 900°C, with a temperature range of 3 (three) hours and a heating ramp of 10°C/min. The mass of the test specimens after burning (Mb), with analytical balance Adventurer OHUS, model AR 3130 Class II, besides the value of the length (L1), the thickness (h) and the width (b) of these bodies were measured, with ZAAS Precision caliper, Stainless Hafoi model, graduation of 1/129 "0,05" mm, accuracy of  $\pm 0,05$ .

### 3.4 Evaluation of the ceramic properties of test specimens

The following tests were performed on the test specimens: flexural rupture stress (FRS), Linear retraction after burning (LR), water absorption (WA), Apparent porosity (AP), apparent specific mass (ASM).

These physical and mechanical tests are of extreme importance, and through these tests the quality of the material is determined. The formulas used for the determination of these properties are presented by [27]:

Flexural Rupture Stress (FRS)

$$FRS (Kgf/cm^2) = \frac{3}{2} \times \frac{P \cdot L}{b \cdot h^2} \quad (1)$$

Linear Retraction após a queima (LR)

$$LR(\%) = \frac{L_0 - L_1}{L_0} \times 100 \quad (2)$$

Water Absorption (WA)

$$WA(\%) = \frac{P_u - P_s}{P_s} \times 100 \quad (3)$$

Apparent Porosity (AP)

$$AP(\%) = \frac{P_u - P_s}{P_u - P_i} \times 100 \quad (4)$$

Apparent Specific Mass (ASM)

$$ASM(\%) = \frac{P_s}{P_u - P_i} \times 100 \quad (5)$$

Where,

P = water mass + container mass (Kgf)

L = distance between the device support points (cm)

b = width of the test piece (cm)

h = thickness of the test piece (cm)

L<sub>0</sub> = Length before drying (cm)

L<sub>1</sub> = Length after burning (cm)

P<sub>u</sub> = mass of the moist body (g)

P<sub>s</sub> = dry body mass (g)

P<sub>i</sub> = body mass immersed in water (g)

### 3.5 X-ray diffraction analysis in ceramic products

Para identificação da composição mineralógica dos produtos cerâmicos, as análises de difração de Raios-X foram realizadas nos corpos de prova com formulações de massa cerâmica de 0%, 12%, 16%, e 18% de resíduo

incorporado, sinterizados a temperatura de 900°C. Estes corpos de prova foram pulverizados em moinho de bolas WORK INDEX, da marca CIMAQ, série 005 e modelo MA 08/20, até textura de pó.

## IV. RESULTS

### 4.1 Characterization of samples

#### 4.1.1 Análise Granulométrica da Argila

According to the results of the granulometric analysis (Fig. 2), it is observed that more than 80% of the clay has a particle size less than 0.075mm (# 200 ABNT).

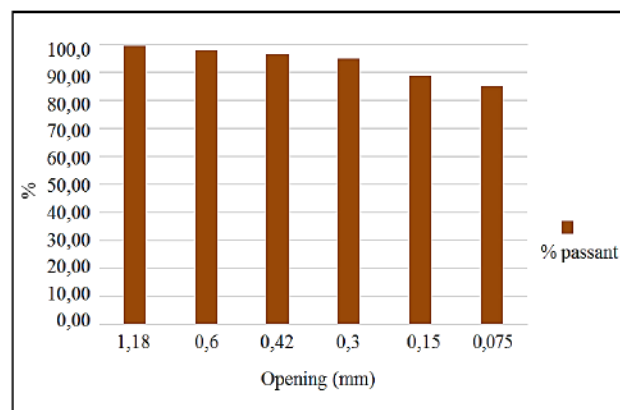


Fig. 2: Granulometric distribution of clay.

Source: Authors, 2018.

The ABNT NBR 6502/ 95 [28], classifies the soil particles according to the grain diameter, being that the clay soil has a granulometry of less than 0.002 mm, this type of fine granulation soil, well grouped, has characteristics of high plasticity, that after wet, facilitates the molding of the bricks. In a study carried out with the soil, from the same region of Iranduba / Am, analyzed in this work, that clay, which in turn is a chemical compound that has a very fine granulometry and, when moistened with water, form a mixture with a certain plasticity [29].

Particle size analysis of the Pará region, performed by [30] observed that more than 70% of the clay had grain less than 0.038mm (# 400 ABNT) and these characteristics were important for the incorporation of the sludge into a ceramic mixture.

#### 4.1.2. Granulometric analysis of the residue

In order to conduct the granulometric characterization of the sludge, the standard ABNT NBR 7181/ 84 were used [31].

It is possible to observe in the results of the granulometric analysis of the WWTP sludge in (Fig. 3), where it presents the percentage of the passing material according to the openings of the sieve, that the residue has continuous graduation in the sieves of 0.3 to 0.075, that is the material analyzed is well graded.

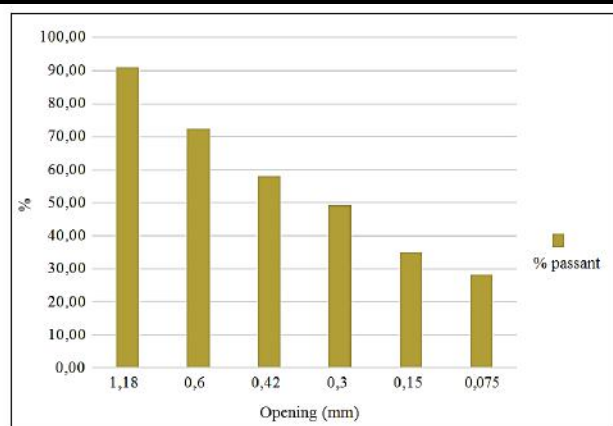


Fig. 33: Granulometric distribution of the residue.

Source: Authors, 2018.

Possibly without void spaces which avoids the porosity of the material and increases its mechanical strength. It is also observed that more than 50% of the material have dimensions lower than 0.42mm, which facilitates the homogenization between the grains of clay and residues. In the particle size analysis of WWTP residue, performed by [32], He verified that the particle size distribution was in the range of 0.001 to 1.2mm, these results showed a wide range of particle size distribution, as it chose to use the residues that left the crusher without prior classification of the granulometry. The author [32], still checked that the sludge particles had an irregular profile due to not having obtained a standard granulometry in the process of preparation of the sludge particles. In this study, the well-graded and continuous WWTP sludge residue is considered a positive result, because, with regular decreasing of grain sizes, it facilitates the homogenization and aggregation of soil particles during cooking.

#### 4.1.3 Real grain density (GD)

The results of the real density of clay and sludge grains (Table 1) reflect the presence of minerals and organic matter present in the soil.

Table 1: Real grain density of clay and sludge samples.

Standard: DNER-ME 093/94	Clay	Sludge
Pycnometer	1	2
Temperature °C	25	26
Weight pycnometer (g)	47,46	47,46
Weight of the pycnometer + dry sample (g)	67, 47	66,15
Weight of the pycnometer + sample + water (g)	159,55	160,01
Weight of the pycnometer + water (g)	151,19	152,20
Weight of dry material (g)	20,0	20,0
Real grain density (g/cm <sup>3</sup> )	1,717	1,718

Source: Authors, 2018.

The limits of actual density vary between 2.3 and 2.9 g / cm<sup>3</sup>, it can be observed in Table 4 that both clay and residue have low real grain density, between 1,717 and 1,718, respectively, which characterizes a soil with high organic matter, positively influencing the porosity, because few porous cavities do not weaken the ceramic material.

#### 4.1.4 Fluorescence of X - rays

It is observed that X-ray fluorescence results in both clay and residue (sludge) presented a higher concentration of aluminum oxide (Al<sub>2</sub>O<sub>3</sub>) compounds at 51.33% and Silicon Oxide (SiO<sub>2</sub>) at 55 , 41 (Table 2). therefore the presence of this compound in the analyzed materials was expected, as for Al<sub>2</sub>O<sub>3</sub>, is mainly due to the type of coagulant (aluminum sulphate) used during the purification of water in the Treatment Station of PROAMA. This fact was verified by [33], in analyzes of the clay and sludge elements, where it found higher concentration of Aluminum Oxide (Al<sub>2</sub>O<sub>3</sub>) and Silicon Oxide (SiO<sub>2</sub>), due to the type of coagulant used to decantation and mineralogical sedimentation characteristics of the Amazon region. The greatest predominance of elements in the sludge was aluminum, iron and silica; being that the highest content was aluminum, due to the use of aluminum sulphate as a coagulant [34]. This chemical similarity between the materials corroborates the addition of the clay sludge to the ceramic brick making, because they prevent undesired reactions during the burning process of the test specimens.

Table.2: Chemical composition in percentage of clay, residue and ceramic mass with 18% of residue.

X-Ray Fluorescence			
Compost	Concentration (%)		
	Clay	Residue	Ceramic mass with 18% of waste incorporated
Al <sub>2</sub> O <sub>3</sub>	51, 33	55,41	51,40
CaO	0,01	3,95	0,15
Cl	0,006	0,04	0,005
Cr <sub>2</sub> O <sub>3</sub>	0,008	-	-
Fe <sub>2</sub> O <sub>3</sub>	2,71	6,61	3,30
K <sub>2</sub> O	0,37	1,25	0,41
MgO	0,18	0,48	0,21
MnO	0,005	0,03	-
Na <sub>2</sub> O	0,14	0,31	0,22
Nb <sub>2</sub> O <sub>5</sub>	0,003	0,02	0,003
P <sub>2</sub> O <sub>5</sub>	0,06	0,31	0,04
Rb <sub>2</sub> O	0,002	-	-
SiO <sub>2</sub>	45, 74	36,38	42,16
SO <sub>3</sub>	0,05	1,44	0,08

Source: Authors, 2018.



#### 4.1.5 Diffraction of X-rays

The results of the microstructural characterization of crystalline materials, performed by means of X-ray diffraction, in the clay are shown in Fig. 4.

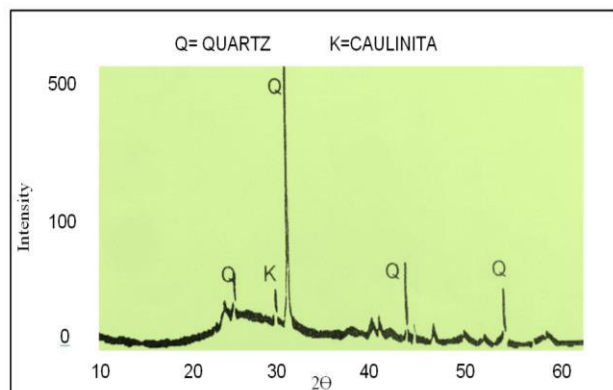


Fig. 44: X-ray Diffractogram of clay.

Source: Authors, 2018.

It is possible to observe that the most pronounced phases are: quartz ( $\text{SiO}_2$ ) with a major peak, followed by kaolinite ( $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ ), this is due to the fact that most of the clay minerals in the state of Amazonas originate from residual deposits formed from alterations of rocks of the Alter do Chão Formation composed, among others, by quartz and kaolinite.

Most of the region of the Manacapuru-Iranduba ceramic pole is constituted of those of the residual deposits. Some studies of the clay extracted from the banks of the Guamá River, in Pará [30] indicate that the mineral quartz is the majority, followed by kaolinite that was also found in that region.

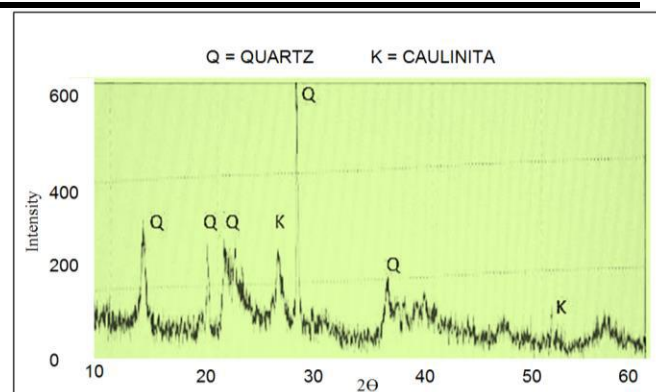


Fig. 55: X-ray diffraction of the sludge.

Source: Authors, 2018.

It is possible to notice that the main mineral found in the residue, as well as in the clay analysis, is quartz, followed by kaolinite (Fig. 5).

This mineral similarity between clay and sludge is of extreme importance due to the physical and mechanical benefits of incorporating the residue into the clay mass [35].

The quartz mineral, found in this study, confirms the chemical composition found in X-ray fluorescence analysis, since the chemical composition of quartz is silica dioxide, which in turn influences thermal expansion during cooking. In Fig. 6 shows the results of the X-ray diffraction in the test specimens with a proportion of 18% of the residue after burning at  $900^\circ\text{C}$ . It is possible to notice that, there was a favorable increase of the quartz peaks and reduction of the intensity of kaolinite. The reduction of kaolinite occurred due to the sintering of the test specimens, with the linear organization of the minerals present, improving the quality of the final product [33].

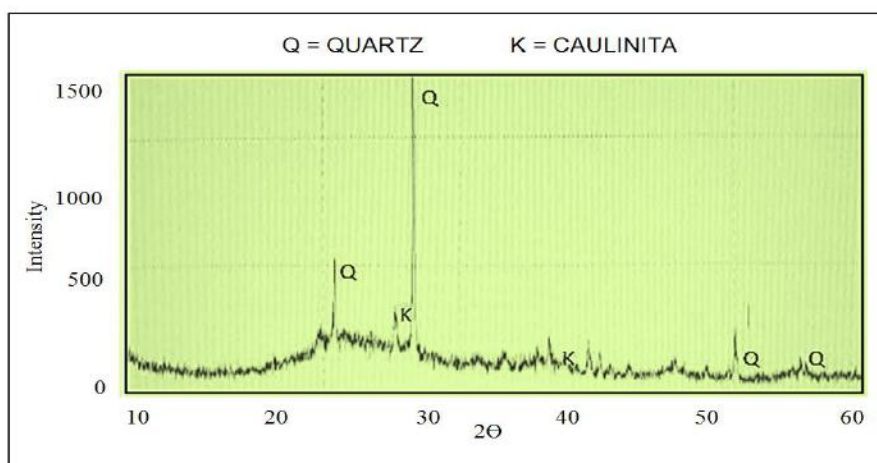


Fig. 6: X-ray diffraction of test specimens after burning, with 18% of residue.

