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Dr. Swapnesh Taterh

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FOREWORD

I am pleased to put into the hands of readers Volume-6; Issue-3: 2019 (Mar, 2019) 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: April, 2019

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Production of Dissertations and Theses on Mobile Learning in Brazilian Postgraduate Courses

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Abstract—This article aims to map and analyze the scientific productions about mobile learning, found in theses and dissertations registered in the Coordination for the Improvement of Higher Education Personnel (CAPES). The present research is characterized as a quantitative, retrospective and documentary study. It was used as a criterion, to present in any part of the abstract or text, the descriptor mobile learning, and to be published between 2014 and 2017. The results found allowed to visualize the academic production of theses and dissertations on the mobile learning in Brazil in recent years.

Keywords—Mapping, Academic Production, Mobile learning.

I. INTRODUCTION

In the last decade we see that mobile devices are spreading at a speed never before seen, about 95% of the world's population is living in an area covered by a mobile cellular network (ITU, 2016). The number of cell phones has grown exponentially, with most adults having even more than one mobile device (Statística, 2016). For Bairral, Assis e Silva (2015) digital technology is part of the daily life of young people, in the most varied models of mobile devices, highlighting the need and possibilities of diffusion of this theme. Pimmer, Mateescu and Grohbiel (2016: 492) also report that even after more than 20 years of research on mobile learning, there is still relatively little systematic knowledge available on the subject.

Mobile learning enables numerous improvements in student education environments, allowing the use of mobile devices as an educational tool for learning anytime, anywhere, making them more convenient for students. Along with day-to-day activities, students can at any time study and share their doubts about the subjects studied with their colleagues and teachers. Thus increasing your study times and possibly contributing to

better grades during the exams. Mobile learning encourages collaborative learning by allowing students in different locations to be in contact with their peers to discuss and learn the topics being taught, forming an excellent learning support environment (MURSHIDI, 2017).

In this perspective, this article aims to map and analyze the scientific productions on mobile learning, found in theses and dissertations registered in the Coordination of Improvement of Higher Education Personnel (CAPES). The realization of this mapping is justified in order to consolidate a field of knowledge that is in an advanced constructive process. It was decided not to deepen in conceptual and methodological questions of mobile learning in the conception of the authors of the works investigated.

In this work, we present, besides this introduction, considerations about the relevance of the study of mobile learning. The method and procedures of the research are described below. Afterwards, the main results of the analyzes carried out and discussions of the general panorama about the publications are presented, finally, the final considerations of the study emerge.

II. CONSIDERATIONS ON THE RELEVANCE OF THE REVIEW OF MOBILE LEARNING

Mobile learning is defined by Crompton (2013, p. 4) as "[...] learning in multiple contexts, through social and content interactions, using personal electronic devices [...]". There are some studies that have proposed to verify the state of the art in relation to mobile learning in Brazil, such as:

Almeida and Araújo (2013) in the article entitled "The use of mobile devices in the educational context: analysis of national theses and dissertations", analyzed the state of the art of the use of mobile devices in formal education in Brazil from 2003 to 2012. The results pointed to the need to investigate this field of research with precision. The

analysis of the focus of the research on the use of mobile devices in teaching allowed to identify that a large part is focused on Higher Education, requiring, therefore, initiatives that also contemplate the other levels of education. Also, the results pointed out the need to encourage the learning process outside the traditional classroom, since the use of these resources is still restricted to the physical space of a classroom. There was a need for more research that analyzes the role of the teacher as mediator in this process.

Carvalho, Galvanin and Santos (2018), in the article "Mobile learning in Brazil: a mapping of theses and dissertations", mapped Brazilian theses and dissertations on mobile learning in the areas of education and / or education, published after 2013 to November 2016. The analysis carried out data related to: distribution of work per year, degree, regions, institutions, area of concentration, research line and study topic.

These studies provided a valuable synthesis of research on mobile learning. A review is added to these studies, including an updated synthesis of the general characteristics of the empirical studies, through the mapping and analysis of the scientific productions on mobile learning found in theses and dissertations registered in CAPES between 2014 and 2017. Being unique, to be (academic masters, master's and doctoral), programs (education, teaching and letters, among others) and teachers (orientation and participation in the area's).

III. METHODOLOGY

This research is characterized as a quantitative, retrospective and documentary study, presenting a mapping of dissertations and theses available in the catalog of theses and dissertations of CAPES ([http://catalogodeteses.capes.gov.br/catalogo-teses/#! /](http://catalogodeteses.capes.gov.br/catalogo-teses/#!/)), which presented in any part of the abstract or text, the mobile learning descriptor, carried out between 2014 and 2017.

The CAPES Portal was used as the highest body in the evaluation of stricto sensu postgraduate studies in Brazil. This research tool brought together the dissertations and theses defended from 1987, and this information was provided by the postgraduate programs to CAPES, being these responsible for the veracity of the data. Another reason for choosing this tool was the practicality, allowing the realization of filters. As a limitation of the study, it highlights the breadth of this mapping, which did not seek to deepen the conceptual and methodological questions of mobile learning in the conception of the authors of the investigated works.

Thus, a systematized search was carried out in the thesis and dissertations database of CAPES, using as inclusion criteria: theses and / or doctoral dissertations, academic

masters and professional masters that presented at least one of the descriptors the term mobile learning and be registered in the CAPES database from 2014 to 2017. Then, the researches found were evaluated to ensure that they met the stipulated inclusion criteria.

With the accomplishment of the electronic search in the site of the CAPES returned 22943 studies, being 4494 of theses of doctorate, 12042 of dissertations of academic masters and 6387 of dissertations of professional masters. CAPES's own page filters were used to carry out analyzes in the database. However, since there were countless other papers that presented the established term, they were filtered in a new cut of 292 papers with a specific focus on education and / or teaching, for a more in-depth analysis of the lines of research studied and experiences in Brazilian graduate programs. Next, we present the results obtained by means of the survey of the theses and dissertations that present the term mobile learning in the stipulated period.

IV. RESULTS AND DISCUSSIONS

In the search carried out in the thesis and dissertations database of CAPES, 22943 studies were classified as descriptive, in any part of the abstract, of the terminology mobile learning. According to table 1, there was a predominance of the production of works in which mobile learning was cited in the academic masters of the three categories of programs analyzed (academic masters, master's degrees and doctorates), confirming the work of Carvalho, Galvanin and Santos (2018). also highlighted a considerable difference in the amount of master's and doctoral work, attributing this to the possibility of being due to the greater amount of programs existing in the Brazilian territory of master's degree than doctorate.

Table.1. Frequency of theses and dissertations recorded between 2014 and 2017.

Types of courses	Absolute value	Percentage (%)
Academic Masters	12042	52,5 %
Doctorate degree	4494	19,6 %
Professional Master's Degree	6387	27,9 %
Year	Absolute value	Percentage (%)
2017	6373	27,8 %
2016	6098	26,6 %
2015	5667	24,7 %
2014	4805	20,9 %

Table 2 identifies the main areas of knowledge developed by post-graduate studies, in which mobile learning was cited, with the education area registering the most jobs, followed by science and mathematics education. Confirming the work of Carvalho, Galvanin and Santos

(2018) who also pointed out these areas as the ones with the greatest amount of work, and according to the same authors this indicates the interest in developing methodologies and knowing new techniques to improve such areas.

Table.2. Frequency of the area of knowledge of theses and dissertations recorded between 2014 and 2017.

Knowledge area	Absolute value	Percentage (%)
Education	5033	21,9 %
Teaching science and mathematics	3008	13,1 %
Teaching	1371	5,98 %
Letters	1128	4,92 %
Mathematics	924	4,03 %

When analyzing separately the programs of academic masters, professional master's and doctorate, Table 3 shows a significant growth in the productions of theses and dissertations in which were cited mobile learning in both academic and professional masters as in doctorates, Para Almeida and Araújo (2013, p. 30) to "[...] progressive decrease in the cost of mobile devices, increased number of brands and models of tablets in the market, incentive to government projects to use tablets in elementary and middle school [...]] "Are some of the reasons for the growing number of mobile learning surveys.

Table.3. Frequency of theses and dissertations recorded between 2014 and 2017, separated by course.

Year	Academic Masters	%	Professional Master's Degree	%	Doctorate degree	%
2017	3152	13,7 %	1898	8,2 %	1323	5,7 %
2016	3106	13,5 %	1839	8,0 %	1153	5,0 %
2015	3008	13,1 %	1577	6,8 %	1082	4,7 %
2014	2784	12,1 %	1081	4,7 %	940	4,0 %

In relation to the production in the three types of course, it is noticed that the academic masters are the most productive, possibly seen the largest number of courses in this modality. But it is possible to perceive in all three types a growth in the quantity of productions, in which mobile learning was mentioned.

Table 4. Frequency of the main institutions of theses and dissertations recorded between 2014 and 2017.

Institution	Absolute value	Percentage (%)
University of Sao Paulo	954	4,16 %

Federal University of Rio Grande do Sul	660	2,88 %
University of Brasilia Pontifical Catholic	620	2,70 %
University of São Paulo	589	2,57 %
Federal University of Minas Gerais	512	2,23 %

As for educational institutions, both public (federal and state) and private, it has contributed to the development of research in which mobile learning has been cited in recent years. With emphasis on the University of São Paulo, which is the educational institutions that produced the most work in this condition in recent years, as presented in Table 4.

Table 5. Frequency of major theses and dissertations programs between 2014 and 2017.

Name of Programs	Absolute value	Percentage (%)
Education	3882	16,9 %
Mathematics in National Network	907	3,95 %
Letters	768	3,35 %
Administration	530	2,31 %
Mathematics Education	422	1,84 %

The program that stands out most is education, as shown in Table 5, which is justified considering the objective of the current National Basic Education Plan that aims to train professionals for Basic Education through professional qualification through the stricto sensu Postgraduates in the area of Education (BRAZIL, 2011). In addition to this, the "digital natives" according to Prensky (2016) are the current public of the schools, seek to research emerging issues of this new reality of society, and are eager for technological tools that support the learning process.

Table 6. Principal teachers on the subject between 2014 and 2017.

Advisors' Name	Absolute value
Jose Claudio Del Pino	32
Fernando Luiz Affonso Fonseca	18
Júlio Gomes Almeida	17
Jose Aires de Castro Filho	16
Alex Sandro Gomes	14

Table 6 presents the most prominent teacher in the orientation of research in which mobile learning was cited, which was the teacher Jose Claudio Del Pino. As for participation in newsstands, the professor with the largest participation in newsstands was Professor Fernando Luiz Affonso Fonseca, as shown in Table 7.

Table 7. Main professors in the stands on the subject between 2014 and 2017.

Name of Teachers	Absolute value
Fernando Luiz Affonso Fonseca	50
Cristina Massot Madeira Coelho	39
Saddo Ag Almouloud	39
Vera Lucia Messias Fialho Capellini	39
Ana Maria Iorio Dias	34

Tables 8 and 9 show respectively the main guiding teachers separated by type of course and the main participating bank teachers by type of course. Aiming this way, the main professional references involved with researches in which mobile learning was cited in recent years.

Table 8. Principal teachers between 2014 and 2017, separately by type of course.

Academic Masters	Absolute value	Professional Master's Degree	Absolute value	Doctorate degree	Absolute value
Julio Gomes Almeida	14	Adriano Salmar Nogueira E Taveira	13	Jose Claudio Del Pino	16

Table 9. Main teachers in the cages between 2014 and 2017, separately by type of course.

Academic Masters	Absolute value	Professional Master's Degree	Absolute value	Doctorate degree	Absolute value
Fernando Luiz Affonso Fonseca	32	Cleide Carneiro e Eliane Scheid Gazire	15	Roger Miarka	15

The analyzes also showed that the experiences currently carried out in works focused specifically on education and / or teaching, on the theme of mobile learning, cover aspects such as: verifying the use of mobile devices and creating applications for teaching and learning. Borba et al. (2016) states that studies on this subject cover the potential of devices for teaching and learning, the use of devices by pupils and teacher training.

In order to complement the information regarding the areas of concentration and lines of research studied, we synthesized what is being researched and which are the most significant experiences being developed with mobile learning in works with a specific focus on education and / or teaching. Literacy, the training of tutors and teachers, and the learning of contents from diverse areas such as mathematics, physics, chemistry, biology, history, English, letters and Portuguese, were investigated. learning and strategies of use of mobile devices and applications in the process of teaching and learning. Evidencing that the mobile learning theme is essentially multidisciplinary, challenging graduate programs to involve numerous areas of knowledge.

Finally, this analysis of theses and dissertations became important, as it provided an overview of the production involving the theme of mobile learning in Brazil in recent years.

V. FINAL CONSIDERATIONS

Research on academic production in the area of mobile learning provides professionals and researchers of education and areas for purposes an update of how is the development of research in this field in a general context. Thus, in performing a mapping on mobile learning, we identified the growth in the number of jobs in which mobile learning was cited in both academic master's, professional master's and doctoral studies.

In spite of the limitation, due to the amplitude of this mapping, which did not aim to deepen the conceptual and methodological questions of mobile learning in the conception of the authors of the works investigated, this study allows a synthesis on the researches developed in the postgraduate courses, allowing the discussion between teachers, students and institutions on mobile learning in Brazilian universities, through an overview of the research situation in which mobile learning was mentioned at the national level.

The present study confirmed that the scientific researches involving mobile learning presented significant growth in both academic and professional masters as well as in doctorates, identified the main areas of knowledge developed by the postgraduate studies, in which mobile learning was cited, presented the main institutions which has contributed to the development of these researches in recent years, the programs that stand out most in these researches and the main professional references involved with works in which mobile learning have been cited in recent years.

The results allowed to visualize the academic production of theses and dissertations on the theme of mobile learning, we have established a quantitative panorama of academic publications in recent years. Further deepening

in the areas of concentration, lines of research studied and important experiences that are being developed with mobile learning in works with specific focus on education and / or teaching. Needing additional studies to delve into scientific productions in this topic, considering that there is much to be explored in this area of research, from its potentialities and limitations to its reflections in society.

com/statistics/245501/multiple-mobile-

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Monte Carlo Simulation for Data Volatility Analysis of Stock Prices in Islamic Finance for Malaysia Composite Index

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Abstract— The objective of this study is to evaluate the volatility rate of sharia-company in Malaysia Stock Exchange using Monte Carlo Simulation (MCS). This study collected daily stock price form Thomson Reuters Datastream for calculating monthly return and volatility rate. In validating the findings of volatility rate, this study performed normality diagnostics test, and Monte Carlo Simulation (MCS). Result indicates the distribution of volatility rate is follows normal distribution. In addition, Monte Carlo Simulation also proved the volatility rate is 4.85% and standard deviation is 2.23. Result of process capability shows the value of volatility rate is under statistical control with implementation on Monte Carlo Simulation. The significant of this study is it provides a better understanding for investors regarding the financial environment in Malaysia Stock Exchange. This information will help investors to make proper selection of their investment portfolio.

Keywords— Monte Carlo Simulation, Malaysia Stock Exchange, Volatility, Islamic Finance.

I. INTRODUCTION

Financial economists, market participants and international organizations view shariah-compliant companies as a main key in contributing capital into financial market in Malaysia. An accurate forecast of future volatility delivers important information to market participants and, consequently, there is an option to essentially bet on volatility (Kongsilp, Mateus, 2017).

Various empirical investigations have been performed to analyze the volatility of shares price. Forecasting volatility of shares price plays important roles in investment market (Abu Bakar and Rosbi, 2017). Volatility is measure variation of price of financial instrument over time, and as much the market is volatile, it creates risk which is associated with the degree of dispersion of returns around the average (Siddikee and Begum, 2016). Lack of efficiency in monitoring, regulating and supervising would result with the collapse of stock market such as high volatility and bad company

performance in term of revenue, dividend and etc. (Abu Bakar, et al., 2018a).

Therefore, the purpose of this paper is to determine level of volatility among shariah-compliant companies on Malaysia Stock Exchange. The main important to be listed on the shariah board is that companies must be free from prohibited element in shariah law such as riba, gharar and maisir (Abu Bakar and Rosbi, 2016).

The method implemented in this study is volatility calculation, normality checking procedure and Monte Carlo Simulation. Monte Carlo Simulation approach is widely used in the literature (Prakash and Mohanty, 2017; Watzenig et al., 2011; Ghiani, et al., 2004). Currently, Monte Carlo approach is tested in the financial field. According to Adkins and Gade (2012) Monte Carlo simulations are a very powerful way to demonstrate the basic sampling properties of various statistics in econometrics. The main function of Monte Carlo approach is to develop large data set. Thus, this study try to fulfill the gap by investigate the level of volatility among shariah-compliant companies listed on the Malaysian Stock Exchange using a Monte Carlo Simulation method.

II. LITERATURE REVIEW

Investment is the complex process involving decision making regarding the possible expected rate of return (Abu Bakar and Rosbi, 2018b). Investors can reduce risk even more substantially if they hold an internationally diversified fund as globally diversified portfolios would dominate domestic-only ones on the efficient frontier (Bahlous and Mohd. Yusof, 2014). Study by Mohd Thas Thaker, et al., (2018) regarding the influence of information content and the informativeness of analyst reports towards cumulative abnormal return in the Malaysian market found target price, earnings forecast, return on equity, cash flows to price and sales to price ratio variables are shown to have a strong association with the returns.

Messis and Zapranis (2014) investigate the existence of herding in the Athens Stock Exchange over the 1995-2010 periods and examine the effects on market volatility. They found that the large differences are observed among the portfolios regarding the herding periods. The results confirm a linear effect of herding on all volatility measures considered. Stocks exhibiting higher levels of herding or adverse herding will also present higher volatility, and from this point of view, herding can be regarded as an additional risk factor. Study from Coskun and Ertugrul (2016) regarding volatility housing price in Turkey suggest several points. First, city/country-level house price return volatility series display volatility clustering pattern and therefore volatilities in house price returns are time varying. Then, a significant economic event may change country/city-level volatilities. Lastly, house price return volatilities differ across geographic areas, volatility series may show some co-movement pattern.