Source: Authors, 2018.

This behavior occurs due to the addition of residue that favors the appearance of hematite and the more residue

added, the iron present in the sludge tends to accelerate the solid state reactions, giving rise to a new crystalline

phase, cristobolite [20].

## 4.2 Physical and mechanical analysis after burning

### 4.2.1 Linear Retraction (LR)

It is possible to observe in the results of the linear retraction, after the burning in temperature around 900 ° C, as a function of the percentages of 0%, 12%, 14% and 18%, of residue added in the formulation of the clay mass (Fig. 7), that the linear retraction increased with the increase of the clay content to the clay mass in all the percentages, this fact is due to the sintering process of the heated test specimens at high temperatures.

The grouping of the molecules is an important and necessary factor in the cooking of the ceramic materials, as it causes hardening to take place and, consequently, to give resistance of the final product.

During the cooking the pieces contract due to the occurrence of coalescence of the powder particles by the sintering process [36].

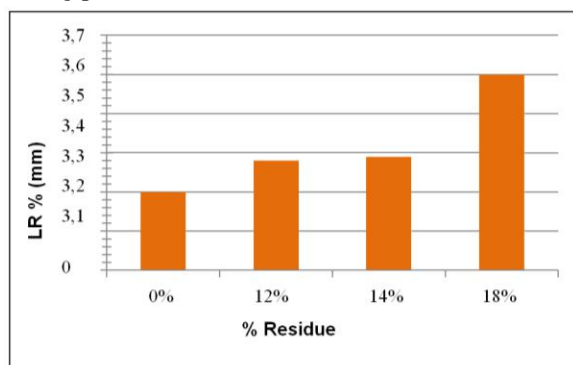


Fig. 7: Linear retraction in test specimens.

Source: Authors, 2018.

The driving force of sintering is the reduction of the surface of the powder [37]. This behavior indicates a favoring in the process of sintering of the test specimens [30]. This sintering process, which occurs during firing, creates a change in the microscopic structure due to the minerals, such as quartz, causing the part to become solid, which results in good resistance of the ceramic product.

All retraction values are in accordance with the limits established by the Brazilian standard [38] which is below 8%. The incorporation of WWTP sludge in the ceramic brick manufacturing process, in the proportions of 0%, 12%, 16% and 18% of residue, showed an increase in the linear retraction, at sintering temperature at 900°C, possibly due to the presence of organic matter that volatilizes in the burning. This behavior indicated that the organic matter volatilized in the burning of the ceramic material at high temperatures [39].

### 4.2.2 Water Absorption (WA)

The results of the water absorption test of the test specimens as a function of the percentage of residuals added in the clay of 0%, 12%, 14% and 18%, can be observed in Fig. 8.

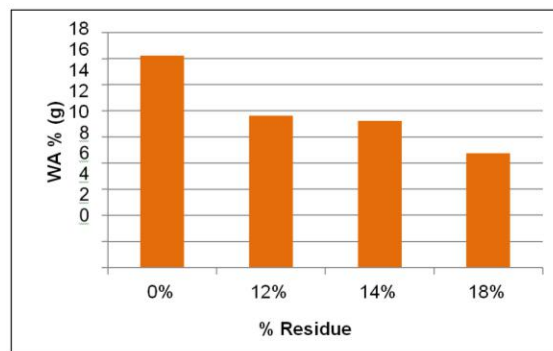


Fig.8: Water absorption of test specimens.

Source: Authors, 2018.

It is possible to note that the larger the amount of residue incorporated into the clay, the lower the occurrence of water absorption. Each of the raw materials influences the changes that occur during the cooking process and the characteristics of the finished piece [36]. In this case, the water absorption decreases with the increase of the sludge content to the clay mass in all proportions, confirming that the more sintered the material is in function of the firing temperature, the greater the linear retraction, and the lower the water absorption, due to the grouping of the molecules. The decrease in WA is expected due to the large presence of clayey property and low presence of sand. Organic matter, as well as moisture, are important parameters that can influence the final quality of the ceramic blocks [39].

The humidity is important to determine the handling of the sludge, since a high moisture content can hinder the routing of the manufacturing components, obstructing passages or adhering to parts of the system [1].

The maximum and minimum water limit is 8% to 22%, respectively [13]. It is noted that the results of moisture content are within the limits allowed by the standard, implying a good result of the material studied.

### 4.2.3 Apparent Porosity (AP)

After compacting the powder particles into the desired shape, there will be pores or empty spaces between the particles and that, after heat treatment, most of this porosity will be eliminated, however some residual porosity remains [36]. The results of the averages of the apparent porosity, after burning at 900 ° C, as a function of the formulations with residue percentage at 0%, 12%, 14% and 18%, added to the ceramic mass, is presented in Fig. 9.

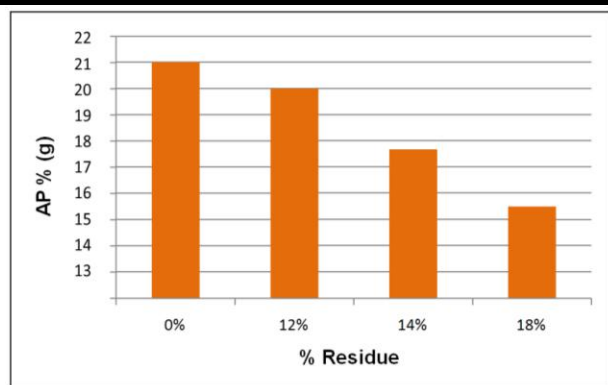


Fig. 96: Apparent porosity of test specimens.

Source: Authors, 2018.

It is noticed that at a temperature of 900°C, there is a contraction in the tests specimens provoking the reduction of the porosity. These microstructural shrinkage and pore reduction changes occur during cooking. During the cooking, the shaped piece shrinks and exhibits a reduction in its porosity, together with an improvement in its mechanical integrity [36]. The apparent porosity decreases with increasing temperature and the decrease in water absorption is similar to that of porosity reduction.

For the present study, the percentage of porosity in the pieces is very important, because the higher the porosity and the water absorption, the lower the resistance and the quality of the ceramic brick, besides other advantages. Because the low porosity has as positivity, greater thermal comfort and less possibility of infiltration for the proper purposes of use in the constructive process and structuring.

However, the total porosity changes negatively, the mechanical properties of the ceramics; however, on the other hand, points out that porosity may be useful to increase resistance to thermal shock [37].

It is possible to admit that, due to these low porosity characteristics, the proportion of 0%, 12%, 14% and 18% of residue incorporated in the ceramic mass will not compromise the flexural strength, so what is intended in this study is the successful incorporation of sludge in the clay for brick making, since what is expected is a non-shock resistant material shock resistant, but a product that supports and resist the stress applied to it in accordance with the standard [38].

#### 4.2.4 Apparent Specific Mass (ASM)

The results of the apparent specific mass of the ceramic products were analyzed as a function of the firing temperature for the formulations of 0%, 12%, 14% and 18% of residue incorporated into the clay (Fig. 10).

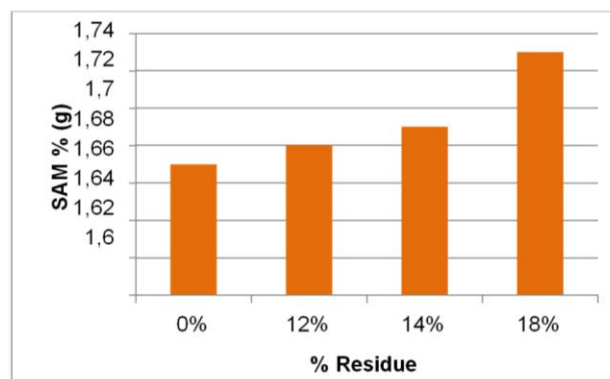


Fig. 107: Apparent specific mass of test specimens.

Source: Authors, 2018.

It is possible to note that in temperature at 900 ° C there was an increase of ASM in all formulations. This fact, too, was evidenced in other similar studies [1, 26, 30, 39], which had the ASM increased under the influence of elevated temperatures. It is possible to notice that the MEA of the proportions was between 1.85% and 2%. This small difference between the values demonstrates a good performance of the residue added to the clay mass. For, the increase of the mass would occur due to the function of the density of the incorporated sludge, as well as the organic matter that dissipates in the process of burning of the test specimens.

The apparent porosity and apparent specific mass are associated with the absorption of water [3]. There was an increase in the mass and decrease of the water absorption, as well as the apparent porosity, these characteristics are expected, as they positively favor the resistance of the final product.

#### 4.2.5 Bending rupture stress (BRS)

It can be noted that the results of the flexural strength tensions (BRS) as a function of the test specimens burning temperatures of 900°C in the 0%, 12%, 14% and 18% formulations (Fig. 11) there was a decrease in BRS with the incorporation of the residue.

This fact was expected, since a good sintering was observed, that is, good union of the existing particles in the test specimens, which were repeated in the linear retraction, water absorption, apparent specific mass and confirmed with the test rupture, since the values found are within what is defined by the standard [38].

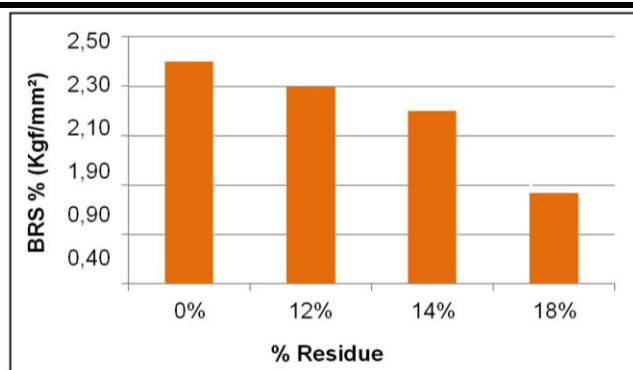


Fig. 118: rupture stress of test specimens.

Source: Authors, 2018.

The decrease of the BRS due to the increase of residue to the ceramic mass was expected, however, does not negatively influence the test specimens. To [39] in tests, showed that the BRS decreased with the concentration of sludge added to the ceramic mass, confirming a good final result of the material.

## V. CONCLUSION

By means of the granulometric characterization of soil samples, it can be concluded that clay has more than 80% of particle size less than 0.075mm (#200 ABNT), being classified as clay soil.

In relation to the sludge residue, more than 50% of the material has dimensions lower than 0.42% of continuous grade, that according to ABNT NBR 7181/82, which facilitates the homogenization between the clay and residue grains.

Due to the type of coagulant used in the decantation and mineralogical sedimentation characteristics of the Amazon region, the chemical analysis by X-ray fluorescence, both in the clay and in the WWTP sludge residue, the elements found in the highest concentration were Aluminum Oxide ( $Al_2O_3$ ) and Silicon Oxide ( $SiO_2$ ). The presence of quartz ( $SiO_2$ ), Caulinite ( $Al_2Si_2O_5(OH)_4$ ) in the clay and in the residue was identified in the X-ray test. This is due to the fact that most of the clay minerals of the state of Amazonas comes from residual deposits formed by alterations of rocks of the Alter do Chão Formation composed, among others, by quartz and kaolinite. This facilitates, due to the similar characteristics of the two raw materials, the mixture for the manufacture of brick.

Physical and mechanical analyzes such as water absorption, apparent porosity, apparent specific mass and bending rupture stress, show that WWTP sludge in the proportions of at most 18% can be incorporated in clay mass for the manufacture of brick with satisfactory results, since they are in conformity with the parameters established by ABNT (NBR 15270-1,2 e 3 de 2005).

To contribute to the reduction of the mineral extraction of the clay, as well as the reduction of the discharge of the

sludge in dumps or bodies of water, will bring benefits to the environment with the reduction of the impacts generated by the potteries and water treatment plants for public supply in the capital of the state and municipality of Iranduba.

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# Weightless Neural Network with Transfer Learning to Detect Distress in Asphalt

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**Abstract**— The present paper shows a solution to the problem of automatic distress detection, more precisely the detection of holes in paved roads. To do so, the proposed solution uses a weightless neural network known as Wisard to decide whether an image of a road has any kind of cracks. In addition, the proposed architecture also shows how the use of transfer learning was able to improve the overall accuracy of the decision system. As a verification step of the research, an experiment was carried out using images from the streets at the Federal University of Tocantins, Brazil. The architecture of the developed solution presents a result of 85.71% accuracy in the dataset, proving to be superior to approaches of the state-of-the-art.

**Keywords**— Distress detection, Transfer Learning, Wisard.

## I. INTRODUCTION

In Brazil, most of the traffic is driven on asphalt roads. According to the August 2018 statical bulletin of the CNT (National Confederation of Transport), the freight transport matrix is 61% done by road traffic<sup>1</sup>. Due to such high traffic demand, the need for more asphalt roads is a reality in Brazil.

Despite the importance of road transport in Brazil, there is a serious problem due to the roads and highways condition. The detection of problems, such as cracks and other distress, is costly and usually is made manually by the transportation agencies. Unfortunately, the appearance of potholes in highways is faster than its detection. Consequently, the lack of better quality roads has led to consequences that outreach economic monetary values, such as fatal accidents which have claimed many lives that are irreplaceable.

The advances in the artificial intelligence techniques merged with image processing studies offers background for a new field, called computer vision. This area applies techniques capable of simulating the human brain's

behavior through algorithms that try to emulate the visual perception of human beings. In this way, this paper shows the results of a system based on computer vision techniques to detect the existence of distress in images of a paved road. Therefore, the architecture of the presented solution uses a weightless neural network model called Wisard [1], along with transfer learning that is able to select features of input images.

The problem of distress detection has been investigated by many another researches. Ouma and Hahn [2] proposed the extraction and identification of incipient or micro-linear distresses in asphalt. To do so, their system is composed of three main approaches: Discrete Wavelet Transform to isolate and classify failures; Successive morphological Transformation Filtering to detect shapes in failures; Circular Radon Transform for angular-geometric orientation analysis for the identification and classification of distress types. As a result, their system achieved 83.2% of accuracy.

Rodopoulou [3] showed a method to detect patch in asphalt pavement through videos. The patches were detected through its visual features, which include closed contour and texture around them. The algorithm had 84% of precision in detection.

Gopalakrishnan et al. [4] use of Transfer Learning (TL) to classify whether there are or aren't damages on asphalt. For this task, the model used a VGG16 [5] that is a pre-trained neural network which is used to transfer learning task. For the classification task, it has been used a single layer perceptron. As result Gopalakrishnan obtained an precision of 0.9 on his dataset.

For automatic crack detection, Hoang, et al. [6] Applied two approaches, edge detection and a machine learning algorithm. For the edge detection, it has been used the Sobel and Canny algorithms, both using the Flower Pollination metaheuristics which is responsible for determining the threshold of the edges. The second algorithm uses a Convolutional Neural Network for detection and classification. The first approach, using the filters, both accuracies were 76.69% and 79.99% for the

<sup>1</sup>Source: [http://www.transportes.gov.br/images/PAC\\_SITE\\_Fechado.pdf](http://www.transportes.gov.br/images/PAC_SITE_Fechado.pdf). Accessed on: December, 2018.

Canny and Sobel, respectively. The second approach resulted in an accuracy of 92.88%, when using the CNN. Moreover, Zhang [7] investigated a dataset composed of 800 low similarity images. Its classification system also used the transfer learning paradigm in order to extract generic knowledge from the first layer of a deep convolutional neural network. Such ANN was pre-trained using the ImageNet [8] database. After that, a fine-tuning strategy was used over the next ANN layers. Zhang's method reached values of recall as 0.951, precision as 0.847 and a F1-measure as 0.895.

The rest of this paper is structured as follows: The Section 2 presents the fundamentals of neural network and transfer learning. The proposed methodology is shown in Section 3. In addition, Section 4 summarizes the experiments and results of this proposed work. Lastly, in Section 5 there are some final remarks and future appointments of this research.

## II. ARTIFICIAL NEURAL NETWORKS AND TRANSFER LEARNING

Usually, regression and classification models are comprised as linear combinations of fixed basis functions. These models have analytical and computational properties that, in practical scenarios, are limited by dimensionality. This way, before the application of these models in large-scale problems, it is necessary to make the basis function adaptable to the data.

According to Bishop [9], for pattern recognition tasks, the most successful model to fit the data properly is the Artificial Neural Networks (ANN). This term began to be used in attempt of [10] to represent the perceptron mathematically which have encouraged the creation of a range of models of perceptrons and ANNs.

### 2.1 Deep Convolutional Neural Networks And Transfer Learning

A Convolutional Neural Network (CNN) is a type of ANN which is able to create models that are invariant to certain input transformations [11]. This ANN is probably the most well known Deep Learning (DL) model and the most used in computer vision tasks, particularly for image classification. The CNN combines three architectural mechanisms to guarantee the invariance of distortions. Specifically, these mechanisms are: local receptive fields, weight sharing and sub-sampling [12]. The basic building blocks of its architecture are convolutions, the pooling layers (sub-sampling) and the fully-connected layers (like *Multilayer Perceptron*). The basic structure of a CNN is shown in Fig 1.

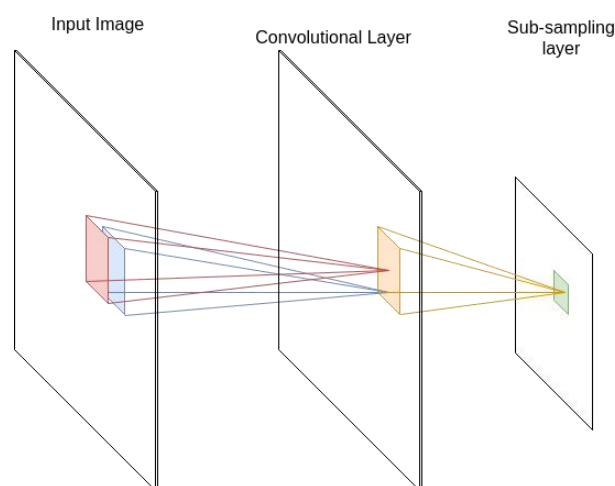


Fig. 1: The general architecture of a CNN to classify images. Three different layers are normally used, being such: input layer to receive the image, convolutional layer and sub-sample layer.

The convolutional layer is composed of units, which are organized into planes. Each such unit is called *feature map*. Each feature map is derived from small subregions of the input matrix. It is important to mention that the convolution operator in the image may have many parameters such as: stride, border mode and kernel size. The sub-sampling layer is responsible for making the network more invariant. In cases like that, the max-pooling operator is the most frequently used. Thus, the fully connected layers are at the end of the convolution layers and work in a similar way as the *Multilayer perceptron*, in order to learn weights to classify the data.

Deep Convolutional Neural Network (DCNN) usually requires large image dataset to achieve high values of accuracy. Unfortunately, in certain problems, there is no such amount of data. In such cases, the Transfer Learning (TL) methodology is an interesting alternative. Sinno [13] defines TL as: given a source domain  $D_s$  and a learning task  $T_s$ , a target domain  $D_t$  and a learning task  $T_t$ , transfer learning aims to help improve the learning of the target predictive function  $f_T(\cdot)$  in  $D_t$  using the knowledge in  $D_s$  and  $T_s$ , where  $D_s \neq D_t$ , or  $T_s \neq T_t$ .

Thus, in practice when one wants to work with transfer learning, there are many off-the-shelf models. For example, the well-established neural networks which are pre-trained in large image datasets (such as *ImageNet*<sup>2</sup>). These models allow transfer their learning ability to a new classification scenario, instead of the need of training a DCNN from scratch. Some of these pre-trained models are found in frameworks like Tensorflow<sup>3</sup>. Only to illustrate, some examples include: VGG-16 [5], AlexNet

<sup>2</sup> <http://www.image-net.org/>

<sup>3</sup> <https://www.tensorflow.org>

[14], Inception V3 [15] and Xception [16]. This last one has been chosen in this research study.

The architecture of the Xception model [16] is composed of 36 convolutional layers forming its feature extraction basis. These layers are structured into 14 modules which are all interconnected, except for the first and last ones. In short, its architecture is a linear stack of depthwise separable convolution layers with residual connections.

## 2.2 The Wisard weightless neural network model

According to [17], Wisard is a pattern recognition machine based on neural principles (projected to be implemented in a hardware device). Wisard is composed of class units called discriminators. Each discriminator accommodates a set of RAM-based neurons. These neurons have a memory behaviour such as the Random Access Memory. The address is the binary pattern, and if there is information in such address, then the neuron fires. In summary, the main components of a Wisard device are: an address decoder, a group of memory registers, a register with the input data and a register for the output data.

The RAM-based neuron described earlier can be seen as a neuron in the sense that given an input pattern, it stores the desired output. In the training and possible re-training steps, the pattern of a given address can be overwritten by other values in subsequent training steps. Therefore, Wisard is different from an ordinary ANN because it does not need a sophisticated training algorithm.

Inside the Wisard, the simplest RAM-based network with generalization properties is called Discriminator. A Discriminator consists of a layer with  $K$  RAMs, which deals with  $N$  inputs. Each RAM stores  $2^N$  words of one bit, and the single layer receives a binary pattern of  $K \times N$  bits. The training consists in presenting the input patterns (binary) and storing the desired value (either 1 or 0) in memory locations addressed by the displayed pattern. Each RAM then stores part of the input pattern. When a test pattern is presented, the discriminator outputs the number of fired RAMs. Fig. 2 illustrates the architecture of a Wisard's discriminator.

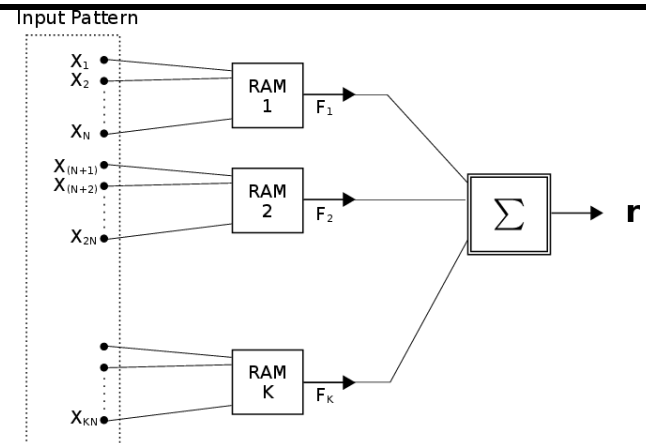


Fig. 2: Discriminator Structure of Weightless Neural Network. The  $X_{KN}$  means the input pattern for  $K$  RAMs, generating  $F_K$  output function of each RAM [1].

The Wisard consists of a multi-discriminator system where each of its discriminators are trained to recognize a different class.

## III. THE PROPOSED SOLUTION: WISARD WITH TRANSFER LEARNING

The proposed solution uses a pre-trained Xception deep convolutional neural network to pre-process the input image. When the input image is plugged in the Xception model, it produces an output vector with 2048 features. These features are then used as input to the weightless neural network Wisard, which calculates the sum of fired RAMs. In this case, if the sum of fired neurons is greater than a given threshold, the input image is classified as positive, i.e. it has any kind of distress.

In the proposed solution, the Xception has been pre-trained using general images from the *ImageNet* database. Furthermore, in order to apply the transfer learning, the last layer of the pre-trained Xception has been replaced by the Wisard model. The choice for the Wisard model as the final classifier is given by its high performance in both utilization as well as in learning [18]. Therefore, the overall system is illustrated in Fig. 3.

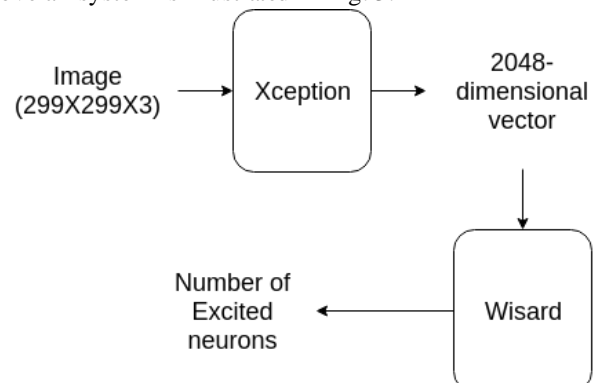


Fig. 3: The architecture of the Wisard with Transfer Learning to the proposed solution. After the Xception, the images are dimensioned to be able to apply in the Wisard.

One of the configuration parameters of the Wisard model is the amount of RAMs composing the network layer. As the last layer of the Xception network generates an output of 2048 features, the amount of RAMs in weightless networks depends only on the number of inputs defined for each RAM. In this case, the influence of this parameter was also investigated by this work. The evaluated values of the input size for each RAM is better addressed in Section 4.

Finally, it is also necessary to pre-process the input data used by the Wisard model. The standard input retina used by the Wisard is a binary data stream. In this way, the output of Xception has been binarized using the array average as threshold. The whole model was implemented using the Python programming language version 3.6 and using the Keras API for the deep neural networks.

#### IV. EXPERIMENTAL RESULTS AND DISCUSSION

In order to evaluate the proposed model, a dataset with real images has been collected. A drone model Phantom 4 was used to take the pictures. The drone flew over the streets of a University Campus. From this experiment, an amount of 78 (seventy-eight) images were collected, including 63 photos with potholes and 15 images without any problems. Each image was labelled manually. Fig. 4 shows some samples of the collected database.

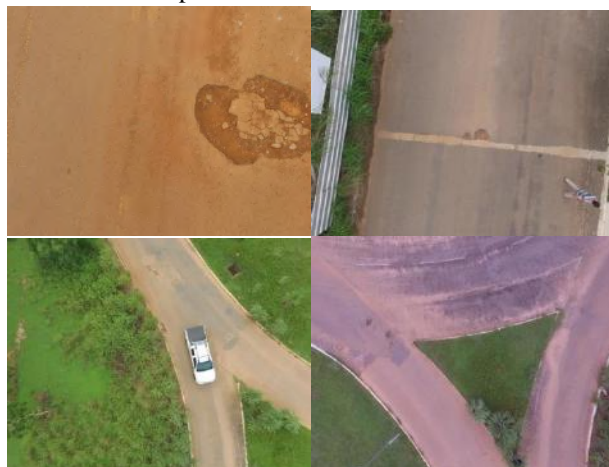


Fig. 4: Samples of collected images of paved roads used in the tests of the proposed model.