Ismal (2010) uses Value at Risk (VaR) approach to compute the volatility (risk) of returns and expected losses of Islamic bank financing in Indonesia found that the equity and debt-based financing produce sustainable returns of bank financing. He also found that the performance of service-based financing is very sensitive to the economic conditions and finds that risk of investment and expected losses are well managed. While studying the materials of Floros and Salvador (2015) regarding the effect of trading volume and open interest on the volatility of futures, markets found that market depth has an effect on the volatility of futures markets but the direction of this effect depends on the type of contract. Akhtar and Khan (2016) analyzing the nature of volatility on the Karachi Stock Exchange and develop an understanding as to which model is most suitable for measuring volatility among those used. The results reveal that daily, weekly and monthly return series show non-normal distribution, stationary and volatility clustering. The study shows the high persistence of volatility, a mean-reverting the process and an absence of a risk premium in the Karachi Stock Exchange market with an insignificant leverage effect only in the case of weekly returns. In addition, to analyze the impact of global financial crises upon volatility, their findings show that the sub-periods demonstrated a slightly low volatility and the global economic crisis did not cause a rise in volatility levels. Therefore, this study tries to fulfill the gap by investigate the volatility of shariah companies using Monte Carlo Simulations method.

III. RESEARCH METHODOLOGY

The purpose of this paper is to determine level of volatility among sharia-compliant companies on Malaysia

Stock Exchange. The method implemented in this study is volatility calculation, normality checking procedure and Monte Carlo Simulation.

3.1 Data selection and volatility calculation

This study selected daily stock prices from database of Thomson Reuters Datastream. Then, this study calculated average monthly price and calculated return for each month using Equation (1).

$$Re_t = \left(\frac{P_t - P_{t-1}}{P_{t-1}} \right) \times 100\% \dots\dots\dots (1)$$

In Equation (1), the parameters are described as follows:

Re_t : Return rate at observation monthly period t ,

P_t : Stock price at observation monthly period t , and

P_{t-1} : Stock price at observation monthly period $t-1$.

Next, volatility in this study is represented by using standard deviation in Equation (2).

$$s = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1}} \dots\dots\dots (2)$$

The parameters in Equation (2) are described as follows:

s : Standard deviation of sample

x_i : Observed variable

\bar{x} : Mean of observed variable x

N : Number of observations in the sample.

3.2 Normality checking for data distribution

This study performed normality for volatility data distribution. All statistical tests discussed in this study assume normal distributions. The probability density of the normal distribution is represented by Equation (3).

$$f(x|\mu, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \dots\dots\dots (3)$$

The parameters in Equation (2) are described as follows:

σ^2 : Variance of sample

x : Observed variable

μ : Mean of observed variable x

Next, Shapiro-Wilk normality test is represented by Equation (4).

$$W = \frac{\left(\sum_{i=1}^n a_i x_{(i)} \right)^2}{\sum_{i=1}^n (x_i - \bar{x})^2} \dots\dots\dots (4)$$

a_i : constants generated from the means, variances and covariance of the order statistics of a sample of size n from a normal distribution

$x_{(i)}$: variable x for i th order statistic

3.3 Monte Carlo approach for volatility rate

Monte Carlo Simulation is probability simulation to develop large data set. By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables. The Monte Carlo method is method for analyzing uncertainty propagation to determine variation affects the sensitivity and reliability of the system that is being modeled. Monte Carlo Simulation is defined as a sampling method because the inputs are randomly generated from probability distributions to simulate the process of sampling from an actual population.

A Monte Carlo method is a technique that involves using random numbers and probability to solve problems. Monte Carlo simulation uses random sampling and statistical modeling to estimate mathematical functions and mimic the operations of complex systems. Monte Carlo simulation produces distributions of possible outcome values. Figure 1 shows Monte Carlo Simulation framework. Input variables are represented by variables X, that as independent variables for mathematical system. Next, all of input variables is transformed using mathematical function model of particular system. Finally, the outcome of study is produced and represented by Y variable.

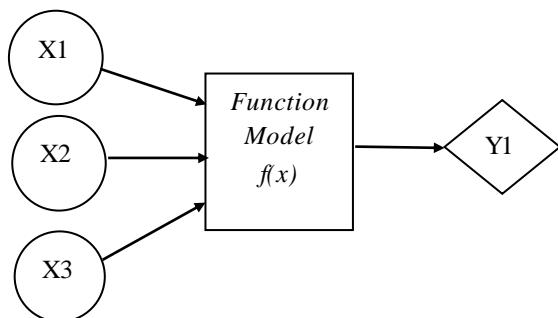


Fig. 1: Monte Carlo Simulation (MCS) framework

IV. RESULT AND DISCUSSION

Main objective of this study is to develop evaluation method for volatility rate among sharia-compliant companies listed on Malaysia Stock Exchange. This study performed normality diagnostics using graphical and numerical approach. In addition, in producing a valid finding, this study implemented Monte Carlo Simulation method.

4.1 Data selection and return analysis

This study collected daily stock prices from Thomson Reuters Datastream. Then, average monthly returns are calculated for 19 companies that sharia-compliant. Table 1 indicates the companies with corresponding average monthly return.

Table.1: Average monthly return for 19 companies

No.	Company name	Average monthly return (%)
1	Axiata Group Berhad	-2.0114
2	Dialog Group Berhad	1.5649
3	DiGi.Com Berhad	-0.3985
4	Hartalega Holdings Berhad	0.8898
5	IHH Healthcare Berhad	-0.1053
6	IOI Corporation Berhad	0.1589
7	Kuala Lumpur Kepong Berhad	-0.0659
8	Maxis Berhad	-0.3394
9	MISC Behad	-0.4377
10	Nestle (Malaysia) Berhad	3.1582
11	Petronas Chemicals Group Berhad	1.1685
12	Petronas Dagangan Bhd	0.4660
13	Petronas Gas Berhad	0.7287
14	PPB Group Berhad	1.7246
15	Press Metal Aluminium Holdings Berhad	-0.7758
16	Sime Darby Berhad	0.8678
17	Sime Darby Plantation Berhad	-0.2969
18	Tenaga Nasional Berhad	-0.8097
19	Top Glove Corporation Berhad	2.9111

Table 1 shows average value for monthly return is 0.442% with standard deviation is 1.248 %. The value of average return for companies is positive that indicates all companies shows a positive gain. In addition, low value of standard deviation indicates the stock price market is stable.

4.2 Volatility analysis

The volatility of this study is calculated from return data for each of 19 companies. Figure 1 indicates histogram of data distribution for volatility rate. Figure 1 indicates data distribution of volatility close to normal distribution line (red line). Therefore, data distribution of volatility is follows normal distribution.

Next, this study performed normal probability analysis. Figure 2 shows normal probability plot for volatility rate. The data distribution of volatility is close to normal straight line (red line). Therefore, data distribution of volatility follows normal distribution.

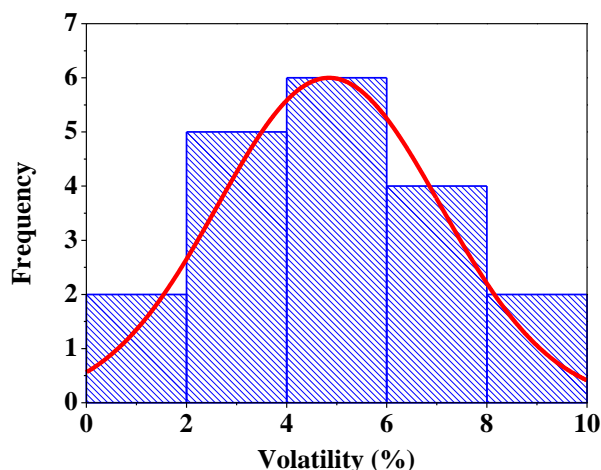


Fig. 1: Histogram of data distribution for volatility

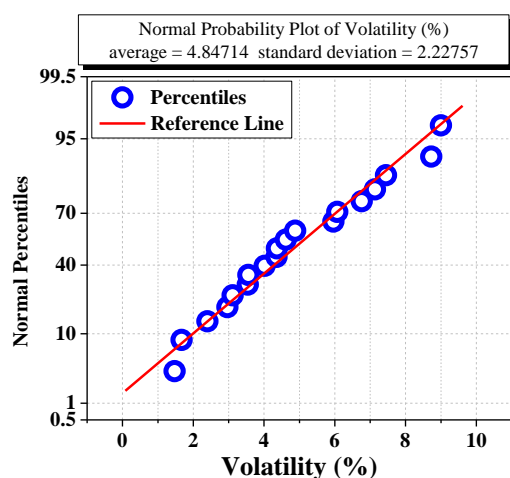


Fig. 2: Normal probability plot for volatility

Next, this study validated the normality findings using statistical test. This study implemented Shapiro-Wilk normality because sample size is less than 50. Table indicates statistical test for normality checking of data distribution. The probability value (p-value) is 0.562 that larger than 0.05. Therefore, this study failed to reject null hypothesis. As a conclusion, data distribution of volatility rate follows normal distribution.

Then, this study analyzed outlier detection using box-and-whisker plot. Figure 3 shows box-and-whisker plot for

volatility rate. Figure 3 indicates there is no outlier exists in data distribution.

Table.1: Statistical test for normality checking

Shapiro-Wilk normality test		
Statistics	Degree of freedom, df	Probability value (p-value)
0.959	19	0.562

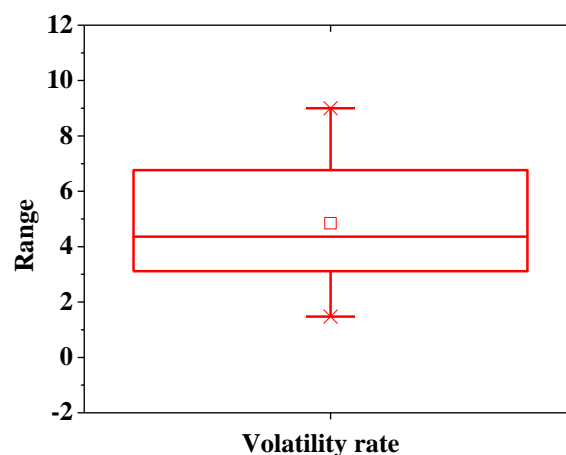


Fig. 3: Box-and-whisker plot for volatility rate

IV.2 Monte Carlo Simulation for volatility rate

This study performed process capability analysis to inherent statistical variability which can be evaluated by statistical methods. Figure 4 shows process capability for volatility rate. Number of sample data is 19 observations. The sample mean is 4.847. Data distribution of volatility is indicated using standard deviation of within is 1.95 and overall is 2.227. Main objective of this analysis is to evaluate statistical control for volatility data. The difference value between C_{pk} and P_{pk} is 0.15 that indicates processes are in a state of statistical control.

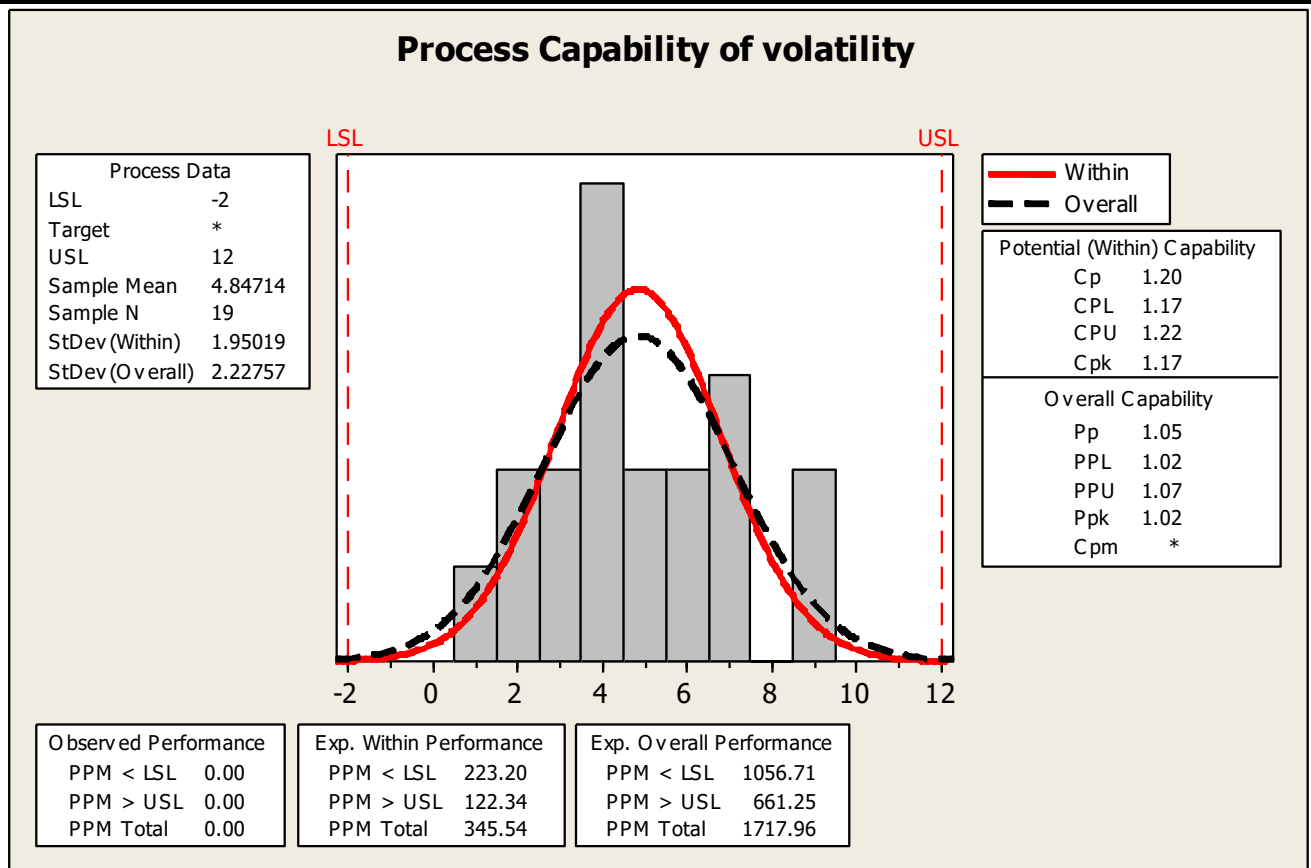


Fig. 4: Process capability of volatility rate

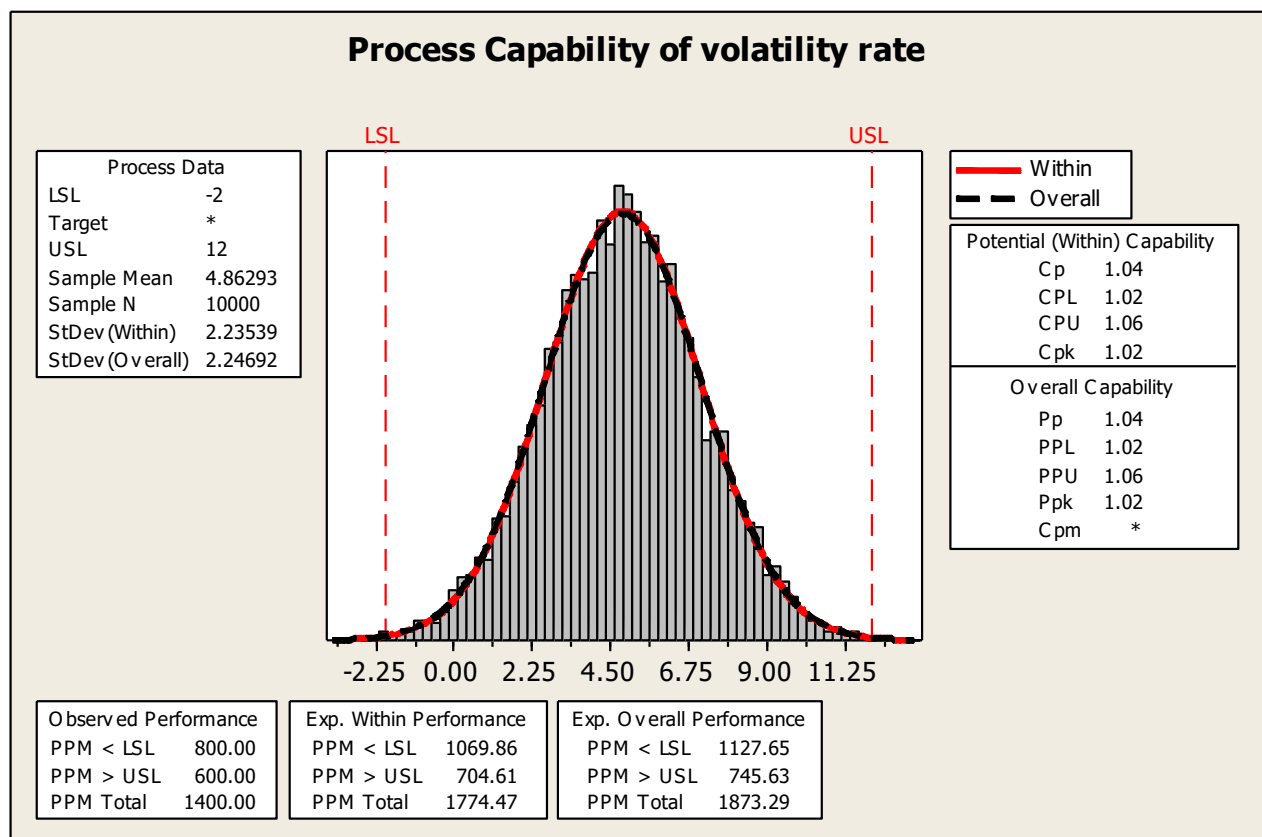


Fig. 5: Process capability of volatility rate

Next, this study implemented Monte Carlo Simulation for simulating volatility rate in process capability method. Figure 5 shows process capability of volatility rate. This study increased number of samples to 10000 samples to attain valid and reliable findings of volatility rate. The difference value between C_{pk} and P_{pk} is almost zero that indicates processes are in a state of statistical control. As conclusion, with the implementation of Monte Carlo Simulation, the level of reliability of process control is increased.

V. CONCLUSION

Main purpose of this study is to analyze volatility rate of 19 sharia-compliant companies listed on Malaysia Stock Exchange. Findings of this study are listed as follows:

- Average value for monthly return is 0.442% with standard deviation is 1.248 %. The value of average return for companies is positive that indicates all companies shows a positive gain. In addition, low value of standard deviation indicates the stock price market is stable.
- This study validated the normality findings using statistical test. The probability value (p-value) is 0.562 that larger than 0.05. As a conclusion, data distribution of volatility rate follows normal distribution.
- Monte Carlo Simulation has proved that reliability of process control is increased with implementation of large data set.

The important of this findings are enabling investors to gain knowledge about real financial market condition in Malaysia Stock Exchange. In the same time, Monte Carlo Simulation can be implemented to get reliable result although the real sample size is small.

Future work of this study can be venture to development of determinants that contribute to dynamic behavior of volatility in Malaysia Stock Exchange.

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A hybrid Algorithm for Deployment of Sensors with Coverage and Connectivity Constraints

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Abstract— Finding optimal node deployment for a Wireless Sensor Network (WSN), while maximizing both coverage and connectivity as well as minimizing costs is a challenging task. In the considered scenario, coverage and connectivity are used as QoS (Quality of Service) measures for the desired wireless sensor network. In this case, the problem was handled as a multi-objective optimization problem. In this paper, we propose a hybrid optimization algorithm (GA-BPSO) based on Genetic Algorithm (GA) and Binary Particle Swarm Optimization (BPSO). In order to show the effectiveness of the proposed algorithm, we present some simulations and comparisons with existing methods in the literature.

Keywords— Genetic Algorithms, Particle Swarm Optimization, Wireless sensor networks.

I. INTRODUCTION

Technological advances brought several benefits in the communication field in the past few years. The combination of wireless communication elements and microcontrollers enabled the development of nodes with sensing capabilities. The joining of multiple nodes allowed the creation of comprehensive low-cost monitoring systems. While each node has restrictions such as power consumption, limited coverage, sensing capabilities and signal processing [1]–[3]; new challenges have been created. These systems of interconnected nodes are denominated in Wireless Sensor Networks (WSN).

Aiming an efficient operation, regardless of the used criteria, its nodes need to form a connected component. This way, it is possible that data can be transmitted by multiple sensors. However, maintaining connectivity coverage across the entire network is of utmost importance. Nodes have limited scope and power source or can be damaged, extinguishing their use in the network.

At the organizational level, each sensor can connect with neighboring sensors in order to reduce the assigned power consumption in its communication, minimizing external interference, and forming a connection network. By its nature, a WSN may run the risk of losing a partition of its

network by some possible obstacle blocking the signals sent between sensors, whether by the existence of natural (mountains, trees, valleys, etc.) or artificial (buildings, monuments, walls, etc.) reasons. In this way, we must prevent such occurrence by requiring that each sensor has a defined range in order to have a finite number of neighboring sensors at any instant of time. Taking care in fulfilling this critical requirement may ensure that the sensor mesh remains connected [2], [4].

In order to avoid loss of connection, a network can make use of a restriction called m -connectivity. A WSN is said to be m -connected if, and only if, each sensor is connected to at least m other sensors. Thus, each sensor can hold up to $m-1$ faulty neighboring sensors [1]. Another QoS measure is related to the number of nodes covering a target. This constraint is given by the k -coverage restriction, i. e., each target must be covered by at least k different sensors [1, 2]. Fig 1 shows a WSN with $k=1$ and $m=1$.

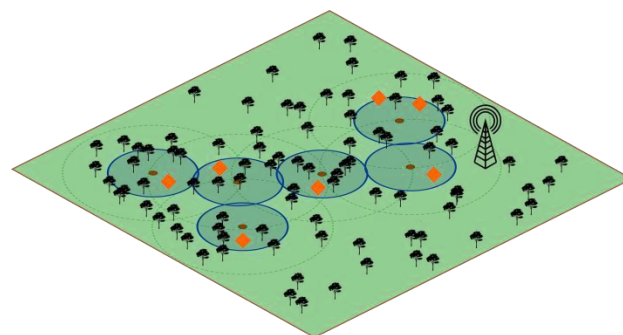


Fig. 1: Example of a one-connected and one-covered WSN.

In [5], the author proposes a hybrid evolutionary algorithm, mixing the benefits of the Particle Swarm Optimization (PSO) algorithm followed by evolutionary operators, in the discovery of the optimal position of sensors in a WSN network. Simulation results show that such a method can not only improve the location accuracy but also reduce its location response time.

Authors in [6] used a LEACH (Low Energy Adaptive Clustering Hierarchy Protocol) based algorithm, mixed

with genetic algorithms to achieve increased lifetime and energy efficiency in WSN. The genetic algorithm is used to select cluster heads and create efficient clusters for data transmission. Simulations results show that the proposed hybrid protocol results in prolonged network lifetime and optimal energy consumption for sensor nodes inside a wireless sensor network.

In this sense, this work has as its main objective the proposition of a hybrid algorithm, composed of a Genetic Algorithm and a Particle Swarm Optimization algorithm, similar to the work done by [5], however, discovering an optimal position of sensors, as well as maximizing their coverage and connectivity.

The remainder of this paper is organized as follows.

Section 2 cites the background of Multi-objective Optimization, GAs, PSO and BPSO. Section 3 defines the problem formulation. Section 4 presents GA-BPSO. Section 5 presents results in two case studies. Finally, Section 6 concludes this paper.

II. BACKGROUND

2.1 Multi-objective Optimization

Multi-objective optimization (MOO) aims to find the Pareto optimal solution, forming the *Pareto-front* in the objective space [7]. It can be defined as:

$$f(x) = [f_1(x), f_2(x), \dots, f_n(x)] \quad (1)$$

where $f_i(x)$ is the i th objective, x is the decision vector for $n > 1$ objectives.

Pareto optimal solutions for a multi-objective problem are virtually infinite. Thus, it is necessary to incorporate various objectives in order to determine a single suitable solution. Methods such *a priori articulation* depends on user indicated preferences before running the optimization, allowing the algorithm to determine a single solution that reflects what the optimal solution should represent, alternatively, *posteriori articulation* requires the user to manually select a single solution from the Pareto optimal set [8].

2.2 Genetic Algorithms

Genetic Algorithms (GAs) are simulated biological evolutions used to solve the optimization of nonlinear problems[9]. Vectors are encoded as possible solutions, which are representations of individuals, and they are made up of binary, real or integer elements, which represents their individual genes. A group of individuals is denoted as a population[10]. A fitness function is used as a means of measuring how close a given individual is to the optimal solution.

A GA starts by generating a random initial population, and a fitness value is calculated to each individual. The

higher an individual's fitness, the higher its likelihood of reproduction. Evolution takes place by means of *crossover* and *mutation* operations, producing offspring that replace part of the population. This is repeated until the convergence criteria are met, the fittest individual of the last population is assumed to be the optimal solution found.

2.3 Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a simulation based on the behavior of bird flocks and fish schools, also used as a means of finding optimal solutions for nonlinear problems. Individuals are represented by particles in a swarm and act according to self-acquired knowledge but also with the collective knowledge obtained by the swarm [11].

All particles move in a multidimensional space, where each particle has a position x and a speed vector v in relation to the time t . For each step of time, the velocity of each particle is updated according to the equation (2):

$$v_i^{t+1} = w \cdot \alpha_1 \cdot (p_i^b - x_i) + \alpha_2 \cdot (p_i^{gb} - x_i) \quad (2)$$

where w is the inertia factor, p_i^b is the best local solution found by the particle so far, p_i^{gb} is the global best position found by all particles of the swarm, α_1, α_2 are coefficients of local and global learning, respectively.

With the new velocity, each particle i has its position updated by equation (3):

$$x_i^{t+1} = x_i^t + v_i^{t+1} \quad (3)$$

3.2 Binary Particle Swarm Optimization (BPSO)

The BPSO modifies the original PSO algorithm, by using a similar methodology in a discrete binary search model. Therefore, since the position vector is binary, the speed is used as the probability of a bit to change. This way, the speed factor is limited to $[0,1]$ using a Sigmoid function.

Thus, the speed is still obtained using equation (2), but the position is updated using the equation (4):

$$x_i^{t+1} = \begin{cases} 0 & \text{if } rand() \geq S(v_i^{t+1}) \\ 1 & \text{if } rand() < S(v_i^{t+1}) \end{cases} \quad (4)$$

where $rand() \in [0,1]$ and $S(v_i^{t+1})$ is given by equation (5):

$$S(v_i^{t+1}) = \frac{1}{1 + e^{v_i^{t+1}}} \quad (5)$$

III. OPTIMIZATION PROBLEM

This work approaches the problem of given a set of targets $T \subset \mathcal{R}^2$ and a set of potential positions $P \subset \mathcal{R}^2$, the k -coverage and m -connectivity deployment sensors

problem is defined as selecting a subset $S \subseteq P$ such that each target in T is covered by at least k sensors and each sensor in S connected with at least m other sensors. In this context, a target is covered by a sensor, when within sensing range of that sensor. In addition, a sensor is said to be connected with another sensor whenever they are in each other connectivity range.

A solution S is said to be optimized if it minimizes the number of sensors while respecting the constraints. In addition, S is considered the global optimum if, for every solution $S' \subseteq P$, the number of sensors in S is less or equal to the number of sensors in S' .

This work uses the same mathematical model as [12]. In this way, this problem is modeled as an integer decision problem. The decision variables are stated in equations (6) to (8).

$$b_{ij} = \begin{cases} 1, & \text{if target } T_i \text{ is covered by } S_i \\ 0, & \text{otherwise.} \end{cases} \quad (6)$$

$$c_{ij} = \begin{cases} 1, & \text{if a sensor } S_i \text{ is connected} \\ & \text{to another sensor } S_j \\ 0, & \text{otherwise.} \end{cases} \quad (7)$$

$$q_i = \begin{cases} 1, & \text{if a potential position } P_i \\ & \text{is selected for node placement} \\ 0, & \text{otherwise.} \end{cases} \quad (8)$$

where T_i is the i th element of T , and S_i is the i th element of S . Thus, the problem can be formulated as follows:

$$\text{Minimize } \sum_{i=1}^{|P|} q_i \quad (8)$$

subject to:

$$\sum_{j=1}^{|P|} b_{ij} \geq k, \quad \forall i, \quad 1 \leq i \leq |T| \quad (9)$$

$$\sum_{j=1}^{|P|} c_{ij} \geq m, \quad \forall i, \quad i \neq j, \quad 1 \leq i \leq |P| \quad (10)$$

Constraint (9) ensures that every target is covered by at least k sensor nodes, while constraint (10) states that each sensor should be connected with at least m other ones.

IV. THE PROPOSED SOLUTION: GA-BPSO

In order to approach the considered problem, it is proposed a hybrid evolutionary algorithm combining the Genetic Algorithm and the Binary Particle Swarm Optimization (GA-BPSO).

4.1 Encoding

A sequence of potential positions S is encoded as a binary vector. Whether a position i of S has the value 1, it means that the i th potential position is selected to deploy a sensor. Fig 2 shows an example of such encoding.

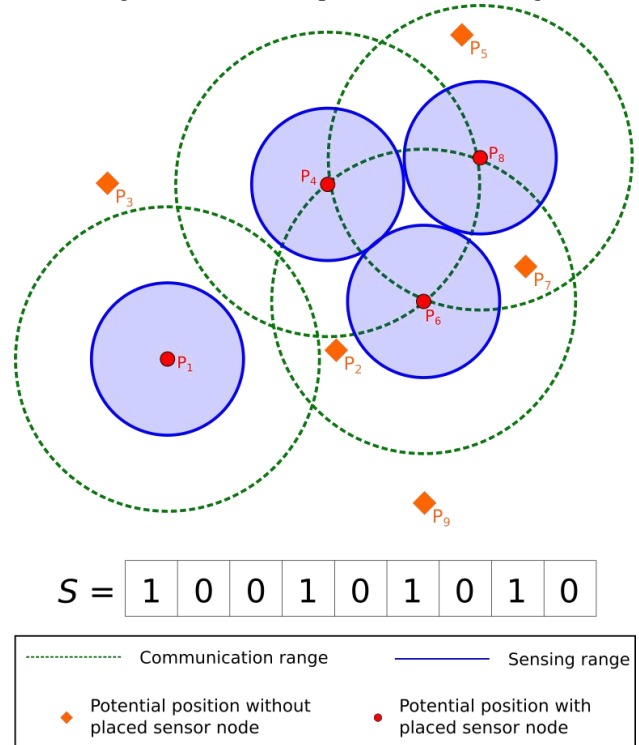


Fig 2: Example of encoding based on the potential position of sensor nodes.

4.2 Fitness

The fitness function is divided into three other objectives: F1, F2, and F3. F1 stands to minimize the number of potential positions selected by the algorithm. This quantity is related to the number of employed sensors of the network. F2 and F3 handle the k -coverage and m -connectivity restrictions, respectively.

Let $N = |P|$ be the total of potential positions of P that have been selected for placing sensor nodes, the first objective function is given by equation (11):

$$\text{Minimize } F_1 = \frac{N}{|P|} \quad (11)$$

Let $Cov(T_i)$ be the set of sensors nodes within sensing range of target T_i , the second objective is then described by equation (12):

$$\text{Maximize } F_2 = \frac{1}{N \cdot k} \sum_{i=1}^N FCov(T_i) \quad (12)$$

where $FCov(T_i)$ defines the full coverage by sensor nodes based on the set of sensors covering every target. Function $FCov(T_i)$ is given by equation (13):

$$FCov(T_i) = \begin{cases} k, & \text{If } |Cov(T_i)| \geq k \\ |Cov(T_i)| - k, & \text{otherwise.} \end{cases} \quad (13)$$

Let $Com(P_i)$ be the set of sensors nodes within coverage range of P_i , the third objective can be described as follows:

$$\text{Maximize } F_3 = \frac{1}{N \cdot m} \sum_{i=1}^N FCom(P_i) \quad (14)$$

where $FCom(P_i)$ defines the full communication by sensor nodes based on the set of sensors covering every active sensor node. Function $FCom(P_i)$ is defined in equation (15):

$$FCom(P_i) = \begin{cases} m, & \text{If } |Com(P_i)| \geq m \\ |Com(P_i)| - m, & \text{otherwise.} \end{cases} \quad (15)$$

It is important to note that both F_2 and F_3 conflict with F_1 , this happens because the objective aims to maximize the k -coverage and m -connectivity, this may be obtained by placing a substantial quantity of sensor nodes, shadowing the first objective. This way, the multiobjective is then modeled as a weighted sum. These weights can be applied without any transformation of the objective functions, as they merely represent the relative importance of the objectives [8].

Let W_i be a weight value applied to each objective, and all objectives are summed up into a single scalar objective function generating the following model:

$$\begin{aligned} \text{Maximize Fitness} = & W_1 \times (1.0 - F_1) + \\ & W_2 \times F_2 + \\ & W_3 \times F_3 \end{aligned} \quad (15)$$

Subject to:

$$0 \leq W_1, W_2, W_3 < 1 \quad (16)$$

where

$$W_1 + W_2 + W_3 = 1 \quad (17)$$

4.3 Description of GA-BPSO

The proposed approach is a combination of a Binary Particle Swarm Optimization (BPSO) algorithm and a Genetic Algorithm (GA). Following the logic presented by [13] and [14], this hybrid method is divided into two phases. In the first phase, the fitness of the generated population of size P_{size} is calculated, then the population is divided into two parts of equal size. The best individuals are used as input for the GA, while the worst ones are used as input for the BPSO algorithm. In this way, the approach takes the benefits of GA, which GAs has genetic operators, so the individuals can evolve and find better offspring. While PSO does not provide such operators, it can perform exploration of solutions, which hopefully can guide the particles to possibly finding global optimal solutions.

In the second phase, a new population is generated by GA operators using the fittest individuals, while the worst individuals are enhanced by the BPSO evolution. These new and evolved individuals are merged back into a single population of size P_{size} and sent back to phase 1 until the termination criteria are met.

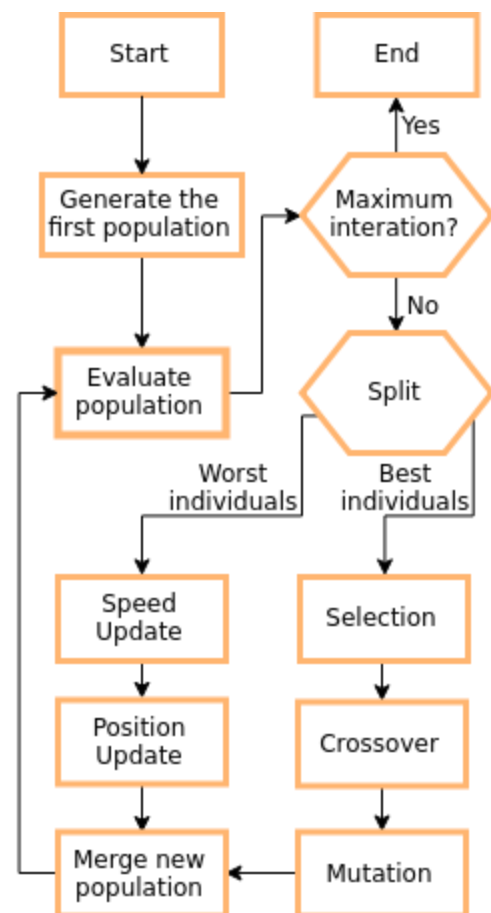


Fig 3: GA-BPSO diagram

4.4 Advantages of GA-BPSO

PSO shares many common points with GA. Both algorithms start with a group of a randomly generated population. Both use fitness values to evaluate the population. Both update the population and search for the optimum using stochastic algorithms. But, PSO is distinctly different from other evolutionary type methods in a way that it does not use the filtering operation and the members of the entire population are maintained through the search procedure so that information is socially shared among individuals to guide the search towards the best position in the search space [15], [16].

One of the advantages of GAs is the ability to finding local optima, by means of genetic operators that gradually improve the fitness of its individuals throughout generations. However, GAs can do less exploration for global search when compared to PSO solutions [17]. One disadvantage of PSOs is premature convergence. In order to avoid this effect, the PSO can be used to find better solutions from individuals with smaller fitness values in the population. On a PSO solution, every individual shares information among themselves, this way, such individuals converges to a better solution faster than GA [18]. Therefore, the proposed algorithm (GA-BPSO) combines the advantages of both GAs and PSO.

V. RESULTS

The evaluation of the GA-BPSO algorithm is done using the same two case studies as used by [12]. In both cases it is assumed an sensing field of $300m^2$. Case Study I considered that each potential position could be positioned only on cross-points over a grid pattern with steps of $25m$. In the other hand, Case Study II assumed random potential positions inside the given sensing field.

Table.1: Presents all the simulation parameters.

Table 1: Simulation parameters.