The test methodology is cross-validation, where the database was divided into 60 positive images (with potholes) for training and 3 positive images for test. Negative images (without potholes) were split in a way that the system trained with 14 samples and was evaluated using only 1 (one) negative sample for each subset, selected by the cross-validation procedure. Furthermore, the operational procedure for the test was Leave one out [18], a widely used methodology to evaluate classification systems. Therefore, each subset of tests is composed of 3

positive images and 1 negative one, while the remaining images are used for training. At the end of one cross-validation step, the test subset is inserted again into the whole set, while another subset of tests is separated to be evaluated by the system

Using the aforementioned dataset, two experiments were carried out, which included: a) using the Wisard method without the transfer learning (labeled 'Without TL'); and b) using the architecture proposed in the section 3 (labeled 'With TL'). In addition, the related work proposed by Gopalakrishnan [4] was also implemented in order to compare with the reported findings of this work. Fig. 5 summarizes the results of the experiments a) and b).

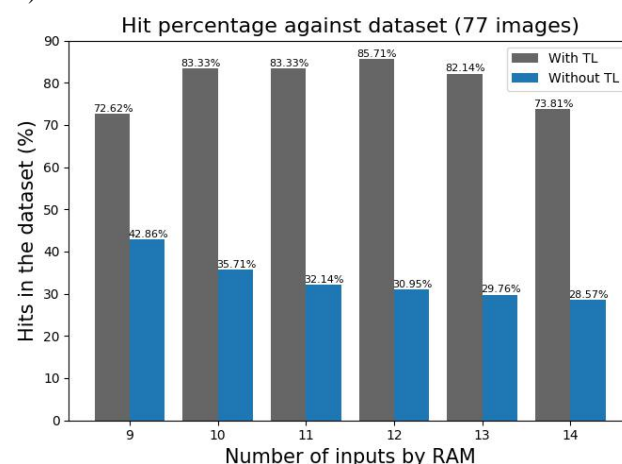


Fig. 5: Accuracy values between Wisard ('Without TL') and the proposed system ('With TL'). In the horizontal axis is the input size for each RAM (a parameter for the Wisard neural model).

As shown by the plot in Fig. 5, the use of transfer learning considerably improved the accuracy of the classification system. As noted in the Section 3, one of the Wisard parameters is the number of inputs used by each RAM-based neuron. Thus, Fig. 5 shows the sensitivity of the variation (9 to 14) of such parameter, in the whole classification performance. It could be seen that when this parameter is set to 12, the classification system reached 84.71% of accuracy, which was the best so far. On the other hand, when evaluating the system without transfer learning, the best result was 42.86%.

In order to verify the effectiveness of the model, a comparison was done with the related work proposed by Gopalakrishnan [4]. Its architecture consists of using the pre-trained neural network model VGG16 for transfer learning basis and as a classification model, a single-layer Perceptron neural network with 256 neurons in the input layer. Gopalakrishnan's model was trained and tested under the same test methodology as this work. The best results of each system are summarized in Tab. 1.



Tab. 1: Comparison of the best results on the test set images using the three evaluated systems.

Classifier	Accuracy (%)
Wisard with TL	85.71
Wisard without TL	42.86
Gopalakrishnan Model	74.51

As can be seen in Tab. 1 the proposed model was able to overperform one of the state-of-the art solutions, for the detection of potholes in paved roads. Since the database used by Gopalakrishnan [10] is not public, performance tests of the proposed work could not be evaluated.

## V. CONCLUSION

This research addressed the problem of classification of images with holes in paved roads using computer vision. In this work, the Wisard weightless neural network was evaluated as a detection system of images with and without holes. The proposed approach made use of a pre-trained convolutional neural network, known as Xception. With the knowledge of general images saved in the Xception, a detection system architecture that uses transfer learning to preprocess the input images and produce characteristics as the outcome. Such characteristics was then plugged in the input data of the Wisard network, which produced the label for the input image.

In order to evaluate the proposed architecture, an experiment was carried out, which included 77 images with and without potholes. In the conducted experiment, the transfer learning approach proved to be an effective solution, because it allowed to improve the general accuracy from 42.86% to 85.71%. In addition, when compared with a state of the art solution, the proposed approach overcame the previous one in 11.2%.

Some future insights include locating the potholes in the image, using a real-time detection solution.

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# Figuring out Extinct Values of Yeast Gene Microarray Expression (YGME) and Influencing Successive Time for Hierarchical Clustering Technique – An Improvement

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**Abstract**— The numerous missing value computation approaches for yeast data have been suggested in the literature. Throughout the past few years, investigators are keen on driving a lot of research effort on giving methodical assessments of the dissimilar computation procedures. The problem of controlling the missing values are designed with samples of tough microorganisms, such as yeast. Expensive strategies are present which has targeted to develop a varied collection of samples. They are regularly in effect for concurrently disturbing various small samples, but are greatly lesser effective for larger samples. The manufactured devices highlight interference rates after these minor samples having 5% of cells interrupted in 2 to 38 seconds range, frequently ignoring to indicate the organism interrupted or the small sample size. At the outset, maximum procedures continued to be evaluated by means of highlighting on the accuracy of the computation, using metrics such as the Correlation (uncentered), Correlation (centered), Absolute correlation (uncentered), Absolute correlation (centered), Spearman Rank correlation, Kendall's tau, Euclidean distance and City block distance. This proves the best clustering range. In the proposed approach running time is also computed for the various used methods using the same above mentioned metrics. On the other hand, it has turn out to be strong that the attainment of the accuracy and running time of the whole yeast gene data had a better assessment in further applied relations by way of hierarchical clustering approach. Accuracy and running time are sorted out for both large and small samples once after computing the missing values. Running times of the different clustering methods in a yeast dataset are existing in the work for the missing value rate of 4%. The hierarchical clustering was the fastest among the specified clustering methods (K-Means (gene) clustering technique, Self-Organized Mapping and Principle

Component Analysis). However, the SOM was still about 10 times faster than k means. The running time of the original hierarchical method was about one third for that of its proposed version.

**Keywords**— Cluster, Yeast data, Hierarchical clustering, k means clustering, filtering data.

## I. INTRODUCTION

The greatest evidence result of small sample size, does not affect the quantification procedure. The whole yeast gene data are processed in the similar way from both small and large sample size. The missing value in the yeast gene data indications are visualized by reducing the dimensionality with hierarchical clustering approach. The objective of the research involves predicting the missing values and it is an essential step to determine missing values in microarray data as the whole dataset is necessary in several expression profile analysis in bioinformatics. Surely, any individual approach to confirm the investigation procedure of the microarray data with missing values is to repeat the computation, and evidently it is very costly and time consuming. Uniquely, one can be able to reflect, for instance, the capability clustering methods such as single linkage, complete linkage, average linkage and centroid linkage. These clustering methods of hierarchical clustering approach allows the dataset to preserve the important yeast gene data in the dataset, or its discriminative/predictive influence for classification/clustering determinations

The K-Means (gene) clustering technique, Self-Organized Mapping and Principle Component Analysis algorithms were clearly the slowest computation methods. The hierarchical clustering method made, on unusual case, assesses for missing values which were up to 4 times larger than the original values. This appears to put forward an inconsistency in the method's employment or process.

Integrative Missing Value Assessment through hierarchical clustering is the initial technique to include data of microarray datasets to improve missing data computation [1]. Though, it is hard to discover data in the datasets and even further demanding to discover a set of genes often indicate expression resemblance to the target gene over numerous genes. In the meantime, centroid linkage, single linkage, complete linkage and average linkage are the foremost algorithm that exploits the useful similarities fixed in the yeast microarray data along with the expression similarities to enable the neighbor gene selection [2]. It outperformed k means, at high missing percentages, owing to the control of the amount and accuracy of the gene utilities interpreted in yeast data, Self-Organized Mapping and Principle Component Analysis algorithms miscarried to improve the time consumption in the computation process.

To the understanding, first study has inspected the consequence of missing values and their computation on the maintenance of clustering results. Other studies determined missing values on K-Means (gene) clustering technique, Self-Organized Mapping and Principle Component Analysis computation method did not deliberate genetic analysis on the clustering results; their core outcomes were that even a small amount of missing values may intensely drop the steadiness of K-Means (gene) clustering technique, Self-Organized Mapping and Principle Component Analysis computation and hierarchical clustering algorithms evidently recover this steadiness [3]. Hence the outcomes are in worthy with these conclusions.

The three steps to retrieve data are Loading, Filtering and Adjusting Data in clustering. Information in the form of dataset are loaded and processed as a Cluster. The four clustering methods such as centroid linkage, single linkage, complete linkage and average linkage are provided for adjusting and filtering the data that has been loaded. These methods gain access to Filter Data and Adjust Data. Filtering data permits to get rid of yeast gene expression datas that ensure not satisfy certain desired conditions. Adjusting data leads to perform conditional operations. The primary choice made essential is how similarity between yeast gene expression data expression data is to be well-defined. There are several methods to compute exactly how comparable two series of records are. Cluster provides eight options namely Correlation (uncentered), Correlation (centered), Absolute correlation (uncentered), Absolute correlation (centered), Spearman Rank correlation, Kendall's tau, Euclidean distance and City block distance.

## II. RELATED WORKS

There are several computation techniques have been proposed since 1963, such as hierarchical grouping, hierarchical clustering, and since 2009 such as K-Means (gene) clustering technique, Self-Organized Mapping and Principle Component Analysis. [4, 5, 6, 7, 8, 9]. The most commonly used technique among these is the hierarchical clustering. However all of the methods of hierarchical such as centroid linkage, single linkage, complete linkage and average linkage measures are merely recognized on the yeast gene expression datasets themselves and employ nothing of the external microarray datasets or genetic associated data. Here numerous modest methods are present to determine the missing values, e.g. eliminating the genes with missing values from supplementary study, substituting missing values by zeros, or satisfying the missing values with the row or column means/medians present [10, 11, 12]. These methods are not ideal as they did not deliberate the relationship of the data, which stimulated the progress of further refined missing value ways that strained to exploit the data associations by means of the data present in the entire dataset [13].

As per data given in Table 1, missing value is a common difficulty that has to be addressed even for further modern educations [14, 15]. Likewise, here exists several genes with high missing percentages. In this circumstance, for genes with numerous missing values, little values are persisted to conclude in what way the gene is associated with other genes in the dataset, which leads to less accurate assessments. It is well known that gene expressions in cells are concertedly measured by similarity factors and information encoded in the nuclear and mitochondrial genomes of the yeast [16]. The major iterating unit of mitochondrial genomes, which consists of approximately 1000's of microorganisms around Genome Database [17]. For instance as mentioned in [18, 19, 20], mitochondrial genomes might modify the structure. Thus, the similarity factor is greatly measured by the mitochondrial genomes states in mitochondrial. Nevertheless, definite objective existed to examine the consequence of missing values on the hierarchical clustering algorithms, such as centroid linkage, single linkage, complete linkage and average linkage, and to discover whether new progressive computation methods, such as SOM, will be able to offer improved clustering results than the old-style k means method. The outcomes recommend that hierarchical clustering runs fast, robust and accurate outcomes, particularly when the missing value rate is lower than 4%. None of the computation methods might sensible and correct for the stimulus of missing values above this 4% threshold. In these circumstances, one must think through in eliminating the genes with many missing values or iterating the tests if

likely. As prominent before, clustering related to datasets are naturally regularized therefore a data value near to zero shows the nonexistence of any relations in the midst of a pair of genes. Thus a simple key to the problem of missing values is to substitute those items with zeros. However this might give the impression to be a hierarchical cluster methodology, it has some validation: the probability is that maximum genes do not work together, and hence their relations score is probably to be close to zero. Likewise it is perceived that the mean /median of the non-missing entries in the datasets defined before is almost zero. This method helps as a starting point for investigational assessments.

**Loading, Filtering and Adjusting Data:** A machine learning system is established for deciding gene functions from assorted source of data sets using hierarchical clustering. Through a prearrangement, in the Group of input data tables rows signify genes and columns denote samples or interpreted values known as yeast data microarray hybridization. On performing the three steps to retrieve data namely Loading, Filtering and Adjusting Data in clustering, a small size Cluster input data resembles as in Table I [21].

**Loading data:** The YORF field contains an alpha-numeric value. It is forecasted in Tree View to state how the rows are connected. The left over chambers in the table contain data for the suitable gene and sample. The readings are observed as data for instance 1 at 0 min for YAL001w and missing value for gene YAL001C at 2 hours was 5.8. Omitted data are tolerable and are nominated by blank cells. In order to identify the missing value, the operation "Present % >= X" is enabled.

Table. I YORF-Yeast open reading frame

S. No	(YORF)	0 min	30 min	1 hour	2 hour	4 hour
1	YAL001w	1	1.3	2.4	5.8	2.4
2	YAL002w	0.9	0.8	0.7	0.5	0.2
3	YAL003W	0.8	2.1	4.2	10.1	10.1
4	YAL005C	1.1	1.3	0.8		0.4
5	YAL010C	1.2	1	1.1	4.5	8.3

The large size sample data file similar to small size sample data file as given in Table I comprises yeast gene expression data defined in Eisen et al. Move this data to testing and training in addition to loading the

Cluster bunch. Each Cluster bunch resolved will provide information roughly about the loaded data file. Once loaded, the listed, used and calculated measures such as Correlation (uncentered), Correlation (centered), Absolute correlation (uncentered), Absolute correlation (centered), Spearman Rank correlation, Kendall's tau, Euclidean distance and City block distance are used as the testing and training statistics for different cluster analytical methods. Grouping is a significant tool for exploring such Cluster bunch of microarray information, usual properties of which are its intrinsic ambiguity, noise and fuzziness [22, 23, 24, 25, 26, 27, 28]. The columns and rows in the dataset are elective. Hence the Tree View practices to use the ID in YORF column by the means of labelling for each individual gene and YORF column permits to identify a label for each individual gene that is isolated after the ID is specified in the YORF column. The 31 rows and 79 columns will be labelled well ahead in the dataset for loading purpose. The Filter Data permits to take out the genes that do not take part definitely sought after setting the properties of dataset. The properties such as enable and disable options are used to load, apply filter and accept filter as shown in Table II.

**Filter data:** The filtering of data is the process of eliminating genes that abstain in certain preferred properties which is described in Table II. Also the presently accessible properties that can be capable to be used to filter data are existing [28]. These stay impartially understandable. As soon as filter are implemented, the filters are not instantly used in the dataset. Primarily the filter implementation expresses exactly how many genes would have been accepted by the filter. If accepted, genes passes through the filter, or else certainly no modifications are made.

Table. II Eliminate genes lacking desired properties from dataset of 31 rows and 79 columns

S.No	Limitation	Status
1	Present % >= 80=A	Enabled
2	SD(Gene vector)>2.0=A	Disabled
3	At least 1 observation with abs(Val)>=2.0=B	Disabled
4	High Value-Low Value>=2.0=A	Disabled
5	Apply filter	21 passed out of 31
6	Accept Filter	Enabled

- Step 1 eliminates the entire genes that have missing numerical information in larger than (100 - A) percentage of the columns.



- Step 2 eliminates the entire genes that have normal abnormalities of detected numerical information lesser than A.
- Step 3 eliminates the entire genes that do not have minimum of A interpretations analysed through total numerical information larger than B.
- Step 4 eliminates the entire genes whose higher value subtracts the low value that are less than A.

The genes are passing the filter when applying and accepting the filter. In order to filter data, the default value is set to read the result. Hence they are kept NIL as given in Equation 1 and Equation 2.

Apply filter = NIL .....Eq 1

Accept filter = NIL .....Eq 2

The default values are presented in Table 3 for passing the genes through the filter.

Table. III Assign default values to filter genes lacking desired properties from dataset of 31 rows and 79 columns

S.No	Option	Entry	Value
1	Disabled	% present>=	80
2	Disabled	SD (Gene vector)	2.0
3	Disabled	At Least	1
4	N/A	Observation with abs (val)>=	2.0
5	Disabled	High Value-Low Value>=	2.0

There are six conditions to pass the genes through the filter. They are illustrated as follows:

**Condition 1:** After applying filter operation for the given dataset with an assigned default value as given in Table III, then the numerical information in the entire 31 rows passes out of 31 rows without any missing information. It is found that there are no missing values. This is proved by identifying the result through the gene cluster tool. Hence the result is presented in Table IV.

Table. IV Identifying genes lacking desired properties from dataset of 31 rows and 79 columns > 100-80

S.No	Option	Entry	Value
1.	Enabled	% present>=	80

**Condition 2:** Next, if the genes have %present >=80, then the result shows that it has no missing information and also filtering task is not further necessary while passing the genes.

**Condition 3:** This condition where, if the abnormality of the Standard deviation, SD (gene vector) is enabled, none of the numerical information passes out of 31 rows. Then

all the detected numerical information less than 2.0 (SD) are removed.

**Condition 4:** The genes are passed for at least 1 observation by means of total absolute value as given in the Equation 3, where the abs(Val) is larger than 20, which allows 3 rows to pass out of 31 rows.

$$\text{abs(Val)} > 20 \quad \text{.....Eq 3}$$

**Condition 5:** The filtered gene for the High value is subtracted from Low Value as given in Equation 4.

$$\text{High Value} - \text{Low Value} > = 2.0 \quad \text{.....Eq 4}$$

This condition also passes 3 rows out of 31 rows similar to condition 4.

**Condition 6:** If the filtered genes have high value as given in Equation 5 then the filter passes 21 rows passed out of 31 rows.

$$\text{High Value} > = 20 \quad \text{.....Eq 5}$$

Finally, the filter process is accepted for condition 3, 4, 5 and 6 in order to accept filtering rows further.

**Adjust Data-Units mean:** There are five number of tasks used to adjust the information and the tasks are performed by modifying the original information. The information is adjusted in terms of log transform data, center gene-mean, center arrays-mean, normalizing gene and normalizing arrays subsequently the middle gene and middle array imperative process has its median for an assessment to fine-tune information.

### III. PROPOSED STUDY ON CLUSTERING FOR SMALL SAMPLE SET -HIERARCHICAL (GENE) CLUSTERING

The procedures for establishing hierarchical clusters are of commonly private subgroups (genes and arrays). An individual of private subgroups which has members that are extremely alike with an esteem are used to identify features integrating nearest neighbour searching algorithm. These weights are determined in addition to grouping [29,30]. Then the cutoff value (0.1) and the exponent value (1) are set as a default value and the similarity metric measure, correlation uncentered is chosen for determining the weights. The correlation (uncentered) metric is the one that rely on centroid linkage where a vector is assigned to compute the distance. The distances are computed with the centroid linkage method that will cluster and generate the cluster bunch. Firstly, the gene tree file (.gtr) is generated with node and gene value with its exponent. Secondly, an array tree (.atr) disk image (a copy of 8 bit formatted disk) file is generated with node and its array value with the same exponent 1. Thirdly, a coral draw text editor image template (.cdt) is generated with the E weight (exponent weight) of G weight (Gene Weight). The similar performance process of generating files for the centroid

linkage method in hierarchical clustering is followed to single linkage method, complete linkage method and average linkage method. For instance, the centroid linkage method involves two node and two gene value for generated gene tree as shown in Table V (as sample1).

Table.V Node gene Sample 1

Node	Gene Matrix		Range
Node 1x	Gene 0x	Gene 1x	-0.527353
Node 2x	Gene 1x	Gene 2x	-0.94495

The interference for the single linkage method is derived as given in Table VI (ie.,sample2).

Table.VI Node gene Sample 2

Node	Gene Matrix		Range
Node 1x	Gene 0x	Gene 1x	-0.527353
Node 2x	Gene 1x	Gene 2x	-0.611316

The rest of the files are similarly generated for centroid linkage and single linkage method. The complete linkage method differs in value from others. It generates the value as given in Table VII (ie., sample 3).

Table..VII Node gene Sample 3

Node	Gene Matrix		Range
Node 1x	Gene 1x	Gene 0x	-0.527353
Node 2x	Gene 2x	Gene 1x	-0.819574

For average linkage method, gene tree file is generated as given in Table VIII (ie., sample 4) showing one different value for the second node similar to other two methods.

Table.VIII Node gene Sample 4

Node	Gene Matrix		Range
Node 1x	Gene 0x	Gene 1x	-0.527353
Node 2x	Gene 1x	Gene 2x	-0.715445

After performing hierarchical clustering, k-means clustering is chosen for evaluation. The similar dataset of Eigen which is fed for hierarchical clustering is used in k-means clustering.

**K-Means (gene) clustering technique:** The genes and arrays of the dataset are analysed using the k-mean clustering algorithm. Both genes and arrays have 10 numbers of cluster k and 100 numbers of runs each where the k-means and k-medians are determined. On execution of k-means with the Euclidean distance similarity metric for both gene and array, it is found that clusters are

available more in number than the genes. Then the entire dataset is passed without any gene filter irrespective of number of observations or absolute value specification. Also, the data is adjusted and it is independent of hierarchical technique. After execution, the cluster k generates a cluster gene file (.kkg) where gene groups 10 clusters and the data in open reading frame (ORF) is a .kkg file and .kag file. It groups the gene into 10 groups and Cluster, k for 10 gene and 10 array are listed with gene weight and experiment weight.

#### Self-Organized Mapping and Principle Component

**Analysis:** After the execution of k-means clustering technique, the same Eisen dataset is tested in Self Organized Mapping (SOM) and Principle Component Analysis (PCA). The SOM organizes the genes and arrays similar to k-means clustering. The X dimension and Y dimension are assigned for the genes and arrays (as 3). The number of iterations for genes by default is 1, 00,000 and arrays is 20, 000 respectively. The initial tau is set to 0.02 by default and the outcome of both the genes and arrays of SOM are similar. The similarity metric here is the Euclidean distance and the three files generated of which GNF file shows the gene vectors and ANF file shows the array vectors. The gene/array file together shows the gene weight and experiment weight of the vectors. The mean values are not presented in the self-organized maps [31]. So the clustering technique of principle component analysis (PCA) is applied for Genes & Arrays to calculate the mean. PCA execution results in generating the principle component of array and gene. The gene and array are coordinating in two ways. The array co-ordinate is showing Eigen value of experiment weight and gene co-ordinate showing gene weight. All the clustering technique such as hierarchical, k-mean, self-organized mapping and PCA have adjusted the data to the mean. When adjusting data to median the result on filter data is as shown below. Hence the data must be filtered before adjusting process.

**Filter data:** Filtering the data with mean is similar to the process of filtering the data with median.

**Adjusting data with median for Atleast 1 observation with  $abs(val) \geq 2.0$**

The difference discovered in filtering data with mean and median shows that when adjusting mean first and then filtering, shows no rows have passed out of 31 rows. Adjusting median first and then filtering also shows no rows have passed out of 31 rows. When filtering gene for at least 1 observation with  $abs(val) \geq 2.0$  shows 3 rows passing out of 31 rows. The filter is being accepted to perform clustering after the rows are passed. Adjusting the data for the center gene and center array to mean and median respectively and vice versa filter no rows have

passed out of 31 rows. Adjusting data with median is similar to adjusting data with mean in log transform data and normalizing gene or arrays for center genes and center arrays respectively.

#### **IV. PROPOSED STUDY ON CLUSTERING FOR HIERARCHICAL (GENE) CLUSTERING TECHNIQUE - LARGE SAMPLE SET**

The various similarity metric performances are measured. They are: Correlation (uncentered), Correlation (centered), Absolute correlation (uncentered), Absolute correlation (centered), Spearman Rank correlation, Kendall's tau, Euclidean distance and City block distance.

Table. IX Comparison between clustering methods

Clustering method	Gene/array similarity metric	31 rows node/gene		31rows node/array		2467 rows node/gene		2467 rows node/array	
Centroid linkage	Correlation uncentered	0.642641	0.16757	0.90082	0.668934	0.988387	0.354391	0.929455	0.075474
Single linkage		0.642641	0.336574	0.90082	0.722635	0.988387	0.414903	0.929455	0.288938
Complete linkage		0.642641	-0.34663	0.90082	-0.805213	0.988387	-0.883172	0.929455	-0.489157
Average linkage		0.642641	0.100977	0.90082	-0.110935	0.988387	-0.28906	0.929455	0.0223
Centroid linkage	Correlation centered	0.640981	0.123294	0.896823	-0.541497	0.989404	-0.606245	0.926293	-0.141204
Single linkage		0.640981	0.287747	0.896823	0.418646	0.989404	0.961167	0.926293	0.287638
Complete linkage		0.640981	-0.335755	0.896823	-0.750119	0.989404	-0.89763	0.926293	-0.520852
Average linkage		0.640981	0.090961	0.896823	-0.082129	0.989404	-0.068484	0.926293	-0.018541
Centroid linkage	Absolute correlation uncentered	0.642641	0.167570	0.900820	0.063715	0.988387	0.094143	0.929455	0.054159
Single linkage		0.642641	0.336574	0.900820	0.444248	0.988387	0.414903	0.929455	0.332774
Complete linkage		0.642641	0.000931	0.900820	0.000000	0.988387	0.000000	0.929455	0.000056
Average linkage		0.642641	0.130989	0.900820	0.158227	0.988387	0.114757	0.929455	0.092952
Centroid linkage	Absolute correlation centered	0.640981	0.123294	0.896823	0.018289	0.989404	0.013264	0.926293	0.071195
Single linkage		0.640981	0.293646	0.896823	0.418646	0.989404	0.404155	0.926293	0.335699
Complete linkage		0.640981	0.001184	0.896823	0.000083	0.989404	0.000000	0.926293	0.000074
Average linkage		0.640981	0.117903	0.896823	0.152002	0.989404	0.126558	0.926293	0.087962
Centroid linkage	Spearman rank correlation	0.693216	-0.049660	0.910012	-0.274194	0.973099	-0.001144	0.906171	-0.126924
Single linkage		0.693216	0.283253	0.910012	0.337878	0.973099	0.412512	0.906171	0.265874
Complete linkage		0.693216	-0.414645	0.910012	-0.691423	0.973099	-0.818796	0.906171	-0.477460
Average linkage		0.693216	0.064168	0.910012	-0.051662	0.973099	-0.024957	0.906171	-0.022292
Centroid linkage	Kendall's tau	0.508900	-0.056484	0.746514	-0.135484	0.885758	0.011360	0.749915	-0.085986
Single linkage		0.508900	0.195261	0.746514	0.246734	0.885758	0.296595	0.749915	0.183322
Complete linkage		0.508900	-0.267782	0.746514	-0.510871	0.885758	-0.636636	0.749915	-0.340330
Average linkage		0.508900	0.044218	0.746514	-0.037265	0.885758	-0.002423	0.749915	-0.015095
Centroid linkage	Euclidean distance	0.928197	0.000000	0.954213	0.000000	0.995196	0.000000	0.928997	0.000000
Single linkage		0.914380	0.000000	0.924451	0.000000	0.991290	0.000000	0.894987	0.000000
Complete linkage		0.950895	0.000000	0.981846	0.000000	0.998144	0.000000	0.978606	0.000000
Average linkage		0.936194	0.000000	0.964699	0.000000	0.995290	0.000000	0.956165	0.000000
Centroid linkage	City block distance	0.732687	0.000000	0.775965	0.000000	0.928988	0.000000	0.737505	0.000000
Single linkage		0.712875	0.000000	0.690699	0.000000	0.909338	0.000000	0.675318	0.000000
Complete linkage		0.774877	0.000000	0.867530	0.000000	0.960542	0.000000	0.854260	0.000000
Average linkage		0.748284	0.000000	0.795720	0.000000	0.932525	0.000000	0.791840	0.000000

Table IX gives a comparison of similarity measure performance on different clustering methods. Also it helps in identifying the missing values of yeast which leads to determine the time complexity.