Parameter	Value
Max iterations	100
Number of target points	100
No. of potential positions	100-500
Communication range	100 m
Sensing range	50 m
Initial population size	60
Mutation rate	3%
Elitism rate	50%
W_1, W_2, W_3	0.4, 0.3, 0.3
$BPSO - [V_{min}, V_{max}]$	[-6,6]
$BPSO - \alpha_1, \alpha_2$	2
$BPSO - \nabla w$	[0.6-0.2]

Fig. 4 and Fig. 6 depict results in terms of the number of selected potential positions by varying the number of given potential positions, ranging from 100 to 500, with

steps of 100. In both scenarios, a total of 100 target points were given and (k, m) values vary from (1,1) to (3,2).

It should be noted that the number of given potential positions does not affect the quality of generated solutions. This is due to the fact that the optimal solution for any objective function is not mutable by the search parameters. It can also be observed the difference of selected potential positions varying k values, this is explained by a rise in complexity of the network mesh, when trying to adjust itself aiming to met its objective. The GA-BPSO results are compared with [12]. Fig. 5 shows the comparison results of Study Case I, as well as Fig 7, shows the comparisons results of Study Case II. Comparing Fig 4 and Fig 6, there is a difference generated by the initial distribution of the network mesh. As depicted by Fig 4, on a grid-like pattern, GA-BPSO performs better. This is expected due to a guaranteed consistent distribution of sensor nodes on the field. This does not happen when using random potential positions instead. It is important to note the lack of substantial improvement when considering scenarios $(k=2, m=1)$ and $(k=2, m=2)$. A large communication range is responsible for keeping the sensors from disconnecting from each other while the algorithm evolves its population. This would not happen on a larger field though.

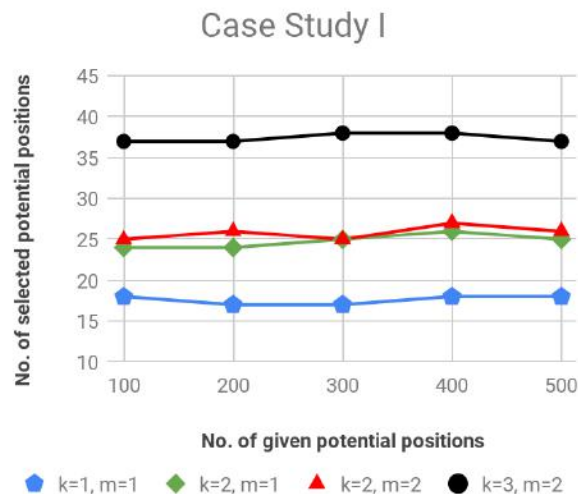


Fig 4: Comparison in terms of the number of selected sensor nodes for Case Study I.

Observing Fig 7, with instance $(k=3, m=1)$ and Fig 6 with instance $(k=4, m=1)$, it can be seen that GA-BPSO performed worse than the algorithm proposed by [12]. An investigation should be carried out in order to determine the sensitivity of GA-BPSO using $(k > 4)$ scenarios as well as on larger sensing fields.

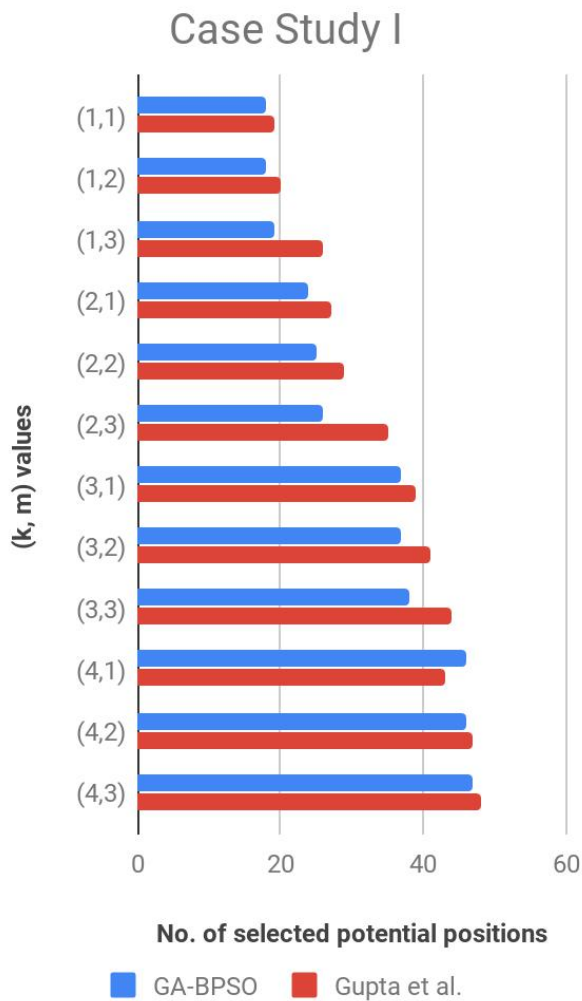


Fig 5: Comparison in terms of selected sensor nodes for Case Study I

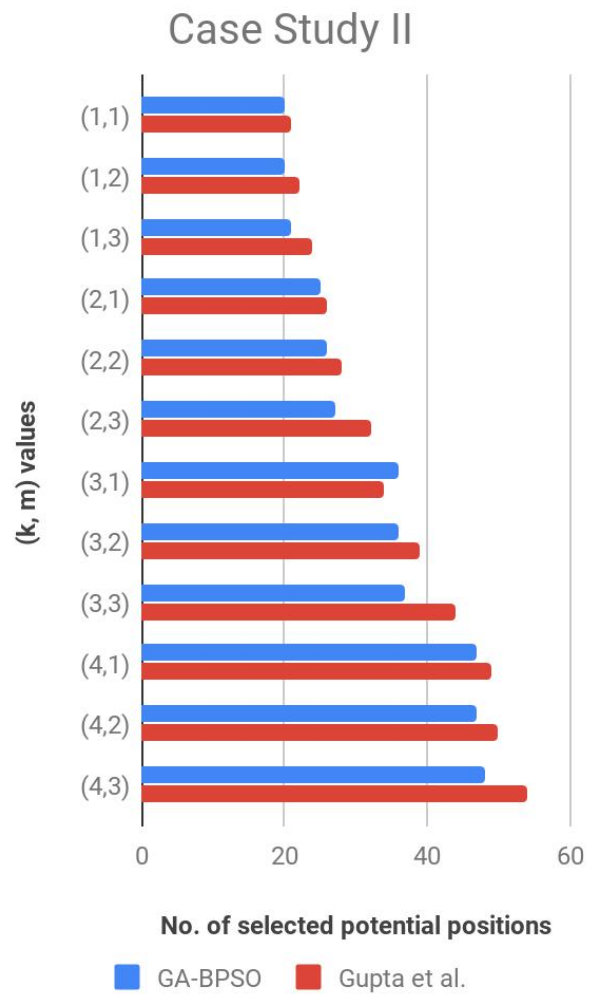


Fig 7: Comparison in terms of selected sensor nodes for Case Study II

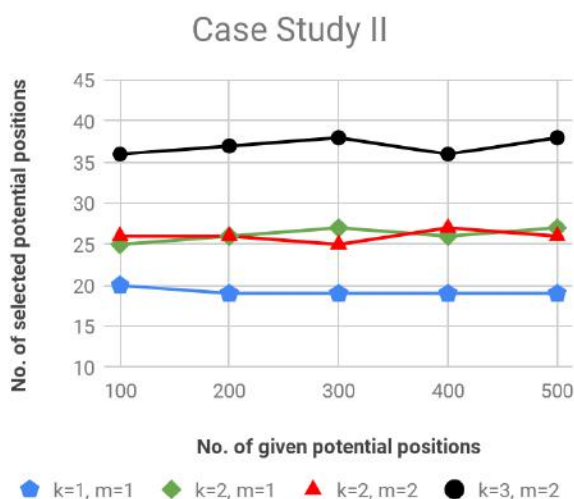


Fig 6: Comparison in terms of the number of selected sensor nodes for Case Study II.

VI. CONCLUSION

This paper proposed an alternative method, called GA-DPSO, for finding optimized solutions to the problem of sensor deployment, with k -coverage and m -connectivity restrictions. The GA-DPSO uses a combination of PSO algorithm and GA, mixing up the global search feature provided by the PSO algorithm (exploration) while using the local search with a GA (exploitation).

Results suggest that a large connectivity field can, in fact, make the network rely on the k -coverage for any further optimization. In some cases such as Case Study I instance ($k=2, m=3$), this algorithm found a solution at least 27% better than the results reported in [12]. The comparison results between both methods conclude that GA-BPSO performs better than the proposed in [12]. It improved, not only on finding reasonable less active sensors solutions, but also balancing the contradiction between the number of active sensors, coverage, and connectivity, improving on the WSN localization efficiency.

As future work, some more experimental studies with larger requirement parameters should be conducted. A clustering algorithm can be implemented utilizing AG-BPSO internally, intending to improve its processing power. In addition, mobile sensor nodes should also be considered on experiments.

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Application Focused on English Language Teaching for Children, with Speech Recognition and Synthesizing Capabilities

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Abstract— This project will present an application focused on the teaching of the English language to the children, this application being an important teaching tool, where the child can begin a cycle of learning a new language, something that will be very important in their training academic, and will serve in your professional future. In addition to showing how software is being developed and the resources used in it, this project is also concerned with presenting concepts such as: foreign language learning for children, voice recognition and synthesis, intelligent systems capable of recognizing and synthesizing the voice and the Java API Speech. To aid in English studies, the application makes use of illustrative images, themes, interactive questions, training mode, speech recognition and synthesis, which contributes to the development of writing and pronunciation in the language, mainly for making use of the resources of voice, which are the strongest point of this tool.

Keywords— English; Learning; Educational; Voice and synthesis.

I. INTRODUCTION

The importance of learning a language beyond the mother tongue is one of the characteristics of the process of advancement and globalization of humanity, where the media and all kinds of technology have undergone drastic changes over time, and the labor market has also accompanied this evolution. So that more and more professionals with a higher degree of qualification are required.

According to Pati (2017) in the 53rd edition of the salary survey of Catho, where 13 thousand people were interviewed, knowing how to speak English guarantees a salary jump of up to 61% depending on the employment area, which proves the importance of this language and others in many sectors that need this type of specialty.

Learning a new language is something that requires a certain amount of time and dedication, so it is advisable to learn from an early age, especially in the infantile phase, so that when you reach adulthood, there is no worry of not speaking a second language. According to Duarte and Batista (2013, pp. 293-301), children have a high degree of assimilation, they can absorb content quickly and practically, and they usually have more time available than many adults. the best phase to start learning, including a new language.

Knowing one of the most talked about and important languages in the world, as mentioned above, is extremely significant in the current scenario, but many students do not value this kind of study because English is not the official language of Brazil, even if it is present in the curriculum of many primary and secondary schools, preferring to give more importance to other fields of knowledge, which in a way will also be very useful also in their academic formation, however it is a fact that being able to speak English is requisite for many high-paying jobs, and can also guarantee many academic and exchange opportunities.

The purpose of this project is to offer an alternative that will help in the study of English, and for this reason the team that started this work started the development of a tool that aims to teach English to beginners, especially to children, offering a first contact to the user. will serve as a gateway to more complete learning of that language. The application has already proved to be promising, making use of synthesis and voice recognition, which is its main resource so far, in addition to others, thus helping the student with the pronunciation of words in English. However, even if the software already shows good results, the developer team feels that there is room for further improvements and implementations that can be added later by the developer group of this tool.

II. JUSTIFICATIVE

The project in question was developed due to the lack of software of this type and in order to help and contribute to the basic teaching of the language, so that people who do not speak English (especially children) have a first contact with the language in a fun way and productive, as well as giving an incentive in the study of English of the people who use this tool.

The prototype of the application presented here serves as a first contact with this language, which happens in a relaxed way, facilitating and giving an additional stimulus to the user of the tool, so that it can enter the sphere of knowledge of the English language, since English is a universal and fundamental language for people today, so this first contact is of the utmost importance because it must be something cool, fun and interesting to the beginner in English. Combining all this with speech synthesis technology and speech recognition technologies that are current technologies that facilitate the learning of pronunciation, it makes the project more adequate to what this team of students aims for, thus contributing to the foreign language teaching system in a way effective in the schools or in the pupil's own house, as a kind of aid in his studies.

III. METHODOLOGICAL PROCEDURE

The tool is being produced in the Java language with the help of Netbeans IDE 8.2, until then the Java Speech library for speech synthesis and speech recognition was used. The project whose name was adopted by the team was "SpeakApp" makes use of many colorful figures, which is a way to make the software more attractive to children.

The procedures to achieve this tool were based on the applied study of technologies such as synthesizing and voice recognition, where the knowledge obtained was applied beautifully in the system, from there it was necessary a basic analysis research on how to catch the attention of children. Another important point is to conduct tests with children, which was successful, since the forms used by the team to attract children's attention worked.

SpeakApp works with writing and pronunciation of words in English, always relating them with images, to facilitate learning. At the time this project was written, the principle to be explored, is to work with only four themes, which can be expanded in the future, so that themes are addressed: numbers, letters, animals and colors.

The tool created for this work plan aims to dynamically draw the attention of boys and girls to learn English. For this task were used good coloring drawings and a simple aspect of design, compacting with the interactivity and

the pleasure of the user to enjoy this application for the knowledge of the English language.

IV. TOOL DESIGN

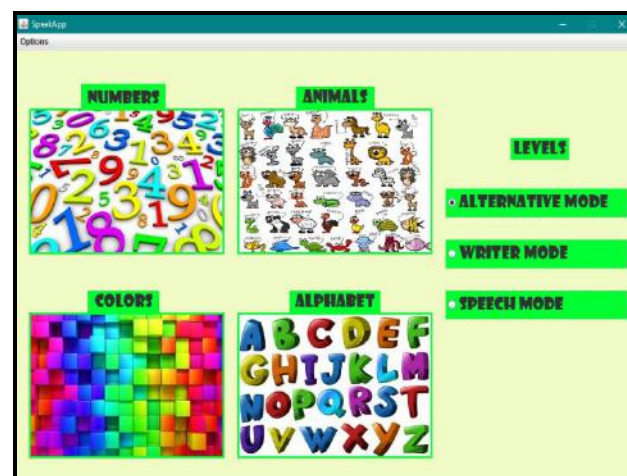


Fig.1: Tool design.

Source: Authors.

In the initial screen that is the menu, are presented four representations containing each one, a theme, whose each one of the subjects can be identified by the characteristics of the image, that is well illustrative and of easy identification, besides being possible to be distinguished by the name that is above the figure. When the drawing with the title "Colors" (example) is clicked, a new screen is opened (this is the case for all themes), which will be shown below and explained accordingly.



Fig 2: Training Screen.

Source: Authors.

It is worth mentioning that there is a menu bar that contains a menu called "Options", in it is an item with the name "Students" that when clicked will show a message with some information about the components of the team that built the application and this project complete. On the right side there are the "Levels" where the user can choose the way in which he wants to start the software,

having "Alternative Mode", "Writer Mode" and "Speech Mode".

Were used very illustrative forms that draw the attention of the boys and girls, in order to make them take an interest in the software already in the menu screen, even before the use of fact of the tool.

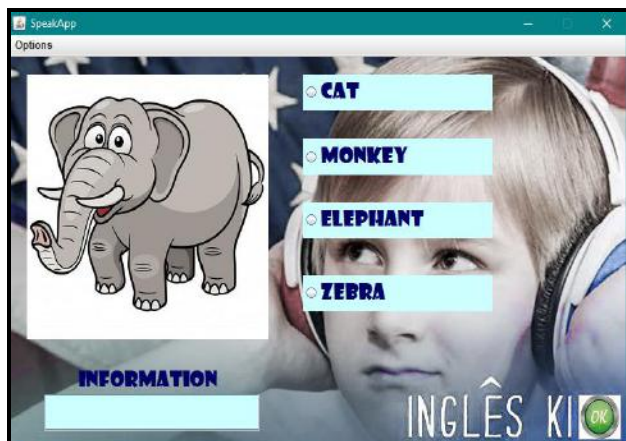


Fig 3: Alternative Mode.

Source: Authors.

V. LEARNING OF FOREIGN LANGUAGES FOR CHILDREN

Researchers in the field of neuroscience have indicated that the ideal age for language learning occurs in the first ten years of life, according to theorists such as Penfield and Roberts (1967, DIMER, SOARES, 2012, p.53). In this stage of life the brain is able to present a high degree of plasticity, this period being the highest point of this peak, and in puberty the brain no longer reaches these same capacities, because they are gradually lost.

According to Castro (1996), it was once believed that initiating a second language at the stage of literacy might be detrimental to the development of the mother tongue.

"The cerebral availability obtained in childhood, according to some studies, will never be obtained again. In addition, up to ten years of age, the number of synapses (neural connections) in the human brain remains stable (increasing gradually), as adolescence, the proportion of synapses is reversed, which also suggests less facility for acquiring language after the first ten years of life" (DIMER; SOARES, 2012, page 53).

Children have a remarkable greater ease of learning, and therefore tend to show greater progress in pronunciation, comprehension and storytelling. Children exposed to a foreign language acquire fluency faster than an adult because they have greater phonological control than older individuals. (DIMER, SOARES, 2012). "At 12 months of age, babies have a vocabulary of up to 50 words, but by the age of six it can reach about 5,000 words" (BRIGGS, 2013).

In the teaching of a language one must take into account the age issue, since children, adolescents and adults have different learning characteristics, and because of this fact, different methods of approaches must be made for each age group, always seeking the best suitability for the study, in order for the student to be able to adapt to the language taught (LIMA, 2008, pp. 297-298).

VI. VOICE RECOGNITION

Speech recognition is a set of techniques with the objective of transforming oral language into a written text, so that with this text the computer or apparatus through software, can perform some desired task using the data obtained by voice recognition.

For an application to effectively do voice recognition, it digitizes speech through a mechanism, converting the vibrations provoked by speech into digital data, this is a kind of analog-to-digital conversion. To avoid noise in the audio, the scanned sound needs to be filtered, thus leaving only the part of the sound that matters, thus eliminating external noise and interference (PEREIRA, 2009).

Then the computation of the frequency characteristics of the voice (spectral domain) is performed, so that it can be synchronized to its classification, where the sound digitization needs to separate the audio into small phonetic parts of the size of a syllable, so that the comparison with a database can be made, and thus identify what is said in the small fractions of sound. In the end, the parts are joined together forming words (PEREIRA, 2009).