## V. RESULTS AND DISCUSSION

Clustering gene and array with hierarchical technique sorts with similarity metric correlation (uncentered) for centroid linkage clustering method. It results in sorting from 0.642641 to 0.167570 (node/gene) for instance.

Table. X The codes for the methods

Method	code
Hierarchical	H
Gene	G
Clustering	C
Gene Array	GA
Correlation (uncentered)	CU
Correlation (centered)	CC
Absolute correlation (uncentered)	ACU

Absolute correlation (centered)	ACC
Spearman Rank correlation	SRC
Kendall's tau	KT
Euclidean distance	ED
City block distance	CBD
Centroid Linkage	CEL
Single Linkage	SL
Complete Linkage	COL
Average Linkage	AL
Cluster	C
Cluster Weights	CW

For single linkage the corresponding node/gene, node/array and the weights are presented in the tabulation for the method (H\_G\_C\_CU\_SL).

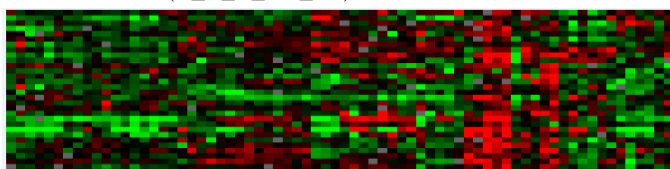


Fig 1. Gene tree view 31rows 79columns

For complete linkage and average linkage, H\_G\_C\_CU\_COL and H\_G\_C\_CU\_AL, the same evaluation is done as in centroid and single linkage. All these methods are tested for all the other similarity metrics and the performance is updated in Table V. For correlation centered, the corresponding procedure code H\_GA\_C\_CC\_CEL, H\_GA\_C\_CC\_SL, H\_GA\_C\_CC\_COL and H\_GA\_C\_CC\_AL are used. The range of node/gene for H\_GA\_C\_CU\_CEL and H\_GA\_C\_CU\_COL are the same. The initial value of node/array range for H\_GA\_C\_CU and H\_GA\_C\_CU are same in all four methods (centroid, single, complete and average).

Table. XI 31rows and 2467 rows (79 columns) – cluster range

Cluster method	Range	31 rows node/gene	31 rows node/array	2467 rows node/gene	2467 rows node/array
SR		0.642641	0.9008	0.988387	0.929455
CEL	ER	0.16757	0.6689	0.354391	0.075474
SL	ER	0.336574	0.7226	0.414903	0.288938
CL	ER	-0.34663	-0.805	-0.88317	-0.48916
AL	ER	0.100977	-0.111	-0.2890	0.0223

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The small scale information involve the observations for only 31rows 79columns. On increasing the size to 2467 rows 79 columns as given in Table XI, clustering performance is maintained in an effective way such that the Euclidian and city block distance measure with large dataset shows better outcome when compared to other similarity measures [32-34]. The time taken to cluster data with the similarity measures ACC, SRC and KT are determined. Also the ACU, ACC, ED and CBD time computation is calculated for the gene/array cluster bunch that involve the weight of cutoff=0.1 and exponent=1 for gene and arrays. Only few similarities and variations are noted in case of CU on comparing two values C and CW, the starting value range for the cluster is nearer to cluster weights for CEL.

Table XII. 31rows and 2467 rows (79 columns) – execution time

Cluster Metrics	Time (sec)			
	31 rows node/gene	31 rows node/array	2467 Rows node/gene	2467 rows node/array
Correlation (uncentered)	38	35	31	34
Correlation (centered)	32	34	30	33
Absolute correlation (uncentered)	30	28	29	27
Absolute correlation (centered)	26	28	28	26
Spearman Rank correlation	22	25	28	24
Kendall's tau	21	23	22	22
Euclidean distance	10	2	4	6
City block distance	7	4	5	2

On comparing the time taken to execute clustering using ED and CBD measure, it takes very less duration to process the data as given in Table XII.

For comparing these techniques used in this work, a statistical test has been conducted. Z-test for testing equality of variance between the similarity measures has been used to test the hypothesis of equality of two population variances shows 6.25 for Correlation (uncentered) and 8.25 for Correlation (centered) and no



variances for Absolute correlation (uncentered), Absolute correlation (centered), Spearman Rank correlation, Kendall's tau, Euclidean distance and City block distance when the sample size of each sample is 30 or larger.

## VI CONCLUSION

Similar to CU, the SR for CC, ACU, ACC, SRC and KT similarity measures are same. The ER differs for CC, ACU, ACC, SRC and KT. In case of ED and CBD, the SR for cluster methods is different and ER is same. The time taken for KT alone takes more time to generate the output. The gene tree view for 31rows 79columns with x and y pixels, mask<0 and corr select cutoff=0.8 are shown in Figure 1. The colour indications are green-negative, black-zero, red-positive and gray missing. The gene tree view for 2467rows and 79columns have reduced missing values. Hence the data mining methods are studied and compared for measuring clustering performance for various methods.

The future progress can be tested with same small and large sample yeast gene data for self-organized mapping and principle component analysis. It uses the similar process that has been used in hierarchical and k means clustering. Also the performance time can be reduced.

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# The use of ISO 37122 as standard for assessing the maturity level of a smart city

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**Abstract**—Existing evaluation models of maturity of smart cities are diversified, and for this reason there is no exact model for this type of assessment. In this sense, it becomes relevant the need for the compression of a maturity model as it is highlighted in the literature. The goal of this article is to present the result of a literature review that was made to identify models of maturity evaluation responsible for measuring the smartness of a city. Results portray the comparison of the evaluation models found, indicating the main features related to their complexities and implantation proposal. In addition, we identified the optimized model that could enable initiatives maturation to promote smart cities.

**Keywords**—Smart Cities, Models, Maturity.

## I. INTRODUCTION

The emergence of the concept of smart cities brought about several indexes and indicators, created to measure the potential of cities, as well as neighborhoods and small localities, with the purpose of developing maturity models to classify these locations [1]. Smart cities monitor and integrate operational conditions of an infrastructure that uses Information and Communication Technologies (ICTs) to innovate the essential services management model [2,3,4,5,6,7].

The term "smart city" refers more to a skill than just focusing on its aspects, if it is necessary to identify certain characteristics possible or not in relation to the domains for evaluation of a smart city. Thus, it is considered that the term smart city is used in a holistic way, varying from cities with high use of TICs, even in relation to cities whose education or intelligence of its inhabitants is recognized. In the literature there are six domains of activities that are described as the main characteristics that conceptualize intelligent cities (see Fig 1).



Fig. 1: Major domains of a smart city. Source: Authors.

In this context, there is great variety of classification indicators, since there are several perspectives on how cities can be classified, viewed and evaluated by different social actors understood as companies, academics, political leaders and the population in general. Most indicators used do not follow a pattern [8].

Not always a solution or standard apply in the same way to more than one location, since each region has its specific characteristics. Thus, in order to measure the performance of a smart city, the classification attribute must be decomposed into indicators, so that cities will be able to evaluate their performance based on their reality and, consequently, adopt the best solutions according to their own demands [9].

It is observed that the perception of Smart Cities is wide due to the existence of several definitions for such, but it is not easy to know if a city is indeed smart and what methods are adopted to measure if a city can receive such status. Among the existing models, ISO 37122 is a standard for smart cities, presenting a synthesis of ideas pointing out strengths and weaknesses of each one.

The maturity models found in the literature present features and domains. Thus, ISO 37122 was used as a starting point, thus relating the main characteristics from the perspective of the main domains of a smart city as discussed in Fig 1 [1]. The goal of this article is to present the results of the literature review of the evaluation

models applied in the measurement of smart cities. We describe these evaluation models in a comparative study, indicating their main authors and, as a result, we describe the model that results in the best adaptation both as application and usability.

## II. MATERIALS AND METHODS

To reach our goal, a literature review was carried out between May and November of 2018, based on periodicals of scientific articles selected from the following databases: Google, Google Scholar, IEEE Explore, Scielo, Bon, Mendeley, Publish or Perish and Researchgate. We have used key words in Portuguese language like *ciudades inteligentes; maturidade; metodologias; modelos de maturidade e níveis de classificação*, as well as their English correspondents (*smart cities; maturity, methodologies; maturity models and classification levels*), used in the context of smart cities, as to make bibliographic review better grounded. Regarding the search for digital archives, the selection included both national and international articles, with dates varying between 2000 and 2018. Studies that reported the use of other analysis modalities that did not include indices, models and maturity were excluded from this review. Thus, of the 168 articles found, 23 met research requirements.

Immediately afterwards, we sought to study and understand the main parameters and form of application used in the studies found, being categorized the following models based on their domains of applicability.

### GIFFINGER-BASED MODEL

They were developed in medium-sized European cities, where dimensions, characteristics, factors and indicators were defined to measure a smart city, existing a hierarchical structure for the analysis of a city, thus defining the pillar of smart cities. Its main areas are: economy, people, governance, mobility, environment and life [1].

### SMART CITY MATURITY MODEL (SCMM)

Developed in India in order to help a region of the country assess its technology readiness and implement a solution that is uniquely aligned with its resources and capabilities. The evaluation structure proposed by [9] positions itself in a city in the developmental trajectory based on its physical, social and technological infrastructure. Model [9] defines that the solution of a smart city must be only aligned with the state's social and infrastructural development to obtain greater benefits. They use governance, technology, transportation, energy, environment, water, health, safety and housing as their main domains.

### BRAZILIAN SCMM MODEL

Such a model is appropriate to Brazilian realities, being quite simple and limited, with interesting application in places that are making their first steps in the smart city's movement. They use education, governance, technology, transportation, energy, environment, water, health and housing as main domains [8].

### WCCD CERTIFICATION MODEL BASED ON ISO 37120

It aims at the accreditation of a city to be smart through indicators adopted in ISO 37120. The evaluation is done through a web platform called WCCD (World Council on City Data), available to any city in the world interested in taking the test to obtain certification. They use the following domains: main economy, solid finance, education, governance, telecommunications and innovation, transport, energy, environment, waste, urban planning, sewage, water and sanitation, incident and emergency response, health, recreation, safety and housing [12].

### TECHNOLOGY MATURITY MODEL - TMM

It understands that a city becomes smart through a gradual process, in which the final intention is to reach an optimum level in the use of technological resources. They use education, governance, transport, energy, water and health as their main domains [13].

### IDC - GOVER MODEL

It identifies the main measures, results and actions required for cities to effectively walk through the stages and progress towards the long-term goal of becoming a smart city. They use strategy, culture, processes and technology / data as main domains [14].

### SMART CITY FOR ALL MODEL - SM4A

It is considered the newest maturity model, still in development stage. It aims to help cities to clearly assess their progress towards accessibility of ICTs and digital inclusion. They use strategy, culture, governance and technology / data as main domains [15].

### URBAN SYSTEMS / RCSC MODEL - RANKING CONNECTED SMART CITY

It is a Brazilian model that assesses the development potential of Brazilian cities considering smartness, connection and sustainability. They use economy, education, entrepreneurship, governance, technology and innovation, mobility, energy, environment, urbanism, health and safety as major domains [16].

### ESC MODEL - EUROPEAN SMART CITIES

It is a European index developed to verify and evaluate the performance of smart cities. In this model a methodology was developed to verify cities' performance through a digital platform, verifying the performance of European cities, which does not go so far as to classify them as more or less smart, but that allows to obtain indicators about and / or make a comparison between

them, through information available on a website. They use as key domains economy, smart people, governance, mobility, environment and lifestyle [17].

#### SCIP MODEL - SMART CITY INDEX PORTUGAL

It is a study developed in order to allow the comparison of the performance of 36 Portuguese cities. The methodology of this study integrates 5 dimensions: governance; innovation; sustainability; quality of life and connectivity. They use governance, innovation, connectivity and quality of life as key domains [18].

#### RBCIH MODEL - BRAZILIAN NETWORK OF SMART AND HUMAN CITIES

This model was created by FNP - National Front of Mayors in 2013, focusing on cities with approximately 80,000 inhabitants. The idea behind RBCIH creation was between the partner company SATOR and Urban System, in the possibility of exchanging experiences and information with a view to fostering the development of cities for the economy of the 21st century. Based on the concept of smart cities, through a bottom-up approach, they use as key domains anthropology, governance, technology, architecture / urbanism and security [19].

#### NBR ISO 37120 MODEL - SUSTAINABLE DEVELOPMENT OF COMMUNITIES

This model uses 17 key domains to evaluate a smart city: economy, finance, education, governance, telecommunication and innovation, transportation, energy, environment, solid waste, urban planning, sewage, water and sanitation, response to incidents and emergencies, health, recreation, safety and housing. The norm takes sustainability as its general principle. The norm takes the sustentabilidade as its general principle. The measurement of performance occurs through 100 indicators that are typified as essential and of support, in the ratio of 54 and 46, respectively, distributed among the thematic sections cited above [20].

#### ISO 37122 MODEL - INDICATORS FOR SMART CITIES

It establishes indicators and definitions of methodologies to measure and consider aspects and practices that dramatically increase the pace at which cities improve their maturity results. This model has become the international reference point for smart cities. ISO specialists and the TC268 technical committee have identified the need to develop an ISO based on indicators for smart cities, and developed ISO 37122: Sustainable Development of Communities - Indicators for Smart Cities that will complement ISO 37120 and establish indicators and definitions of methodologies to measure and consider aspects and practices that dramatically increase the pace at which cities improve their social, economic and environmental sustainability results by responding to challenges such as climate change, rapid

population growth, and political and economic instability, fundamentally improving how cities engage in society, apply collaborative leadership methods, work across disciplines and municipal systems, and use modern data and technology information. It uses as main domains economy, finance, education, governance, telecommunication, transportation, energy, environment and climate change, urban / local agriculture and food security, urban planning, wastewater, water, culture, health housing, security, leisure, population and social conditions and solid waste [21].

#### WEISS MODEL - ASSESSMENT MODEL FOR READINESS

Developed and titled as an evaluation model of TICS readiness, its application was directed to the urban management of the municipalities in order to be able to qualify how smart the cities are. This model is exclusively focused from the perspective of TICS, and propose in their evaluation a modular way, if municipalities have the necessary technologies to be classified as smart cities. The proposed model has six key domains: administration and governance, management of public services, management of public infrastructure, electronic services to the community, service platform and innovation and entrepreneurship [22].

#### IBMCCI MODEL - MULTIDIMENSIONAL BRAZILIAN INDEX OF SMART CITIES CLASSIFICATION

This model was inspired by the U-MULTIRANK evaluative model, focused on the national context in a way that evaded the existing traditional and classical models that inevitably gave rise to rankings. Moreover, in a not totally objective way they seek to establish criteria for cities that have different histories, different characteristics and that are in different maturing points. They use as key domains quality of life, technological readiness, innovation and environmental sustainability [23].

### III. ANALYSIS, RESULTS AND DISCUSSION

To analyze and compare, it is necessary to select a model as a starting point for a proper comparison. A smart city is a city that performs well in six key domains (economy, people, governance, mobility, environment and quality of life). It is based on the premises of smart cities that have as pillar 6 key domains (see Table 1). This work takes as reference the ISO 37122 model, with indicators and specific domains for smart cities, having 19 key areas, which relate to the 6 key areas of a smart city as shown in Table 2.



Table 1: Smart Cities Indicators

SMART CITY INDICATORS	Smart Economy	Smart People	Smart Governance
Giffinger et al. (2007)	Smart Mobility	Smart Environment	Smart Living

Table 2: 37122 ISO indicators for Smart Cities

ISO 37122 (2017)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living

The ISO 37122 development aims to improve smart cities performance. This need arose because ISO and TC268 technical committee specialists identified the need to develop an ISO-based indicator for smart cities.

In order to assist cities with the international standard ISO 37122, it intends to help them implement policies aimed at the development of smart cities, and for this purpose it offers: Better services for citizens; Provide a better living environment in which smart policies, practices and technologies are put at the service of citizens; Achieve their environmental and sustainability goals in a more innovative way; Identify the need for intelligent infrastructure; Facilitate innovation and growth; Build a dynamic and innovative economy ready for future challenges.

This Norm defines and establishes definitions and methodologies for a set of indicators for Smart Cities. The purpose of this standard is to help cities guide and evaluate the performance management of municipal services and all service provision, as well as life quality. It considers the sustentabilidade as its general principle, "smart city" has as concept to guide the development of the cities.

Table 3 presents the domains that are treated in their respective maturity models based on ISO 37122 as the standard of measurement analysis, where what is highlighted/painted is what the model contemplates.

Table 3: Maturity Models

Giffinger et al. (2007)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Meijeringa, Kern and Tobi	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Moraes (2018)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living

Weed (2017)	Smart Economy	Smart People	Smart Governance
Based on ISO 37120	Smart Mobility	Smart Environment	Smart Living
Gamma, Alvaro and Peixoto (2012)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Clarke (2013)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Artieda (2017)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Urban Systems /Connected Smart Cities (2017)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Junkes (2017)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Inteli (2012)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Rbcih (2018)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
NBR ISO 37120 (2017)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
ISO 37122 (2017)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Weiss (2016)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living
Guimarães (2018)	Smart Economy	Smart People	Smart Governance
	Smart Mobility	Smart Environment	Smart Living

Analysis of Table uses top-down approach type, which is essentially to obtain insights that will be demonstrated by the maturity models found in the literature review. The

interpretation of Table 3 is given according to the models found in the materials and methods section following the same order, but in Table 3 we describe the analysis of domains by authors. The following are insights from the models in Table 3.

Model: Meijeringa, Kern and Tobi (2014). In the Model developed by [9] the evaluation structure is in a city in a developmental stage based on its physical, social and technological infrastructure. In this model there is a concern with the domains of economy and people and their data collection is based on public data. This model does not cover economic and people development.

Model: Moraes (2018). It is appropriate to Brazilian realities. Such a model is quite simple and limited, with interesting application in places that are doing their first steps towards the movement of smart cities. This model (see Table [3]) does not cover economic development as well as people and is still in development stage.

Model: Wccd (2017) based on ISO37120. This model aims at the accreditation of a city to be smart through indicators adopted in ISO 37120. The evaluation is done through a web platform called WCCD (World Council on City Data), any city in the world can undergo the test to obtain certification. However, the analysis and the data serve only as a source of consultation, and the techniques and methods of analyzing these data are not known. According to Table 3, it is a model that contemplates all domains but specific to cities that aim to be smart and sustainable.

Model: Gamma, Alvaro and Peixoto (2012). It is quite attractive, but it is deeply focused on measuring ICTs usage. The model only serves for a city to adjust, in an isolated and non-integrated way, its evolution or involution in the use of TICs in each domain described. There is still criticism regarding the methodology, since the calculation methodology used to evaluate the model proposed by the author was not explicit.

Model: Clarke (2013). The model identifies key measures, results and actions required for cities to effectively walk through the steps and progress towards the long-term goal of becoming a smart city. According to Table 3, this journey has many deficits, especially in areas of validation such as lack of environment and life domains.

Model: Artieda (2017). Still in developmental phase, in Table 3 we find faults in its domains for the evolution of a smart city; it is considered the newest maturity model, aiming at helping cities to clearly assess their progress in achieving ICT accessibility and digital inclusion.

Model: Urban System / Connected Smart Cities (2017): This model was initially thought to evaluate the development of Brazilian cities considering smartness, connection and sustainability. In Table 3, although it

shows that the model includes all domains, the same focuses on interconnection and sustainability.

Model: Junkes (2017) is a European index developed to verify and evaluate the performance of smart cities in Europe and this performance evaluation is done through a digital platform. In Table 3, although all domains were included, it was not clear which methodology was used or what domains were used for evaluation at city level.

Model: Inteli (2012) is a study developed to allow the comparison of the performance of Portuguese cities. The methodology of this study integrates 5 dimensions: governance; innovation; sustainability; quality of life and connectivity. In Table 3 the model presented concerns only in the domains of mobility, governance and life, which were defined as primordial for a smart city, not forgetting the importance of technology, information and knowledge to provide higher life quality.

Model: Rbcih (2018), this model is based on the possibility of exchange of experience between cities, and the objective of creating a seal for the classification of a smart city. This model uses as indicators for evaluation the ISO 37120, which is not suitable for smart cities analysis. This model (see Table [3]) does not cover economic development for smart cities, which is premise for evaluation of a city.

Model: NBR ISO 37120 (2017) is a norm that does not seek to define what is a smart city, but rather the levels of quality of services of city halls; it has several indicators, but all aimed at measuring the performance of urban services as well as life quality. In Table 3 the norm contemplates all domains but its indicators are not specific to smart cities.

Model: ISO 37122 (2017), a norm for smart cities as a form of evaluation, establishes indicators and definitions of methodologies to measure and consider aspects and practices that dramatically increase the pace at which cities improve their maturity results. In Table 3 we see that the standard covers all domains and, most important, it is focused and specific and with indicators of evaluation for smart cities; it is the only one standardized with bias for smart cities.

Model: Weiss (2016). Titled as evaluation of the readiness of the TICS, its application is directed to the urban management of the cities, in order to be able to qualify them as smart. This model is exclusively focused from the perspective of TICS; as verified in Table 3, it leaves 3 open domains and thus prioritizing only the TICs.

Model: Guimarães (2018) focused on the national context in a way that escaped from the existing traditional and classic models that inevitably give rise to rankings. However, this model, according to Table 3, leaves a gap

in 3 domains that are extremely important for the development of a smart city.

Based on the raised data, having as parameters ISO 37122 is possible to perceive that some of the models take care of to the demanded minimum domínios for an intelligent city.

Many models provide a set of domains and indicators that measure their dimensions. Some models list and reward smarter cities, others certify, others compare, and so each model tries to fit a single goal, which is the development towards the smart city. However, grievances that contemplate the models mentioned here need a standardization to achieve such accomplishment, and for this reason the standardization norm for smart cities (ISO 37122) is used here. Such norm involves in its completeness all the domains as well as its specific indicators for smart cities.

#### IV. CONCLUSION

Based on the study, it is concluded that the analyzed models present different aspects and with the same purpose: city development. Although some models are in developmental phase, they all corroborate the need for massive insertion of ICTs for such development.

Smart cities are established by essential domains for their development and among the analyzed models, correlating with the characteristics that a smart city should have. The one that best fit was ISO 37122, due to standardized definitions and methodologies for a set of performance key indicators as tools to thus become more sustainable and smarter in data development and construction.

The aim of standardization is to build a data culture and have globally comparable and standardized city data, let cities learn from each other to become smart and sustainable cities.

In order to assist cities, the international standard ISO 37122 will help them implement policies aimed at the development of smart cities, and such adoption will favor the fidelity of the application of a certification adopted by ISO 37122 in cities that claim its application, receiving then the recognition of Smart Cities.

For the above-mentioned studies it was noticed that a standard to be followed is still lacking, since each model is built in order to meet a certain demand, respecting local characteristics, so no model can be considered better, nor even more complete, since it is possible to verify that most models are undergoing maturation process. The methodologies such as those discussed in this work allow other researches to create ways of using these models and / or applying the international standardization ISO 37122.

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# Non-Conventional Food Plants in Paraná Coast-Brazil: A Brief Overview of Production and Trade

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**Abstract**— In Paraná Coast lacks production alternatives in rural areas due to the high natural declivity of the land, as well as the low natural fertility of the soil and few areas available to plant because the large presence of environmental preservation areas. In this context, new alternatives within the pluri-activity perspective should be considered in the generation of income for family agriculture. Non-conventional food plants (NCFP) seemingly meet the prerogatives, but studies were not found on this regional production system that could attest the production and trade of this plants as an income alternative. Thus, from June to October of 2018, a descriptive exploratory research with qualitative nature was carried out with farmers that had recognized tradition in the cultivation of these types of food plants, in order to delineate an overview of the regional activity, as well as the implication and potential of the crops. The study found that farmers lived in rural areas and on average had a cultivation of 0.5 hectares of NCFP, which generated an income of approximately USD 180.00 per month. The most cultivated species were Taioba (*xanthosoma taioba*), serralha (*sonchus oleraceus*) and Hibisco (*hibiscos acetosella*). The main implications of the farmers' perception were the lack of agronomic knowledge for the introduction of new crops, few specialized technicians for technical assistance, and the lack of public sector incentives. The main potentialities observed were the loyal customers, the species of NCFP which are traditionally more resistant to pests and diseases and that favor the cultivation, besides being a factor that provides an alternative of income in the concept of rural pluri-activity.

**Keywords**— Agribusiness, Family Agriculture, Rural pluri-activity, Non-conventional food plants, Caiçara culture, Organic agriculture.

## I. INTRODUCTION

Family agriculture in Brazil is responsible for approximately 70% of the national agricultural production and within this productive context the variability of species and crops is diversified, guaranteeing better food conditions (Fuhr, 2016).

Besides contributing positively to the country economy, the family agriculture also promotes alternative of income to families with lower monetary conditions, although in these cases the cultivation was more oriented toward their own consumption, surplus trade generates income and has a relevant social character (Guilhoto, 2007).

The National Program for Strengthening Family Agriculture, Pronaf, came specifically to meet the demand of these families who do not have guarantees and help such as financing for agricultural production, which further strengthens the practice of farming as a change in the social and economic reality of the Brazilian farmers (Nead-Fipe, 2004).

The public policies created for the family farmer in the National Family Agriculture Policy (Law No. 11.326, 2006) established relevant issues to the national and local development in relation to the farming practices in rural areas. Part of this is because the family farmer is the main agent of a complex heterogeneous and flexible system in terms of the means of production, new markets, being also a provider of income and the main form of farmers' sustenance, reducing the exodus rural (Buainain et al., 2003).

In front of new forms of cultivation, especially with the adaptation to the reality of the upward consumption of new types of food, the small family farmer has been pioneering in these systems combining the social and economic transformations to the modernization of its properties, inserting the cultivation of new species which



previously did not have a high commercial interest (Schneider, 2003; Barreira et al., 2015).

The portfolio of new forms and species of crops for family farming in Brazil has been relevant the production of Non-Conventional Food Plants (Borges, 2018).

The NCFP are an acronym to refer to Non-Conventional Food Plants which, according to Knup and Lorenzi (2014), have one or more parts or even derivatives of these parts which can be used directly in the human food and a significant amount of these species of unconventional food plants are nutritionally richer than domesticated plants (Kinupp, Barros, 2008), which explains the rise of NCFP in some regions of Brazil and the world.

The cultivation of NCFP has been being a relegated activity in Brazil both for the general population as related to the farmers, but it has the potential to generate income, having importance in the family budget, as well as in the local economy and in the guarantee of the food security of the farmers' families, since the majority of the species also present significant nutritive contents (Borges, et al., 2018).

It is estimated that there are approximately 12,500 species, 3,100 genera, within 440 families of eatable plants. They are characterized by flavoring products, condiment species or parts of a plant that can be "reused", such as: roots, bulbs, tubers, leaves, shoots or seeds (Knupp, Barros, 2007).

Thus, for the expansion and production of NCFP, there should be incentives for this sector of the family agriculture, since they can bring considerable gains to all parties involved, especially to the small farmer (Mda - Sead, 2017).