Recognizing speech is an alternative to typing, this offers many benefits to the user, from the convenience of registering a text without having to type until the verification of the pronunciation of a sentence in another language, which helps in learning a new language, and many people with physical and visual disabilities, unable to type something into a computer, can make use of and benefit from this type of technology (WHAT IS SOFTWARE ..., 2018).

VII. VOICE SYNTHESIZATION

Speech synthesis is the conversion of written text into spoken language. Speech synthesis can also be referenced as the TTS (text-to-speech) conversation. Because the speech is being produced through an electronic device, it is an artificial voice that imitates human speech (MARANGONI; PRECIPITO, 2006, page 5-6).

Computers work basically in three stages (input, processing and output), voice synthesis is a form of output, the computer or any other electronic device that makes use of it, uses features such as loudspeakers to offer this kind of output (SUMMARY ..., 2018).

This way you can achieve a multitude of desired types of results for various types of tasks that benefit from this feature, such as learning the pronunciation of words in a new language or helping people with visual impairment to listen to what the computer says, are possible with the aid of speech synthesis.

In order for the computer to be able to synthesize voice some steps must be followed, among them are: Analysis of text structure, text preprocessing, text to phoneme conversion, prosody analysis and waveform production. Within these stages paragraphs, sentences, punctuations, abbreviations, acronyms, dates, times and numbers must be analyzed so that the phonemes are generated for each word of the text, and thus produce a speech with correct rhythm and intonation for each textual occasion (MARANGONI; PRECIPITUS, 2006, pp. 5-6).

VIII. INTELLIGENT SYSTEMS ABLE TO RECOGNIZE AND VOICE SYNTHESIZE

According to Monteiro (2010), recognizing and understanding speech is something that human beings have been developing since the earliest times, human speech is an intelligent means of communication that enabled the evolution of them, being humans considered intelligent beings by this and for other reasons. Over time new techniques and forms of modern communications have been made, to the point where machines with the aid of software have also begun to recognize and even understand the language spoken by man, increasingly passes to be with. Nowadays it is possible to find intelligent personal voice assistants such as Siri (Apple), Cortana (Microsoft), Google Now (Google / Android) and S Voice (Samsung) (STANDARD, 2016).

Through processing after the capture of a natural language, it is possible for the computer to recognize words and even voice commands, as mentioned earlier, being a technique used by some intelligent systems, which somehow recognize the speech pattern. There are three levels of speech recognition (recognizes natural speech), discrete (recognizes spoken speech and pauses between words) and commands (recognizes a very large number of words) (STAIRS; REYNOLDS, 2006 apud GOMES, 2010, page 243).

IX. JAVA SPEECH

In the present application, the Java Speech API is used, which is a tool created to enable speech recognition and synthesis of Java applications.

Sun has defined specifications that represent a generic interface to an engine, the Java Speech API (JSAPI). JSAPI works as a layer between programs and engines that are developed by third parties. The engines are very important because they work with the sound card by

capturing the audio (speech) or synthesizing a text (CASTILHO, 2008).

X. SCHEDULE

Table.1: Schedule

Description of Steps	AUG	SEPT	OCT	NOV	DEC
Literature review	X	X	----	----	----
Data collect	X	X	----	----	---
Data analysis and synthesis elaboration	----	X	X	X	---
First writing and correction	----	X	X	----	---
Delivery of the project	----	----	----	X	---

Source: Authors.

XI. CONCLUSION

The tool performed well and achieved great results, the satisfaction of those who used it was positive. The application is modular and proposes to be interactive in order to involve the child in the learning of the English language, collaborating to the maximum for the ease of handling and help of the teacher.

The software has a good synthesis and recognizes the speech and pronunciation of the user, thus obtaining acceptance of the use of the tool as a learning aid.

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A Comparative Analysis of PID, Fuzzy and H Infinity Controllers Applied to a Stewart Platform

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Abstract—This work presents the design of three controllers, the H infinity controller with output feedback, the PID controller and the Fuzzy controller applied to a Stewart platform. The actuator model was obtained by a step voltage input to the electric motor and measuring its displacement by the encoders coupled, in each of the respective axes of the motors. The motion transmission relation mechanism between the motor shaft and each actuator is obtained by the displacement spindle from the rotation of motor which are measured by the corresponding encoder. The kinematics and dynamics platform's data compose the whole systems models. Several experiments were carried out on the real Stewart platform with the help of an XsensMTi-G inertial sensor to measure the Platform Euler angles. The experimental results obtained by the three controllers were satisfactory in position control and orientation of the Stewart platform.

Keywords—PID Controller, Fuzzy Controller, H infinity Controller, Stewart Platform.

I. INTRODUCTION

Stewart Platforms are composed of two platforms connected by six parallel linear actuators. Extending or retracting actuators can change the relative position between the two platforms. It can be applied in flight simulators, cars simulators, machining of parts and other applications [1].

Attitude and position control of Stewart platforms are complexing problems in several areas of study [9]. They were obtained using different techniques like, PID controllers with gains obtained by cooperative co-evolution algorithm [2], fuzzy PID and feedback controllers with gains defined in reference points and selected in other points by fuzzy algorithm [1], [3], [6], PD controller with gains varying with adaptive algorithm

[4], H infinity controller [5], [7].

In this work, it was used the Stewart platform designed by the Airspace Control Laboratory of the Engineering School of São Carlos – USP. The Figure 1 shows the Stewart platform utilized. It has six electromechanical actuators that are utilized to control the position and attitude of the movable platform. To measure the variation in the actuators' lengths it was used encoders in the shaft of the actuators' motors to measure the number of rotations, and then it has been applied a calibration curve to obtain the actuator length. It was used the acquisition, transmitting, and processing system dSPACE in combination with the speed controller drive RoboClaw 2 and an inertial sensor XsensMTi-G measurement of the Euler angles of the Stewart Platform [7].

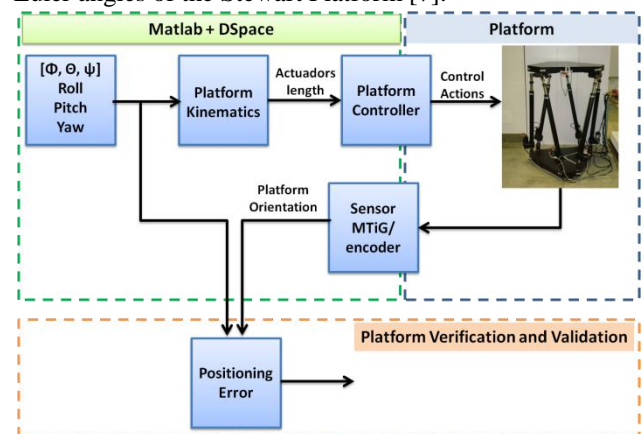


Fig. 1: Stewart platform of the Airspace Control Laboratory.

II. INVERSE KINEMATIC

Defined position and attitude of the Stewart platform, length of six actuators can be obtained using the inverse kinematic of the platform. Joints of actuators and platforms are known for a given platform, and it can be written in relation with the center of each platform in two

coordinate systems, shown in Figure 2. The base platform coordinate system utilizes the center of the base platform F as origin, the xf-axis pointing between joints with actuators 1 and 6, zf-axis is perpendicular with the platform plane, and yf-axis completes the right-hand rule. The movable platform coordinate system center M and its axis xm, ym, and zm are defined in a similar way. The joints positions of the base and movable platforms, in its coordinate systems, are shown in Equation (1) and Equation (2), respectively.

$$\{F_i\}^F = \{F_{i1} \ F_{i2} \ 0\}^T, i = 1, 2, \dots, 6 \quad (1)$$

$$\{M_i\}^M = \{M_{i1} \ M_{i2} \ 0\}^T, i = 1, 2, \dots, 6 \quad (2)$$

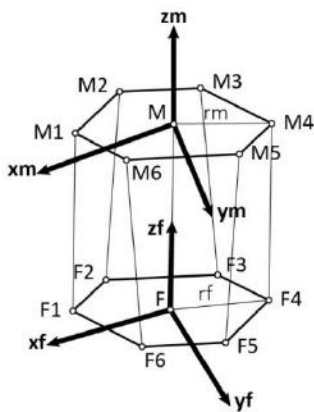


Fig. 2: Base and movable platforms coordinate systems.

The transformation matrix $[T^{MF}]$ to obtaining coordinates of the movable coordinate system for the base coordinate system, can be obtained by using three rotations in sequence. The first rotation is applied in xm-axis until ym-axis is parallel to the base platform plane and this angle of rotation φ is known as roll angle. Then a rotation is applied in the ym-axis until the movable platform is parallel to the base platform, so the pitch θ is obtained. To complete the coordinate systems, a last rotation is applied in the zm-axis generating the yaw angle ψ . The transformation matrix is shown in Equation (3).

$$[T^{MF}] = \begin{bmatrix} c\varphi c\theta & c\varphi s\theta s\psi - s\varphi c\psi & c\varphi s\theta c\psi + s\varphi s\psi \\ s\varphi c\theta & s\varphi s\theta s\psi + c\varphi c\psi & s\varphi s\theta c\psi - c\varphi s\psi \\ -s\theta & c\theta s\psi & c\theta c\psi \end{bmatrix} \quad (3)$$

where c is the cosine and s is the sine function.

The position of the movable platform can be written in the base platform system as shown in Equation (4), then length vectors V_i of six actuators can be obtained utilizing Equation (5) and shown in Figure 3.

$$\{M\}^F = \{x \ y \ z\}^T \quad (4)$$

$$\{V_i\}^F = \{V_{i1} \ V_{i2} \ V_{i3}\}^T \quad (5)$$

$$= \{M\} + [T^{MF}] \times \{M_i\} - \{F_i\},$$

$$i = 1, 2, \dots, 6$$

The actuator's length l_i is the module of the vector $\{V_i\}$ as shown in Equation (6) [8].

$$l_i = \{V_{i1}^2 \ V_{i2}^2 \ V_{i3}^2\}^{0.5}, \quad i = 1, 2, \dots, 6 \quad (6)$$

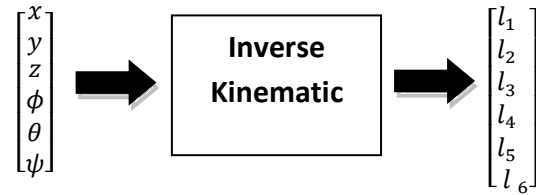


Fig. 3: Inverse Kinematic

III. PID CONTROLLER

We used the PID controller which is widely known, with transfer function presented in Equation (7). A controller was designed and this was applied to each of the six actuators independently [9]. The controller takes as input the signal from the error between the desired actuator length and actual length and then defines the control action that is the sum of proportional, derivative and integrative actions.

$$\frac{U}{E}(s) = \frac{kd(s^2 + \frac{kp}{kd}s + \frac{ki}{kd})}{s} \quad (7)$$

IV. FUZZY CONTROLLER

The position and attitude control of the movable platform in relation to the base platform is executed by controlling the six actuators lengths. A small variation in the response of each real electromechanical actuator is expected and can cause undesired movement of the movable base, in the case of an actuator reaches the desired length before others. To avoid this situation, a fuzzy logic controller was designed to control all the actuators with only one controller [1, 10].

The controller receives the desired position and attitude of the movable platform, utilizes the inverse kinematic to obtain desired lengths for the six actuators, and using two fuzzy sets it sends signals of voltage to the electric motor of each actuator. To define the amplitude and time of application of each signal, it uses the procedure described next.

First, the difference between the desired lengths and the actual lengths are calculated for all actuators and are the inputs of the fuzzy logic controller. These inputs are normalized utilizing the variation of the actuator's length when applied a tension of 10V in its electric motor during 1 second. The normalized inputs are used to define the actuator that will take longer to reach the desired length. Utilizing difference of this actuator the time of application of the signal is obtained.

Fuzzy sets with different variations on the actuator length were created using experimental tests in the Stewart

platform. In these tests, square signals with 10V and -10V were sent to the electric motors of the actuators with different times of application and the variations in the actuator's lengths were measured. These values are presented in Table 1 and Table 2. Utilizing the triangular membership presented in Equation (7), the application time of the square signal is obtained using Equation (8).

Table.1: Variations in actuators' lengths with different time of application and amplitude of 10V [mm].

Time	Act1	Act2	Act3	Act4	Act5	Act6
(s)	10V	10V	10V	10V	10V	10V
0.1	3.86	4.36	3.89	3.93	4.34	3.79
1.0	45.9	54.01	45.54	47.56	51.34	44.71
2.0	91.17	99.48	94.87	96.28	101.25	91.37
2.5	114.51	124.31	118.9	120.2	128.1	115.1

Table 2. Variations in actuators' lengths with different time of application and amplitude of -10V [mm].

Time	Act1	Act2	Act3	Act4	Act5	Act6
(s)	-10V	-10V	-10V	-10V	-10V	-10V
0.1	-4.08	-3.85	-3.92	-3.83	-4.29	-4.42
1.0	-49.61	-50.23	-47.44	-47.14	-49.86	-51.45
2.0	-100.7	-98	-96.2	-94.3	-102.3	-105.1
2.5	-127.3	-122.4	-120.5	-117.8	-127.6	-131.6

$$u_{ij}^t = \begin{cases} \max \left[\frac{\Delta l_{i+1,j} - \Delta l}{\Delta l_{i+1,j} - \Delta l_{i,j}}, 0 \right], i = 1, j = 1, 2 \\ \max \left[\min \left[\frac{\Delta l - \Delta l_{i-1,j}}{\Delta l_{i,j} - \Delta l_{i-1,j}}, \frac{\Delta l_{i+1,j} - \Delta l}{\Delta l_{i+1,j} - \Delta l_{i,j}} \right], 0 \right], i = \\ \max \left[\frac{\Delta l - \Delta l_{i-1,j}}{\Delta l_{i,j} - \Delta l_{i-1,j}}, 0 \right], i = 4, j = 1, 2 \end{cases} \quad (8)$$

where Δl is the higher input; $\Delta l_{i,j}$ are the lengths in Tables 1 e 2 for the actuator with the high input in the i -th line and j -th column, and u_{ij}^t is the membership value for the fuzzy set $\Delta l_{i,j}$.

$$t = \sum_{i=1}^4 \sum_{j=1}^2 u_{ij}^t \times t_i \quad (9)$$

where t is the time of the applied signal and t_i is the time in the i -th line of Tables 1 e 2.

The amplitude of the signal for each actuator is obtained in a similar way. Square signals of voltage of 10 V, 5 V, -10 V, -5 V and minimum values of voltage that cause rotation of the actuator's motors with 0,1 s, 1 s, 2 s and 2,5 s of time of duration were sent and then the actuators lengths were measured. Table 3 shows variations of actuator's 1 length for each combination of voltage and time of application. The amplitude of the signal for each actuator is obtained utilizing Equation (10), where triangular membership functions are utilized to correlate

the required variation in the length of the actuator with the amplitude voltage the controller will send to the actuator's engine.

$$V_K = \sum_{i=1}^6 u_i^V \times V_i \quad (10)$$

Table 3. Variation in the actuator's 1 length [mm]

Time	2.3 V	5 V	10 V	-1,3 V	-5 V	-10 V
(s)						
0.1	0.05	41.82	114.52	-0.06	-52.14	-126.38
1	0.21	34.32	91.18	-0.18	-41.87	-100.74
2	0.41	17.36	45.91	-0.40	-20.64	-49.62
2.5	0.46	1.36	3.86	-0.51	-1.80	-4.09

where V_K is the amplitude of voltage of the square signal for the k -th actuator, μV_i is the membership value of the desired variation in the length of the actuator obtained for the time of application of the signal and the voltage in the i -th column and V_i is the voltage in the i -th column. After the application of the square signal, this procedure is calculated again to correct for errors between the desired length and the actual length.

V. H INFINITY CONTROLLER

In the H infinity design in general weighting functions are employed to specify the stability and performance of the system. Understanding the effects of these functions on the control system is crucial for modeling specifications. A typical model for design, called augmented plant is shown in Figure 4. The weighting functions W_1 , W_2 and W_3 reflect the value specified error for the regime, limitations of the control signal and the stability condition, respectively. The standard method H infinity output feedback is used to stabilize the system. The standard H infinity control problem is formulated in terms of finding a controller K , if one exists, such that for a given $\gamma > 0$.

$$\|T_{zw}\|_{\infty} = \left\| \begin{bmatrix} W_1 S \\ W_2 K S \\ W_3 T \end{bmatrix} \right\|_{\infty} \quad (11)$$

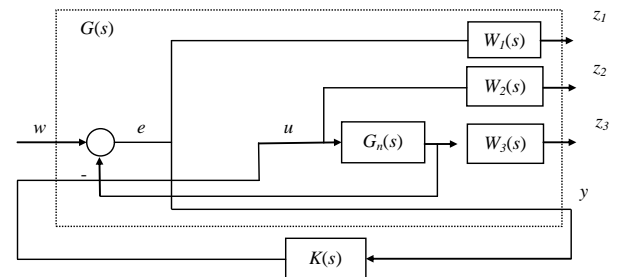


Fig.4: Augmented plant

The weighting functions represent the design specifications and modeling errors, restricting Z_1 , Z_2 and Z_3 of augmented plant output, as shown below:

The $W_1(s)$ function is a limiting factor for the sensitivity function S , and should reflect the rejection of external disturbances, considering the error signal Z_1 system and tolerance to variations in the plant. The sensitivity S should take low value, especially at low frequencies. Therefore, W_1 function, which reflects the performance specifications, must submit a high value at low frequencies.

The $W_2(s)$ function weighs Z_2 that is the control signal, and must have sufficient gain capacity to limit the input control an acceptable range, avoiding the saturation of the actuator. However, a high gain can deteriorate the performance, and this commitment must be taken into account. The W_2 function is linked to limitations in the input signal of the plant G_n such as maximum voltages or currents supported by the plant.

The $W_3(s)$ function weighs Z_3 namely the plant output G_n , and should minimize the peak of the complementary sensitivity function T system, reducing the oscillations and ensuring stability [11].

Thus we have the same sensitivity function $S = (I + GK)^{-1}$, the complementary sensitivity function $T = I - S$ and the sensitivity function of the controller $C = KS$.