According to Embrapa (2014), the overview related to the new ways of producing shows positive trends, in this context it is urgent to evaluate the development of new technologies for the small farmer in the expansion of the crop portfolio, as well as to guarantee quality assurance and food security to these families, which from the expansion of knowledge could also have the aggregation of value and generation of value and family income.

It is fundamental the role of the family farmer in the dynamization of the local economy, promoting the innovation, evidencing its preponderance as a factor that leads to the increase of the cultivation potentialities, aligned the interface with local institutions adding value to the crops (SCHNEIDER, 2010), in this context the NCFP could represent a relevant alternative of production diversification and productive innovation for the benefit of small producers (BORGES, 2018).

As for the Paraná Coast due to the high slope of the land and the low natural fertility of the soil, there are few alternatives of agricultural production, especially those

with scarce planting space (Negrelle, Anacleto, 2013). Thus, the NCFP are easily adaptable, resistant and may represent a viable alternative for cultivation (Kinupp, Barros, 2008; Barreira et al., 2015).

The Paraná Coast covers 7 municipalities, of which in the rural context can be characterized by the practice of family agriculture, having a maximum of 4 fiscal modules, approximately 20 hectares, being the main source of income with agricultural origin (Mda, 2016).

The region has the largest area of conserved Atlantic Forest in Brazil (Ferreira, Negrelle, 2007), which limits agricultural practices in the region, but it is classified as an environment auspicious for the cultivation of NCFP, since there are more than 15 thousand species of plants available along the forest with a large contingent that can be used in agriculture as food and source of resource for family income (Barreira et al., 2015; Sosma.Org 2018).

Despite the relevance of the NCFP as an alternative income and its adaptability the Paraná Coast region, few and sparse studies deal with this regional theme, thus, in this context, this study aimed to elaborate, in the perception of the family farmer, that also produces non-conventional food plants, an overview on the NCFP encompassing the socioeconomic implications and potential in the regional context.

## II. MATERIAL AND METHOD

A prospective study on the possibility of cultivating Non-Conventional Food Plants as income alternative for five small family farmers from Paraná Coast was conducted as the basis for the execution and composition of this paper. Then, similarly to that was proposed by Barreira et al. (2015) it was carried out between June and October of 2018 an exploratory descriptive research with qualitative nature in Paranaguá, Morretes and Guaratuba.

It was used as data collection instrument, a semi-structured interview with a script with a pre-elaborated questionnaire (Triviños, 1987). The interviews were recorded in audio and performed in the residence of the farmers who voluntarily agreed to participate in the research and consented to the recording process.

Initially the interviewees answered about the socioeconomic profile regarding to the age group, time working in agriculture and types of NCFP cultivation. Then, the farmers answered questions about NCFP cultivation, related to the main implications and trade of these species, as well as the greater opportunities of working in this segment, since the farmers that participated of this research had experience in NCFP cultivation.

After collecting data from the previous phase, with the help of the five producers of NCFP and two expert technicians, according to what was proposed by Campos

et al. (2017) and Costa et al. (2018), a cross-impact matrix was organized.

The matrix employs percentage values from 0 to 100 for each opinion that the interviewees shared collectively in relation to the other opinions expressed, comparing each analyzed item in the relation to the influence exerted and the influence suffered in the cultivation and commercialization of NCFP, thus the higher the index, the greater the relevance and attention to be given in order to solve the problem suffered by the family farmers or the valuation to be attributed to the opportunities that can prospect to the activity.

The impact matrix generates an index of relevance (the development importance) that can be obtained by the equation:

$$IR = \frac{FA \times FB \times 100}{\sum SF}$$

IR= Relevance Index of the evaluated situation;

FA = Influence received indexes;

FB = Influence suffered indexes;

$\sum SF$ = Indexes sum (FA x FB) of all the issues analyzed.

hen according to Costa et al. (2018) it was adopted the interpretive and descriptive analysis of the contents obtained through the technique of data triangulation among the observation of the researchers, the similar answers obtained from the farmers and the specialized literature on the subject.

### III. RESULTS

The interviewees in the totality were married or in a stable union, masculine gender, with age average fifty years old, their school level was in the majority of High School (n = 75%) or with Elementary School yet (n = 25%).

The producers lived in rural areas, where they have cultivated traditional agricultural species such as banana, cassava, rice, vegetables among others. As well as they raised small animals such as poultry and pigs for the family alimentation. The average size of the rural properties was approximately 7 hectares, and on average each producer used 0.5 hectare for the NCFP cultivation, and in these areas the cultivation was practiced on average of 11 years. Similar to the traditional foods, most NCFP require a process of transformation such as cooking, boiling or drying for human consumption, and in this context that is a decisive factor in the choice of what species the farmers will cultivate, the simpler the process is, the lower the consumer rejection. The species and parts of NCFP most cited in cultivation or extractivism in

Paraná Coast were Taioba (*Xanthosoma taioba*) for the trade of leaves and rhizomes, Serralha (*Sonchus oleraceus*) for the trade of leaves and Hibiscus (*Acetosella hibiscus*) for the trade of immature fruits that are eatable, used in the preparation of tea, soft drinks, juices and jellies and the pulp of mature seeds of Palmito Juçara (*Euterpe edulis*) for juices and jellies as an alternative to Açaí pulp, amazon Maná Cubiu (*Solanum sessiflorum*) for the trade of fresh fruits that can be used in the preparation of juice, picão preto and pico pico, (*Bidens pilosa* L) in the trade of safflower seeds, Ora-pro-nóbis (*Pereskia aculeata*) for the trade of leaves, Beldroega (*Portulaca oleracea*) for the trade of leaves. The most cultivated species were Hibisco, Taioba and Serralha cultivated in most part of the properties because according to those interviewees they have higher demand and higher profitability.

The lack of technical knowledge about the cultivation of NCFP is linked to the existence of few specialized technicians on the sector, resulting from a scenario that apparently in the short term is difficult to solve (Table 1).

Table 1. Implications of non-conventional food plants in the perception of rural producers in Paraná Coast.

	Implications	IR
1	Lack of agronomic knowledge for cultivation	19,10
2	Few technical experts on technical assistance	14,11
3	Lack of public power incentive	14,11
4	Absence of specialized fairs	11,97
5	Difficulty of products insertion in the conventional market	9,46
6	Little capital of the farmers in order to potentialize the means of production	8,91
7	Unaware of commercial practices	8,07
8	Product does not have the organic product quality stamp	6,52
9	Distance makes logistics difficult between producer and customer.	4,44
10	Some species are difficult to cultivate	3,31

The totality of the interviewees (Table 2) declared that the NCFP cultivation was the second most important income alternative to the family, being relevant in the regional context the cultivation of bananas, rice, artisanal fishing, thus they characterized the activity as an alternative of income supplement in the context of rural pluri-activities. In this sense, the average income of the producers with NVFP commercialization was USD 180.00 per month, and the activity was performed with the use of family labor in the majority of the cases (n = 80%).

The respondents in their totality informed that they were doing the cultivation of NCFP in a totally natural way and with no use of pesticides, but they did not have the stamp for organic certification.

*Table 2. Potentialities of non-conventional food plants in the perception of rural producers in Paraná Coast.*

	Opportunities	IR
1	Customers' loyalty	20,96
2	Species of NCFP resistant to pests and diseases	16,01
3	Provide alternative income in the concept of rural pluri-activity	11,77
4	NCFP market is rising	9,14
5	Organic Production	8,84
6	Weather conditions good for these cultivations	8,12
7	Exotic products with high nutritional content	7,31
8	Low competition among NCFP producers	6,99
9	Next to large consumer centers	5,75
10	Recent research growth on the topic	5,11

Regarding to the market expectations, the most part of the respondents (n = 80%) reported that they feel satisfied and have a desire to cultivate new varieties of NCFP, if the implications of the activity could be mitigated.

#### IV. DISCUSSION

The producers interviewed in their entirety reported that the sale of Non-Conventional Food Plants is seasonal, and that situation is a result of their respective natural cycle. Although they are holders of the cultivation knowledge and cultural treatments of some species, these factors were still classified as the main limiters for the activity to grow, which reduces the commercial prospection of new species.

The technical assistance system in Paraná Coast is composed with a qualified governmental network, but they have to fulfill the governmental attributions in the service of the great commodities such as banana, rice and ginger, mitigating the service to small producers, as those who cultivate flowers, produce sugar cane brandy as well as the promotion of NCFP.

Thus, in front of the fact that technical assistance from the private sector is costly to family farmers in Paraná Coast, the cultivation of new varieties is not carried out because the producers do not have a deep knowledge to work with new species. Since they do not have this know-how or guided agronomic technical assistance, they are limited to the same varieties that they produce for a decade, leaving stagnated the production system that apparently has been

a main alternative condition of family support, as also explained by Barreira et al. (2015).

The stimulus of the public power to the development of NCFP can be done by several ways. The first one is the provision of technical assistance, which although is not available in an individualized and a thematic way, could be treated in the format of a learning field day, technical excursion to other producing regions and technical or theoretical lectures.

Another issue to be analyzed by the public authorities is the inclusion of NCFP in the school lunch programs, which promotes the acquisition of fruits and vegetables from local family producers from all municipalities of Paraná, what nowadays does not contemplate the acquisition of NCFP.

For that, the rural development of small producers, in order to meet new demands, also depend on incentives and support from development institutions that corresponding to these activities, according to Grisa and Schneider (2015), the National Program of Family Agriculture – PRONAF, has made available in the last few years, reduced-interest financing to small family farmers through the Plano Safra Agricultura Familiar (Family Agriculture Plan), which provided subsidies of approximately US\$ 6.51 billion to the conventional agriculture, but there is no investment considering NCFP segment.

In relation to the cultivation of NCFP and the performance of the governmental institutions, a new and contemplative dialogue should be initiated, being a resultant factor in practical actions which could benefit the sector, as described by Balsadi (2001) that there must be the understanding of the increasing incidence of new rural occupations due to crises in Brazilian agriculture in the last decade, and that the new perspectives of cultivation, aligned to the new technologies and agricultural occupations should be viable and have institutional support.

Apparently, the dynamization and growth of this market in relation to the family agriculture production and trade is very associated to the lack of information between producers and governmental institutions, being this question more evident, since all the interviewed producers have attested that they never used pesticides in the production system, and they still do not have the organic products stamp. Thus, the lack of information is evident given that there is an organic institution linked to a university research in Paraná Coast, which for more than a decade has been promoting the organic certification for the regional producers for free.

In this context, the communication between the public institutions for development, education and technical assistance provoked by the producers may result in a new

cycle of information that, using the traditional knowledge of the families involved, may align these new activities in the context of rural development.

The role played by productive sustainability according to Cheung (2013), aligning the rural development should be shared by the small family farmer towards the formation of a community system complex, promoting an environment with habit, historical experiences and values attribution, strengthening the territorial identity. This should also be a vision focused on the development of new technologies and new products for cultivation, promoting a relationship and trust network that supports each other, instigates and seeks new alternatives while creating ways to mitigate the implications of this process. The current overview on Paraná Coast has a diagnosis where the NCFP constitute an important strategy of food sustenance, as well as in the use of surplus family labor, which results in the generation of income. The set of these factors tied to the fact that according to Barreira et al. (2015) depending on the species, NCFP are easier to produce due to their natural resistance to pests and diseases, being in line with the perceived consumer loyalty, resulting in a scenario where the set of opportunities reveal the possibility of expanding the activities planned in the concept of rural pluri-activity what in the short and medium term can positively impact in the regional socioeconomic scenario.

On the other hand, the national economic scenario must be impacted by the entrepreneurial activity of family farmers, but besides that and according to Schneider (2003) it must also be linked to governmental actions, since that in the context of agribusiness public policies affect, in an intensive way, whether positively or negatively, the small family farmers. These producers, then, are the biggest ones affected by the current lack of incentive and promotion of NCFP in the development of pluri-activity.

Still in this context of rural pluri-activity, there is a correlation to the cause and effect phenomenon, where family farmers have a scarce source of income and they are motivated to look for new sources in order to obtain more income. As in the context of NCFP, it was observed that the producers from Paraná Coast region promote other activities related to the conventional agriculture such as fishing, handicrafts, or even rural micro-industry. Thus, the families divide the tasks so that each person performs a given productive activity and the diversified sources of income reduce the influence of the natural conditions such as climate and time on the preponderance of a food and economic guarantee.

The circumstances in which the rural pluri-activity is adopted by producers is emphasized in the integration of various occupational combinations of what is rural, in

order to promote a new perspective of obtaining income for these families and that this characteristic should be maintained as a form of autonomy and rural support.

## V. CONCLUSION

The producers have lived in rural areas and on average cultivated 0.5 hectares of NCFP, generating income of approximately USD 180.00 per month, and the activity was performed using family labor in the majority of cases (n = 80 %).

The most cultivated species were Taioba (*xanthosoma taioaba*) for the trade of leaves and rhizomes, serralha (*sonchus oleraceus*) for leaf trade, hibiscus (*acetosella hibiscus*) for the trade of immature fruits that are eatable, used for the preparation of tea, soft drinks and jellies.

The main implications observed in the producers' perception were the lack of agronomic knowledge in order to introduce new crops, the shortage of specialized technicians for assistance and the lack of public power incentive to the sector. The main potentialities observed were consumers' loyalty, the species of NCFP are traditionally more resistant to pests and diseases what favor cultivation, and the fact that NCFP provide an alternative of income in the concept of rural pluri-activity. Then, related to the market expectations, the biggest part of the respondents (n = 80%) reported that they feel satisfied and have the desire of cultivating new varieties of NCFP, if the implications of the activity could be mitigated, which reveals a scenario where the set of opportunities in the producers' point of view is largely favorable in relation to the implications.

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