The H infinity control in this section is based on a compensator project and an observer whose solutions are obtained by two algebraic Riccati equations and results in a controller with the same number of states of the plant [12]. $P(s)$ is the state-space realization of an augmented plant, according to equation:

$$P(s) = \begin{bmatrix} A & B_1 & B_2 \\ C_1 & D_{11} & D_{12} \\ C_2 & D_{21} & D_{22} \end{bmatrix} \quad (12)$$

Consider the state space representation of the augmented system, including the dynamics of the weighting functions, is given by:

$$\begin{bmatrix} \dot{x} \\ z \\ y \end{bmatrix} = \begin{bmatrix} A & B_1 & B_2 \\ C_1 & 0 & D_{12} \\ C_2 & D_{21} & 0 \end{bmatrix} \begin{bmatrix} x \\ w \\ u \end{bmatrix} \quad (13)$$

The following hypotheses are considered in H infinity problems [12]:

(A, B_2, C_2) is stabilizable and detectable;

D_{12} e D_{21} have (post) complete;

$\begin{bmatrix} A - j\omega I & B_2 \\ C_1 & D_{12} \end{bmatrix}$ has complete column post for all ω ;

$\begin{bmatrix} A - j\omega I & B_1 \\ C_2 & D_{21} \end{bmatrix}$ has complete line post for all ω ;

$D_{11} = 0$ e $D_{22} = 0$;

$D_{12} = \begin{bmatrix} 0 \\ I \end{bmatrix}$ e $D_{21} = \begin{bmatrix} 0 & I \end{bmatrix}$;

$D_{12}^T C_1 = 0$ e $B_1 D_{21}^T = 0$ and

(A, B_1) is stabilizable and (A, C_1) is detectable.

The following Riccati equations are associated with the H infinity problem:

$$A^T X + XA + C_1^T C_1 + X(\gamma^{-2} B_1 B_1^T - B_2 B_2^T) X = 0 \quad (14)$$

so that $\text{Re} \lambda_i[A + (\gamma^{-2} B_1 B_1^T - B_2 B_2^T) X] < 0, \forall i$ and

$$YA^T + AY + B_1 B_1^T + Y(\gamma^{-2} C_1^T C_1 - C_2^T C_2) Y = 0 \quad (15)$$

so that $\text{Re} \lambda_i[A + Y(\gamma^{-2} C_1^T C_1 - C_2^T C_2)] < 0, \forall i$.

Given the hypotheses outlined previously, the equations of Riccati admit stabilizing solutions X_∞ and Y_∞ , and $\rho(X_\infty Y_\infty) < \gamma^2$, with $\rho(\cdot)$ the spectral radius, then there is a controller that internally stabilizes system $u = Ky$ so that the norm of the transfer function of closed loop $T_{zw} = P_{11} + P_{12}K(I - P_{22}K)^{-1}P_{21}$ is small, this is $\|T_{zw}\| < \gamma$, with γ a scalar positive [13]. The controller is given by:

$$\begin{bmatrix} \dot{x}_c \\ u \end{bmatrix} = \begin{bmatrix} A_c & B_c \\ C_c & 0 \end{bmatrix} \begin{bmatrix} x_c \\ y \end{bmatrix} \quad (16)$$

and

$$A_c = A + \gamma^{-2} B_1 B_1^T X_\infty + B_2 F_\infty + Z_\infty L_\infty C_2 \quad (17)$$

$$B_c = -Z_\infty L_\infty \quad (18)$$

$$C_c = F_\infty = -B_2^T X_\infty \quad (19)$$

$$L_\infty = -Y_\infty C_2^T \quad (20)$$

$$Z_\infty = (I - \gamma^{-2} X_\infty Y_\infty)^{-1} \quad (21)$$

VI. RESULT EXPERIMENTAL

To validate the controllers, a step input of 15° in ψ , representing the yaw movement of the experimental Stewart Platform, the angles $[\phi \ \theta]$ remained at zero. The Figures 5, 6 and 7 show the responses of the actuators to the desired input condition.

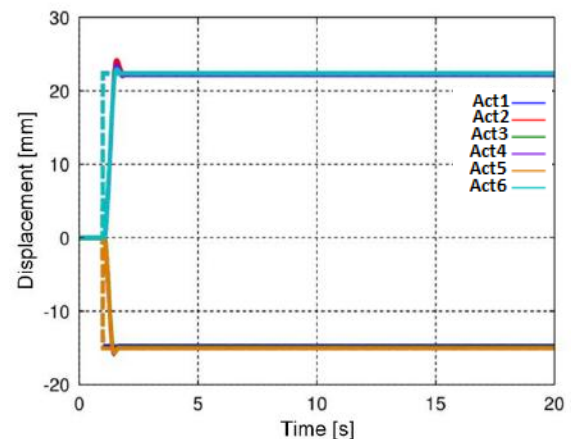


Fig.5: Response for 15° in ψ for H infinity control

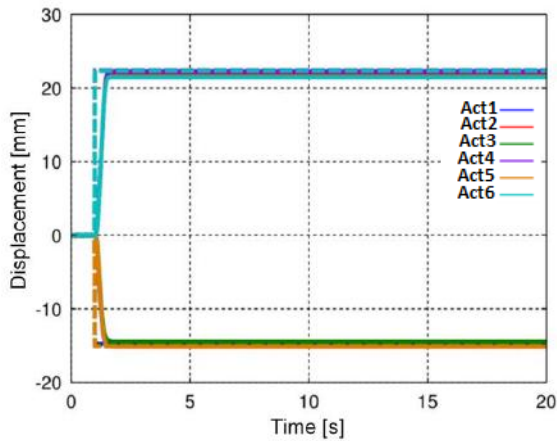


Fig. 6: Response for 15° in ψ for PID control

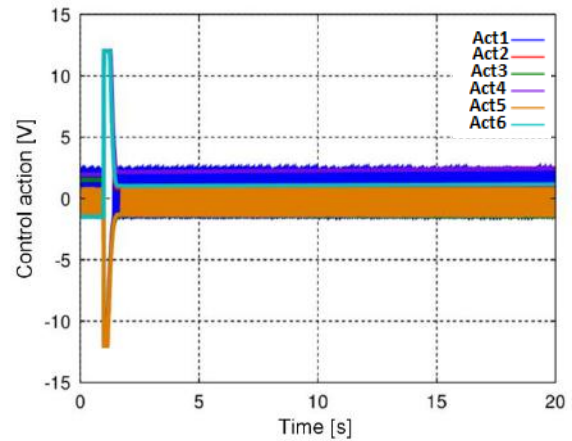


Fig. 9: Control Action for 15° in ψ for PID control

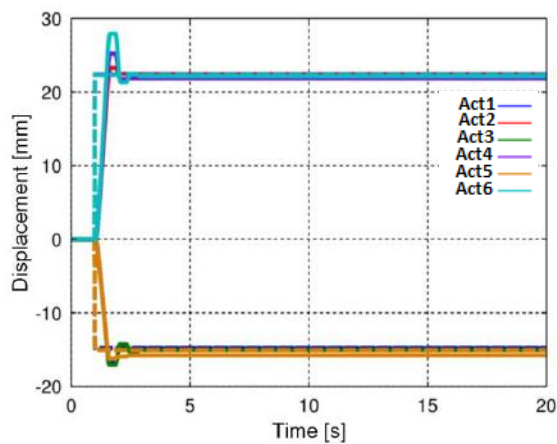


Fig.7: Response for 15° in ψ for Fuzzy control

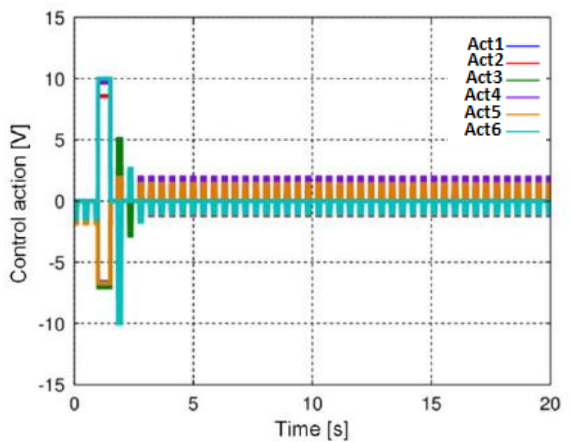


Fig. 10: Control Action for 15° in ψ for Fuzzy control

The Figures 8, 9 and 10 show the control actions of the system to cause the actuators to reach the desired lengths. Figures 11, 12 and 13 show the error tending to zero, showing the efficiency of the designed controllers.

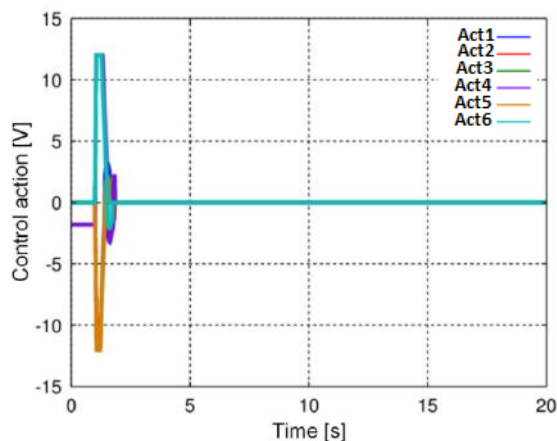


Fig.8: Control Action for 15° in ψ for H infinity control

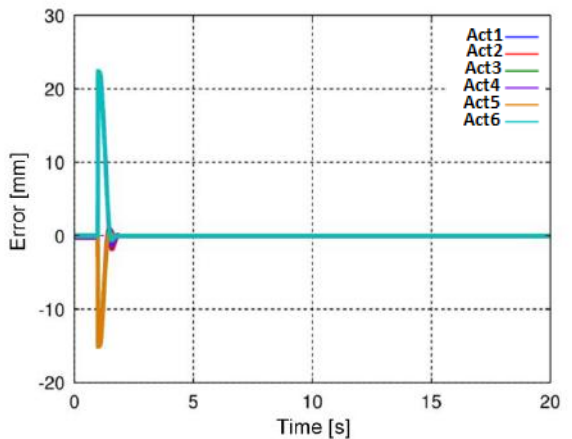


Fig. 11: Error for 15° in ψ for H infinity control

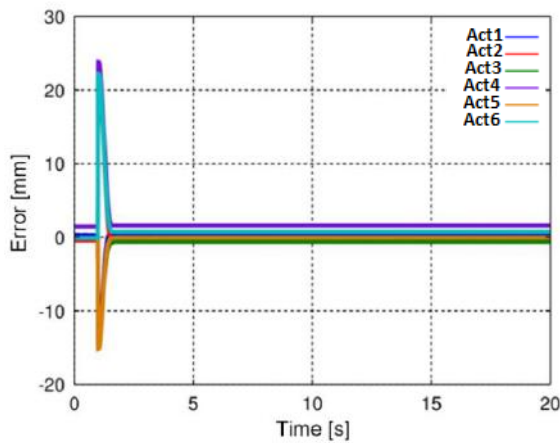


Fig.12: Error for 15° in ψ for PID control

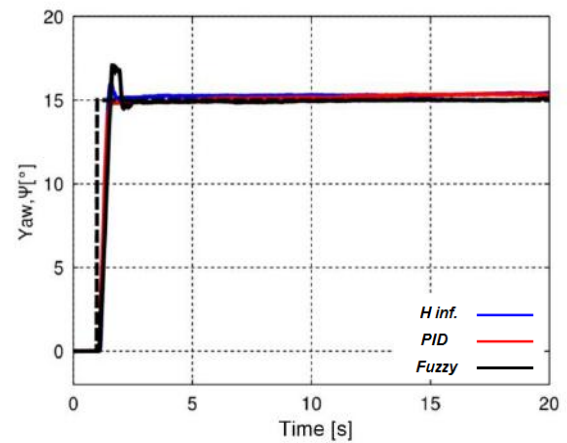


Fig.14: Yaw for ψ in 15°

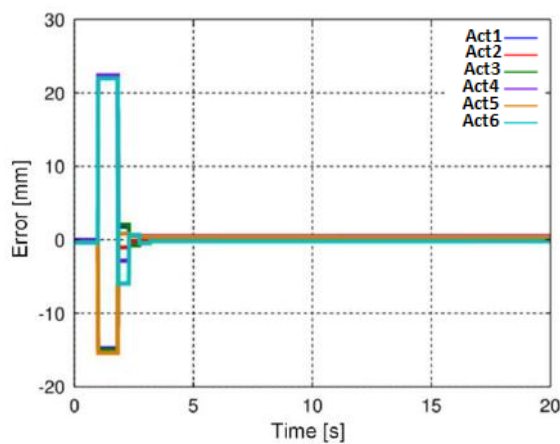


Fig.13: Error for 15° in ψ for Fuzzy control

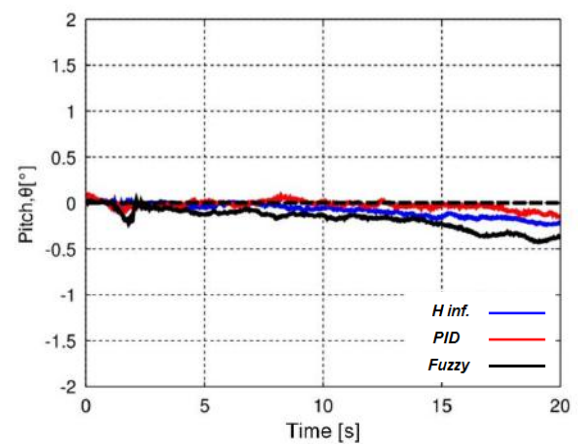


Fig 15: Pitch for ψ in 15°

The Figure 14 shows the orientation reading ψ for the step input of 15°, representing the yaw movement of the Stewart Platform, this acquisition is performed with the XsensMTi-G inertial sensor. It is possible to observe that, also for the movements of yaw, the controllers managed to converge to the desired orientation, but presented a regime error for this angle, where, it is necessary to say that the sensor has an accuracy of $\pm 1^\circ$. The Figure 15 shows the reading of the angle θ remaining close to zero degree, and the Figure 16 shows the reading of the angle ϕ , also close to zero degree.

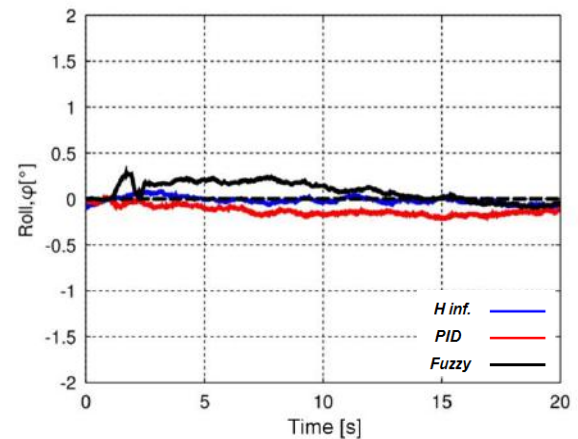


Fig 16: Roll for ψ in 15°

The angular velocities for yaw in 15° are shown in the Figures 17, 18 and 19. It is possible to observe an angular velocity peak in yaw at the beginning of the 15° step input, and as soon as the system arrives at the desired position and orientation, the velocity goes to zero.

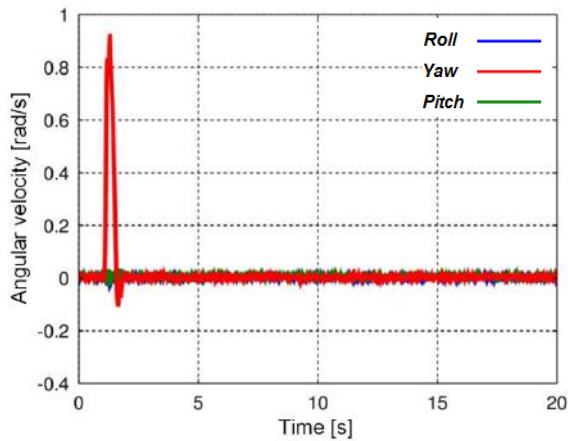


Fig. 17: Angular velocity for 15° in ψ for H infinity control

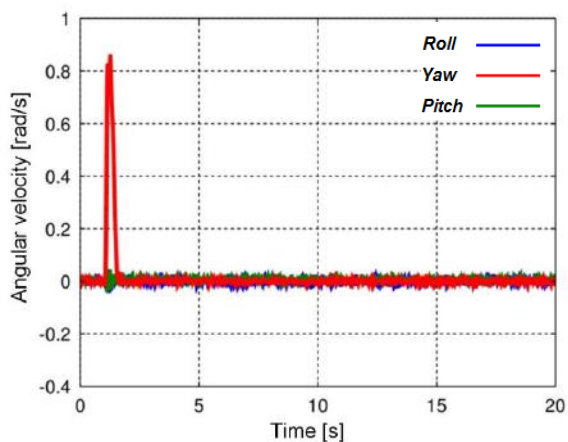


Fig. 18: Angular velocity for 15° in ψ for PID control

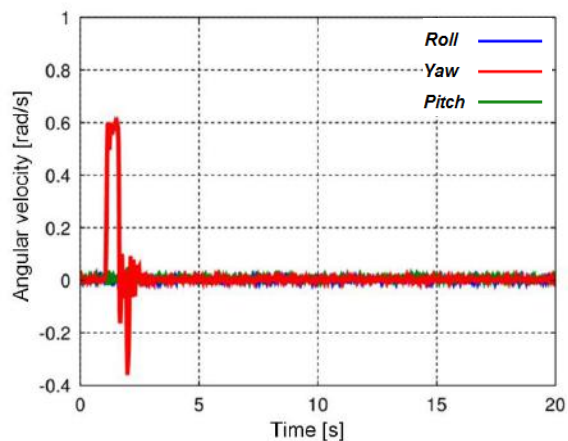


Fig. 19: Angular velocity for 15° in ψ for Fuzzy control

VII. CONCLUSION

The three controllers presented were able to efficiently control the real system of the Stewart platform, for yaw at 15° , but the H infinity controller presented the lowest regime error, as shown in Figure 11. It is also possible to observe from Figure 8 that the control action of the H

infinity controller tends to zero, so the platform arrives at its desired position and orientation, presenting a greater energy savings compared to the Fuzzy and PID controllers.

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The Influence of Vehicle Operational Cost on Building Material Fare and Basic Price (Case Study of Banjarmasin - Puruk Cahu Route)

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Abstract—Vehicle Operational Cost (VOC) of goods/material transportation greatly affects the delivery cost and the determination of destination basic price especially in Puruk Cahu. VOC must satisfy the requirements by calculating actual production cost, which issued by the owner of the transportation, to be government's foundation as the regulator of official fare transportation and unit price of building material in the future. This research analyze the amount of Vehicle Operational Cost (VOC) for truck to bring the building material from Banjarmasin - Puruk Cahu with conventional method, obtains ideal fare based on VOC calculation from the transportation owner in order to pay the production cost, and analyze how big is the influence of VOC upon the increasing of material building price in Puruk Cahu. Based on the discussion, several conclusions are obtained, such as VOC of Banjarmasin - Puruk Cahu route for building material transportation especially iron reinforcement material and cement are in amount of around Rp. 8.744,31 /km and Rp. 891,14 /ton.km. Building material transportation fare based on actual calculation from the sample profil obtains minimum transportation material fare in which Rp. 8.100,00 /km and Rp. 840,00 /ton.km with minimum weight 9 ton, meanwhile, the maximum transportation fare is in amount of Rp. 10.450,00/km and Rp. 1000,00/ton.km with 11 ton capacity. In addition, the average of transportation fare is in amount of Rp.8.848,44 /km and Rp. 902,81 /ton.km with the average transport 9,81 ton. Hence, it can be concluded that the existing material transportation fare is a little bit higher than the VOC calculation fare result for Rp./km and Rp./ton.km unit. Furthermore, the influence of the increasing of VOC fare for iron reinforcement material is in amount of 96,93% and portland cement in amount of 94,63% and the rest 3,07% for iron

reinforcement material and 5,37% for portland cement are affected by other factors.

Keywords— Vehicle Operational Costs (VOC), transportation fare, destination basic price.

I. INTRODUCTION

The development of Puruk Cahu citizen is in accordance with the development of its region and the increasing of citizen's economic activity. Citizen needs social interaction due to the commodity needs or other services which causes a travel and consequently it needs an instrument to make that travel easier. The number of travel demands to the related region is influenced by some important factors such as costs, characteristic of the transportation means, population in the origin region, income, and the main activity which can be done. One of the transportation's good guarantees is to ensure several things such as may carry people/things in a great number, safely arrive in the destination, and arrive fast with proper cost (efficient and effective) especially material transport claim. By remembering financial value which may be happen in goods transportation, so the determination of fare based on VOC is very dominant as the main factor that must be considered due to the wide effect, particularly on goods/material price determination between regions. This case study examines Vehicle Operational Cost (VOC) of goods transportation that affect cost and price of building material spesifically in the City of Puruk Cahu. In this case, the effect of material transportation's operational cost in Banjarmasin – Puruk Cahu route that is not yet examined scientifically makes the basic of fare determination has not yet stipulated by the regulator. Hence, the transpostation fare variance is affected and makes a not economic price of building material because of several factors such as long distance

to the main distributor, road infrastructure which partly insufficient, the doer and provider of transportation, and regulation of transportation funding. Based on the explanation above, this research aims to develop a calculation of goods transportation fare from Banjarmasin to Puruk Cahu, even though this development faces many obstacles due to the limited data that are used in this calculation. The result of the calculation is expected to be used as one of the instruments to know vehicle perational costs by using land vehicle in determining the official fare and to control the operation as effective as possible in order to predict future transportation cost. Based on the explanation above, this research aims to develop a calculation of goods transportation fare from Banjarmasin to Puruk Cahu, eventhough this development faces many obstacles due to the limited data that are used in this calculation. The result of the calculation is expected to be used as one of the intruments to know vehicle perational costs by using land vehicle in determining the official fare and to control the operation as effective as possible in order to predict future transportation cost.

II. LITERATURE REVIEW

2.1 Fare Determination Method

Stipulation of Directorate General of Land Transportation Number SK.687/AJ.206/DRJD/2002 about Technical Guideline of Public Transportation Implementation in Urban Area within Fixed and Well-Organized Route explains conventional fare determination method. In practice, the method can be applied with several adjustments needed. Fare is the amount of cost that charged to each transportation user and expressed in Rupiah. As for goods/material transportation, the level of price or cost that is paid by the user is per unit trip, weight, or per unit volume per kilometer. Fare determination is aimed to encourage maximum use of transportation infrastructure and facility. Calculating fare by using Vehicle Operational Cost (VOC) approach means the price is determined based on the operational cost plus several managements and profit percentages that permitted. Types of Transportation fare are explained as follows (Salim, 1993):

1. Fare based on Route, it is operational management of the transportation which operated by considering the distance traveled by related transportation.
2. Local fare, applicable fare in a region.
3. Different fare, it is different fare based on distance, weight, cargo, speed, or special characteristic of the transpoted goods.
4. Container on flat car fare, applicable fare to carry box in truck based on its size and the origin to the destination place.

2.2 Vehicle Operational Cost (VOC)

To make basic price calculation easier, cost classification using approach technique is conducted as follows:

1. Direct cost
 - a. Fixed cost
Includes vehicle depreciation cost, capital investment for vehicles, vehicle registration cost, vehicle testing cost and assurance both for vehicle and the crew.
 - b. Variable cost
Includes salary/crew premium of insurance, fuel oil, tire usage, regular checking, small service, big service, general checking, body and truck container repair, overhole and rebuilt, wasing truck, terminal/platform/port/warehouse and road levies.
2. Indirect Cost
 - a. Fixed Cost
Crew salary besides transportation crew cost, overtime money, social benefits, health and clothes benefits, as well as assurance. The staff besides crew consists of leader, administration staff, technical and operational. The number of staff beside the crew depends on the size of transportation.
 - b. Variable Cost
Cost of management, depreciation of office building, pool and garage, inventory/office equipment, and garage facility, electricity and water cost, telephone and telegram bill, official trip cost besides staff, company's tax, route and business permission, also marketing cost.
3. Additional expenses and profit
Transportation company is permitted to take additional expenses and profit in amount of 10% for vehicle operation.

III. RESEARCH METHOD

3.1 Data Collection Stage

Pengumpulan data primer ditujukan untuk mengetahui objek penelitian berupa:

1. Vehicle type and specification transport goods from Banjarmasin to the city of Puruk Cahu. Thus, it needs transportation data especially building material transportation and the movement of origin of building material;
2. Production cost and transportation fare;
3. Needed time for travel; and
4. Material specification in form of type, volume, and commodity weight records.

Secondary data are the available data. In this research, data source may be obtained from related institution. As for the data for supporting this research are as follow:

1. Population number, geographical condition, social and economy;
2. Banjarmasin- Puruk Cahu Map;
3. Data of unit price at Murung Raya Regency, 2017;
4. Spareparts data and truck operation service of the transportation.

3.2 Variable Identification

In order to obtain significant variable, this research uses several variables which are identified from the previous research. It is important to take into account the variable in calculating the total of VOC. The variables are:

- a. Internal factor of vehicle, such as cost of refined fuel oil (BBM), lubricant, tire, spareparts, maintenance, operator salary, retribution, permission, depreciation, and additional expenses/overhead.
- b. External factor, such as the price of iron reinforcement material and cement in 2017 in Banjarmasin and Puruk Cahu.

3.3 Data Analysis Stage

Analysis of VOC model is conducted through conventional approach with computer assistance in certain stage. The stages are as follow:

1. Analyze truck profile which pass by/transit on the research's study zone.
2. Run VOC calculation.
3. Analyze the available fare based on commodities weight which is carried.

4. Compare the ideal price based on VOC result with the available fare.
5. Analyze the increasing of basic price in the destination due to the influence of VOC.

IV. SURVEY RESULT

4.1 Survey Data

The survey result obtains from the first respondent in which freelance truck driver or individual service which owned a transportation instrument for delivery material between regions. The survey location of freelance truck driver is in the locations of loading and unloading building material or warehouse areas of building material stores in Puruk Cahu. It is done with a consideration to make the interview with truck drivers easier. The interview aims to know the production cost and observe type and weight of building material commodity in detail, as well as to record the used vehicle profile.

The second respondent is freight forwarding company or the company which gives service in collecting, manging, warehousing, and delivery goods/materials which have legality on its service. The survey locations are where their companies take place.

To ensure a high-quality product, diagrams and lettering MUST be either computer-drafted or drawn using India ink.

Table. 1: Fare of Goods/Material Transportation by Freelance Driver in Banjarmasin – Puruk Cahu

No	Plat Number	Drivers' Name	Truck Type	FARE/TON
1	DA 1424 AL	FAHMI	MITSUBHISI CANTER PS 125HD	Rp 450.000,00
2	DA 1060 BG	BENI	MITSUBHISI CANTER PS 135HD	Rp 430.000,00
3	DA 9001 EF	MARDI	MITSUBHISI SUPER HDX 135	Rp 450.000,00
4	DA 1243 AM	YUDI	MITSUBHISI SUPER HDX 135	Rp 400.000,00
5	DA 1035 FD	PUTRA	HINO DUTRO 300	Rp 400.000,00
6	DA 1267 HB	IWAN	MITSUBHISI CANTER PS 135HDX	Rp 425.000,00
7	DA 8286 EF	ARIF	ISUZU ELF PS 120HD	Rp 450.000,00
8	DA 1998 FD	KASFI	MITSUBHISI CANTER PS 135HD	Rp 400.000,00
9	DA 1939 AK	HENDRA	MITSUBHISI CANTER PS 135HD	Rp 420.000,00
10	DA 9759 FE	ARAB	MITSUBHISI PS 120	Rp 450.000,00
11	DA 1046 EF	MARNO	TOYOTA DYNA 130HT	Rp 450.000,00
12	DA 1989 FE	KHUSAIRI	MITSUBHISI CANTER PS 125HD	Rp 425.000,00
13	DA 9750 E	SUGIANOOR	MITSUBHISI PS 120	Rp 475.000,00
14	DA 9145 WL	INDRA	MITSUBHISI CANTER PS 125HD	Rp 450.000,00
15	DA 8607 FE	JUMAIDI	MITSUBHISI CANTER PS 135HDX	Rp 420.000,00
16	DA 8250 MM	JANUAR	TOYOTA DYNA 130HT	Rp 450.000,00
17	L 9704 VU	MUSLIM	TOYOTA DYNA 130HT	Rp 425.000,00
18	DA 9430 AQ	JUNAIDI	MITSUBHISI CANTER PS 125HD	Rp 450.000,00
19	DA 8724 CF	TAUFIK	MITSUBHISI CANTER PS 135HDX	Rp 425.000,00
20	DA 9431 TW	HUSNI	TOYOTA DYNA 130HT	Rp 450.000,00
21	KH 8030 ET	SAFWANI	MITSUBHISI PS 120	Rp 450.000,00
22	DA 1060 FD	YUSUF	MITSUBHISI CANTER PS 125HD	Rp 425.000,00

Table. 2: The Average Number of Freelance Driver Shipment Every Month

No	Plat Number	Drivers' Name	Truck Type	Every Month Operation	
1	DA 1424 AL	FAHMI	MITSUBHISI CANTER PS 125HD	8	Trip
2	DA 1060 BG	BENI	MITSUBHISI CANTER PS 135HD	6	Trip
3	DA 9001 EF	MARDI	MITSUBHISI SUPER HDX 135	6	Trip
4	DA 1243 AM	YUDI	MITSUBHISI SUPER HDX 135	10	Trip
5	DA 1035 FD	PUTRA	HINO DUTRO 300	8	Trip
6	DA 1267 HB	IWAN	MITSUBHISI CANTER PS 135HDX	8	Trip
7	DA 8286 EF	ARIF	ISUZU ELF PS 120HD	5	Trip
8	DA 1998 FD	KASFI	MITSUBHISI CANTER PS 135HD	6	Trip
9	DA 1939 AK	HENDRA	MITSUBHISI CANTER PS 135HD	6	Trip
10	DA 9759 FE	ARAB	MITSUBHISI PS 120	6	Trip
11	DA 1046 EF	MARNO	TOYOTA DYNA 130HT	8	Trip
12	DA 1989 FE	KHUSAIRI	MITSUBHISI CANTER PS 125HD	7	Trip
13	DA 9750 E	SUGIANOOR	MITSUBHISI PS 120	4	Trip
14	DA 9145 WL	INDRA	MITSUBHISI CANTER PS 125HD	6	Trip
15	DA 8607 FE	JUMAIDI	MITSUBHISI CANTER PS 135HDX	9	Trip
16	DA 8250 MM	JANUAR	TOYOTA DYNA 130HT	6	Trip
17	L 9704 VU	MUSLIM	TOYOTA DYNA 130HT	4	Trip
18	DA 9430 AQ	JUNAIDI	MITSUBHISI CANTER PS 125HD	8	Trip
19	DA 8724 CF	TAUFIK	MITSUBHISI CANTER PS 135HDX	6	Trip
20	DA 9431 TW	HUSNI	TOYOTA DYNA 130HT	6	Trip
21	KH 8030 ET	SAFWANI	MITSUBHISI PS 120	6	Trip
22	DA 1060 FD	YUSUF	MITSUBHISI CANTER PS 125HD	5	Trip

Table. 3: Expedition Shipment Fare

NO	COMPANY	POLICE NUMBER	TRUCK TYPE	FARE
1	CV. BERKAH RAHMAN	DA 1084 BG	MITSUBHISI CANTER PS 135HD	Rp. 500.000,00 /ton
		KH 8241 EP	ISUZU 120 PS ELF HD	Rp. 500.000,00 /ton
		R 1954 CD	MITSUBHISI CANTER PS 135HDX	Rp. 500.000,00 /ton
		AB 8490 ME	MITSUBHISI CANTER PS 125HDX	Rp. 500.000,00 /ton
		DA 1888 ED	MITSUBHISI PS 120	Rp. 500.000,00 /ton
2	CV.BARITO JAYA	DA 9727 CF	ISUZU 125 PS ELF HD	Rp. 475.000,00 /ton
		AD 1971 F	ISUZU 120 PS ELF HD	Rp. 475.000,00 /ton
		DA 1119 FD	MITSUBHISI CANTER PS 135HD	Rp. 475.000,00 /ton
		DA 1507 HB	MITSUBHISI CANTER PS 125HD	Rp. 475.000,00 /ton
		DA 1058 FD	MITSUBHISI CANTER PS 125HD	Rp. 475.000,00 /ton

Table. 4: Data of Expedition Transportation Banjarmasin – Puruk Cahu

NO	COMPANY	POLICE NUMBER	TRUCK TYPE	TRIP	GOODS COMMODITY WHICH CARRIED PER MONTH	
				PER MONTH	BUILDING MATERIA L TRIP	OTHER COMMODI TY TRIP
1	CV. BERKAH RAHMAN	DA 1084 BG	MITSUBHISI CANTER PS 135HD	8	4	4
		KH 8241 EP	ISUZU 120 PS ELF HD	8	2	6

6	CV.BARIT O JAYA MANDIRI	R 1954 CD	MITSUBHISI CANTER PS 135HDX	8	4	4
		AB 8490 ME	MITSUBHISI CANTER PS 125HDX	8	2	6
		DA 1888 ED	MITSUBHISI PS 120	8	1	7
		DA 9727 CF	ISUZU 125 PS ELF HD	8	3	5
		AD 1971 F	ISUZU 120 PS ELF HD	8	6	2
		DA 1119 FD	MITSUBHISI CANTER PS 135HD	8	6	2
		DA 1507 HB	MITSUBHISI CANTER PS 125HD	8	5	3
		DA 1058 FD	MITSUBHISI CANTER PS 125HD	8	4	4

4.2 Data of Production Cost Component (Vehicle Operational Cost)

The data which are obtained from expedition owner or truck owner informs VOC detail components consists of spare parts, service fee, unit price and usage frequency such as in Table 5.

One example of truck production cost calculation according to component unit price is:

Mitsubishi Canter PS 135 HD, Police Number DA 1084 BG

1. Direct Cost

1). Fixed Price

- a. Vehicle Registration : Rp. 2.700.000,00 with unit of 96.000 km so that

$$\frac{Rp. 2.700.000,00}{96.000} = 28,13 \text{ Rp/km}$$

- b. KIUR : Rp. 1.000.000,00 with unit of 96.000 km, so that

$$\frac{Rp. 1.000.000,00}{96.000} = 10,42 \text{ Rp/km}$$

- c. Depreciation : calculated in amount of 20 %
(Rp. 344.000.000 – (20% x 344.000.000))

$$\frac{20}{20} = 13.760.000,00 \text{ Rp/year}$$

$$\frac{Rp. 13.760.000,00}{96.000} = 143,33 \text{ Rp/km}$$

2). Variable Cost

- a. Refined Fuel oil (BBM): Rp. 6.850 /liter with unit of 5 km so that

$$\frac{Rp. 6.850}{5} = 1.370,00 \text{ Rp/km}$$

- b. Tire usage (7 tires)

- a). Outside tire : Rp. 1.400.000,00 per tire with unit of 30.000 km so that

$$\frac{Rp. 1.400.000 \times 7 \text{ pcs}}{30.000} = 326,67 \text{ Rp/km}$$

- b). Inside tire : Rp. 200.000 per tire with unit of 30.000 km so that

$$\frac{Rp. 200.000 \times 7 \text{ pcs}}{30.000} = 46,67 \text{ Rp/km}$$

- c). Tire Layer: Rp. 50.000 per tire with unit of 30.000 km so that

$$\frac{Rp. 50.000 \times 7 \text{ pcs}}{30.000} = 11,67 \text{ Rp/km}$$

- c. Small service every 8.000 Km

- a). Machine oil : Rp. 45.000 / liter with 8.000 km so that (Rp. 45.000 x 10 liter) / 8.000 km = 56,25 Rp/km

- b). Grease : Rp. 25.000 / kg with 8.000 km so that (Rp. 25.000 x 2 kg) / 8.000 km = 6,25 Rp/km

- c). Brake fluid : Rp. 75.000 / liter with 8.000 km so that (Rp. 75.000 x 0,52 liter) / 8.000 km = 4,88 Rp/km

- d). Front brake shoes : Rp. 100.000 /bh with 8.000 km so that (Rp. 100.000 x 2 bh) / 8.000 km = 25,00 Rp/km

- e). Back brake shoes: Rp. 100.000 /bh with 8.000 km so that (Rp. 100.000 x 2 bh) / 8.000 km = 25,00 Rp/km

- f). Service cost : 15% x (56,25 + 6,25 + 4,88 + 25,00 + 25,00) = 17,61 Rp/km

- d. Big service every 24.000 Km

- a). Transmission oil : Rp. 38.000 / liter with 24.000 km so that (Rp. 38.000 x 4 liter) / 24.000 km = 6,33 Rp/km

- b). Axle oil : Rp. 40.000 / liter with 24.000 km so that (Rp. 40.000 x 4 liter) / 24.000 km = 6,67 Rp/km

- c). Grease : Rp. 25.000 / kg with 24.000 km so that (Rp. 25.000 x 4 kg) / 24.000 km = 4,17 Rp/km

- d). Brake seal : Rp. 16.000 / unit with 24.000 km so that (Rp. 16.000 x 1 unit) / 24.000 km = 0,67 Rp/km

- e). Brake shoes : Rp. 135.000 / unit with 24.000 km so that (Rp. 135.000 x 1 unit) / 24.000 km = 5,63 Rp/km

- f). Oil filter : Rp. 125.000 / unit with 24.000 km so that $(\text{Rp. } 125.000 \times 1 \text{ unit}) / 24.000 \text{ km} = 5,21 \text{ Rp/km}$
- g). Fuel filter : Rp. 125.000 / unit with 24.000 km so that $(\text{Rp. } 125.000 \times 1 \text{ unit}) / 24.000 \text{ km} = 6,46 \text{ Rp/km}$
- h). Air filter : Rp. 155.000 / unit with 24.000 km so that $(\text{Rp. } 155.000 \times 1 \text{ unit}) / 24.000 \text{ km} = 6,46 \text{ Rp/km}$
- i). Water cooler : Rp. 100.000 / unit with 24.000 km so that $(\text{Rp. } 100.000 \times 1 \text{ unit}) / 24.000 \text{ km} = 4,17 \text{ Rp/km}$
- j). Service cost : $15\% \times (6,33 + 6,67 + 4,17 + 0,67 + 5,63 + 5,21 + 5,21 + 6,46 + 4,17) = 6,68 \text{ Rp/km}$
- e. General checking
- a). Power steering oil : Rp. 90.000 / liter with 48.000 km so that $(\text{Rp. } 90.000 \times 3 \text{ liter}) / 48.000 \text{ km} = 5,63 \text{ Rp/km}$
- b). Hydraulic fluid : Rp. 85.000 / liter with 48.000 km so that $(\text{Rp. } 85.000 \times 3 \text{ liter}) / 48.000 \text{ km} = 5,31 \text{ Rp/km}$
- c). Clutch plat : Rp. 1.600.000 / unit with 48.000 km so that $\text{Rp. } 1.600.000 / 48.000 \text{ km} = 33,33 \text{ Rp/km}$
- d). Clutch drop : Rp. 2.400.000 / unit with 48.000 km so that $\text{Rp. } 2.400.000 / 48.000 \text{ km} = 50,00 \text{ Rp/km}$
- e). Accumulator : Rp. 850.000 / pcs with 48.000 km so that $\text{Rp. } 850.000 / 48.000 \text{ km} = 17,71 \text{ Rp/km}$
- f). Leaf spring : Rp. 850.000 / one set with 48.000 km so that $\text{Rp. } 850.000 / 48.000 \text{ km} = 17,71 \text{ Rp/km}$
- g). Wiper blade : Rp. 200.000 / one set with 48.000 km so that $\text{Rp. } 200.000 / 48.000 \text{ km} = 4,17 \text{ Rp/km}$
- h). Shock absorber : Rp. 500.000 / one set with 48.000 km so that $\text{Rp. } 500.000 / 48.000 \text{ km} = 10,42 \text{ Rp/km}$
- i). Rubber : Rp. 150.000 / one set with 48.000 km so that $\text{Rp. } 150.000 / 48.000 \text{ km} = 3,13 \text{ Rp/km}$
- j). Timing belt : Rp. 1.450.000 / one set with 48.000 km so that $\text{Rp. } 1.450.000 / 48.000 \text{ km} = 30,21 \text{ Rp/km}$
- k). Fan belt : Rp. 85.000 / one set with 48.000 km so that $\text{Rp. } 85.000 / 48.000 \text{ km} = 1,77 \text{ Rp/km}$
- l). Bearing : Rp. 220.000 / unit with 48.000 km so that $\text{Rp. } 220.000 / 48.000 \text{ km} = 4,58 \text{ Rp/km}$
- m). Bolamp : Rp. 75.000 / pcs with 48.000 km so that $(\text{Rp. } 75.000 \times 4 \text{ pcs}) / 48.000 \text{ km} = 6,25 \text{ Rp/km}$
- n). Fuse : Rp. 8.000 / pcs with 48.000 km so that $(\text{Rp. } 8.000 \times 2 \text{ pcs}) / 48.000 \text{ km} = 0,33 \text{ Rp/km}$
- f. Regular checking
- a). Machine oil : Rp. 45.000 / liter with 500 km so that $(\text{Rp. } 45.000 \times 0,25 \text{ liter}) / 500 \text{ km} = 22,50 \text{ Rp/km}$
- b). Accumulator water : Rp. 25.000 / liter with 500 km so that $(\text{Rp. } 25.000 \times 0,5 \text{ liter}) / 500 \text{ km} = 25,00 \text{ Rp/km}$
- c). Tire repair : Rp. 35.000 per pieces with 500 km so that $\text{Rp. } 35.000 / 500 \text{ km} = 70,00 \text{ Rp/km}$
- g. Repair body and container
- a). Material cost : Rp. 6.000.000 / pcs with 96.000 km so that $\text{Rp. } 6.000.000 / 96.000 \text{ km} = 62,50 \text{ Rp/km}$
- b). Service cost : $15\% \times (62,50) = 9,38 \text{ Rp/km}$
- h. Retribution
- a). Weighbridge : Rp. 25.000 with 500 km so that $\text{Rp. } 25.000 / 500 \text{ km} = 50,00 \text{ Rp/km}$
- b). Parking : Rp. 20.000 with 500 km so that $(\text{Rp. } 20.000 \times 3 \text{ kali}) / 500 \text{ km} = 120,00 \text{ Rp/km}$
- i. Truck washing
- Truck washing: Rp. 100.000 with 500 km so that $\text{Rp. } 100.000 / 500 \text{ km} = 200,00 \text{ Rp/km}$
- j. Crew income
- a). Driver salary : Rp. 1.600.000,00 /rit with unit of 96.000 km

$$\frac{\text{Rp. } 1.600.000 \times (8 \times 2) \times 12 \text{ months}}{96.000} = 3.200,00 \text{ Rp/km}$$
- b). Driver's helper salary : Rp. 450.000 /rit with unit of 96.000 km

$$\frac{\text{Rp. } 550.000 \times (8 \times 2) \times 12 \text{ months}}{96.000} = 1.100,00 \text{ Rp/km}$$
- k. Food on trip
- a). Driver : Rp. 100.000,00 /rit with unit of 96.000 km

$$\frac{(\text{Rp. } 100.000 \times 2) \times (8 \times 2) \times 12 \text{ months}}{96.000} = 400,00 \text{ Rp/km}$$
- b). Driver's helper : Rp. 50.000 /rit with unit of 96.000 km

$$\frac{(\text{Rp. } 50.000 \times 2) \times (8 \times 2) \times 12 \text{ months}}{96.000} = 200,00 \text{ Rp/km}$$

2. Indirect cost $\frac{Rp. 9.000.000,00}{96.000} = 93,75 \text{ Rp/km}$
- 1). Fixed cost
- Salary of non-crew employee:
- a. Cashier : Rp. 3.000.000,00 with unit of 96.000 km
 $\frac{(Rp. 3.000.000 \times 12 \text{ months})}{96.000}$
 $= 375,00 \text{ Rp/km}$
- b. Accounting : Rp. 4.500.000,00 with unit of 96.000 km
 $\frac{(Rp. 4.500.000 \times 12 \text{ months})}{96.000}$
 $= 562,50 \text{ Rp/km}$
- c. Administration : Rp. 4.000.000,00 with unit of 96.000 km
 $\frac{(Rp. 4.000.000 \times 12 \text{ months})}{96.000}$
 $= 312,50 \text{ Rp/km}$
- 2). Variable Cost
- a. Depreciation
- a) Office building : calculated in amount of 20 %
 $\frac{(Rp. 1.500.000.000 - (20\% \times 1.500.000.000))}{20}$
 $= 60.000.000,00 \text{ Rp/year}$
 $\frac{Rp. 60.000.000,00}{96.000} = 625,00 \text{ Rp/km}$
- b). Garage building : calculated in amount of 20 %
 $\frac{(Rp. 520.000.000 - (20\% \times 520.000.000))}{20}$
 $= 20.800.000,00 \text{ Rp/year}$
 $\frac{Rp. 20.800.000,00}{96.000} = 216,67 \text{ Rp/km}$
- c). Office tools : calculated in amount of 20 %
 $\frac{(Rp. 74.000.000 - (20\% \times 74.000.000))}{20}$
 $= 2.960.000,00 \text{ Rp/year}$
 $\frac{Rp. 2.960.000,00}{96.000} = 30,83 \text{ Rp/km}$
- d). Garage facility : calculated in amount of 20 %
 $\frac{(Rp. 225.000.000 - (20\% \times 225.000.000))}{20}$
 $= 9.000.000,00 \text{ Rp/year}$
- b. Office administration cost : Rp. 27.000.000 with 96.000 km so that $Rp. 27.000.000 / 96.000 \text{ km} = 281,25 \text{ Rp/km}$
- c. Maintenance cost : Rp. 54.000.000 with 96.000 km so that $Rp. 54.000.000 / 96.000 \text{ km} = 562,50 \text{ Rp/km}$
- d. Electricity and water bill : Rp. 20.000.000 with 96.000 km so that $Rp. 20.000.000 / 96.000 \text{ km} = 208,33 \text{ Rp/km}$
- e. Communication cost : Rp. 15.000.000 with 96.000 km so that $Rp. 15.000.000 / 96.000 \text{ km} = 156,25 \text{ Rp/km}$
- f. Account cost: Rp. 2.000.000 with 96.000 km so that $Rp. 2.000.000 / 96.000 \text{ km} = 20,83 \text{ Rp/km}$
- g. Business permission fee : Rp. 15.000.000 with 96.000 km so that $Rp. 15.000.000 / 96.000 \text{ km} = 156,25 \text{ Rp/km}$
3. Over head
 Over head is calculated 10 % and multiple with the combination of direct and indirect cost:
 $10\% \times (\text{direct cost} + (\text{indirect cost} / \text{the number of transportation}))$
 $10\% \times (Rp. 7.772,95 + (Rp. 3.789,17 / 5 \text{ bh})) = 853,08 \text{ Rp/km}$
4. Production cost
 Is the total of direct and indirect component cost plus with overhead, so that:
 $Rp. 8.530,78 + Rp. 853,08 = 9.383,86 \text{ Rp/km}$

V. DISCUSSION

5.1 Vehicle Operational Cost (VOC) of truck to carry goods/material

Based on the data, production cost is obtained and presented in table 5

Table 5. VOC Average

No.	Truck Type	Above limit	Under limit	Average Weight	VOC Average	
		(Rp/km)	(Rp/km)	(Ton)	(Rp/km)	(Rp/Ton.km)
1.	Expedition	9.824,60	9.034,94	9,81	9.429,77	961,00
2.	Freelance driver	8.448,37	7.669,33		8.058,85	821,28
Total					8.744,31	891,14

Based on Table 5, the average of VOC which obtained from both of truck types is 8.744,31 rupiah/km and 891,14 rupiah/ton/km.

5.2 Existing Fare Calculation

The list of existing fare calculation result can be seen in Table 6

Table 6. List of Existing Fare Calculation of Truck

No.	Police Number	Total distance (km)	Cost (Rp.)	Material weight (Ton)	Fare Rp/km	Fare Rp/ton.km
1	DA 1424 AL	1000	8.100.000,00	9,00	8.100,00	900,00
2	DA 1060 BG	1000	8.600.000,00	10,00	8.600,00	860,00
3	KH 9001 EF	1000	8.100.000,00	9,00	8.100,00	900,00
4	DA 1243 AM	1000	8.000.000,00	10,00	8.000,00	800,00
5	DA 1035 FD	1000	8.800.000,00	11,00	8.800,00	800,00
6	DA 1267 HB	1000	8.500.000,00	10,00	8.500,00	850,00
7	DA 8286 EF	1000	9.000.000,00	10,00	9.000,00	900,00
8	DA 1998 FD	1000	8.800.000,00	11,00	8.800,00	800,00
9	DA 1939 AK	1000	8.400.000,00	10,00	8.400,00	840,00
10	DA 9759 FE	1000	8.100.000,00	9,00	8.100,00	900,00
11	DA 1046 EF	1000	8.100.000,00	9,00	8.100,00	900,00
12	DA 1989 FE	1000	8.500.000,00	10,00	8.500,00	850,00
13	KH 9750 E	1000	8.550.000,00	9,00	8.550,00	950,00
14	DA 9145 WL	1000	8.100.000,00	9,00	8.100,00	900,00
15	DA 8607 FE	1000	8.400.000,00	10,00	8.400,00	840,00
16	DA 8250 MM	1000	8.100.000,00	9,00	8.100,00	900,00
17	L 9704 VU	1000	8.500.000,00	10,00	8.500,00	850,00
18	DA 9430 AQ	1000	8.100.000,00	9,00	8.100,00	900,00
19	DA 8724 CF	1000	9.350.000,00	11,00	9.350,00	850,00
20	DA 9431 TW	1000	9.000.000,00	10,00	9.000,00	900,00
21	KH 8030 ET	1000	8.100.000,00	9,00	8.100,00	900,00
22	DA 1060 FD	1000	8.500.000,00	10,00	8.500,00	850,00
23	DA 1084 BG	1000	10.000.000,00	10,00	10.000,00	1000,00
24	KH 8241 EP	1000	10.000.000,00	10,00	10.000,00	1000,00
25	R 1954 CD	1000	10.000.000,00	10,00	10.000,00	1000,00
26	AB 8490 ME	1000	9.000.000,00	9,00	9.000,00	1000,00
27	DA 1888 ED	1000	10.000.000,00	10,00	10.000,00	1000,00
28	DA 9727 CF	1000	10.450.000,00	11,00	10.450,00	950,00
29	AD 1971 F	1000	9.500.000,00	10,00	9.500,00	950,00
30	DA 1119 FD	1000	9.500.000,00	10,00	9.500,00	950,00
31	DA 1507 HB	1000	9.500.000,00	10,00	9.500,00	950,00
32	DA 1058 FD	1000	9.500.000,00	10,00	9.500,00	950,00
Average				9,81	8.848,44	902,81
Maximum				11,00	10.450,00	1.000,00
Minimum				9,00	8.100,00	840,00

Recent fare is obtained from freelance driver truck and expedition truck calculation. In order to obtain recent fare from all of the respondents (32 samples), thus:

1. Average fare Rp./km
$$= \frac{\text{Rp.283.150,00}}{32} = \text{Rp.8.848,44 /km}$$
2. Average fare Rp./ton/km
$$= \frac{\text{Rp.28.890,00}}{32}$$

= Rp.902,81 /ton.km

Therefore if it is seen from table 5 and table 6, we can conclude that the calculation of existing fare average is a little bit higher than VOC calculation for fare Rp./km and Rp./ton.km.

5.3 Calculation of Material Basic Price in Destination Region

Table 7. Summary of Transportation Cost and Destination Region Basic Price

NO.	JENIS BAHAN BANGUNAN	KAPASITAS ANGKUTAN TRUK RATA-RATA	ANGKUTAN BESI					
			Kapasitas Angkut	Berat Material Besi	Jumlah Besi	Embulatan	Harga Material per batang di Banjarmasin	Total Harga Pembelian di Banjarmasin
	(Material)	TON	(Ton)	kg	(Btg)	(Btg)	(Rp.)	(Rp.)
1	Besi Ø10mm+Semen	9,81	7,81	7,40	1054,84	1055,00	Rp 78.000,00	Rp 82.290.000,00

Continuation of Table 7

NO.	BUILDING MATERIAL TYPES	AVERAGE CAPACITY OF TRUCK	CEMENT TRANSPORT				
			Capacity	Cement Material Weight	Number of sack	Material/bar price in Banjarmasin	Total purchase price in Banjarmasin
	(Material)	TON	(Ton)	kg	(Sack)	(Rp.)	(Rp.)
1	Iron Ø10mm+Cement	9,81	2,00	50,00	40	Rp 50.000,00	Rp2.000.000,00

Continuation of Table 7

No.	BUILDING MATERIAL TYPES	BBM SOLAR INCREASE (GAS STATION)	TRANSPORATION FARE BASED ON VOC	
	(Material)	(Rp.)	(Rp/Km)	(Rp/Km.ton)
1	Iron Ø10mm+Cement	Rp -	8.744,31	891,14
		Rp 500,00	8.834,01	900,28
		Rp 1.000,00	8.923,71	909,42
		Rp 1.500,00	9.013,42	918,56
		Rp 2.000,00	9.103,12	927,71
		Rp 4.000,00	9.461,93	964,27
		Rp 6.000,00	9.820,74	1.000,84

Continuation of Table 7

TRANSPORT FARE			TOTAL MATERIAL PURCHASE + TRANSPORT FARE	
Iron	Cement	Total of Transport Fare	Iron	Cement
(Rp.)	(Rp.)	(Rp.)	(Rp.)	(Rp.)
Rp 3.479.901,70	Rp 891.140,00	Rp 4.371.041,70	Rp 85.769.901,70	Rp 2.891.140,00
Rp 3.515.598,62	Rp 900.281,34	Rp 4.415.879,96	Rp 85.805.598,62	Rp 2.900.281,34
Rp 3.551.296,74	Rp 909.422,98	Rp 4.460.719,72	Rp 85.841.296,74	Rp 2.909.422,98
Rp 3.586.994,86	Rp 918.564,63	Rp 4.505.559,49	Rp 85.876.994,86	Rp 2.918.564,63
Rp 3.622.692,98	Rp 927.706,27	Rp 4.550.399,25	Rp 85.912.692,98	Rp 2.927.706,27
Rp 3.765.485,46	Rp 964.272,85	Rp 4.729.758,30	Rp 86.055.485,46	Rp 2.964.272,85
Rp 3.908.277,94	Rp 1.000.839,42	Rp 4.909.117,36	Rp 86.198.277,94	Rp 3.000.839,42

Continuation of table 7

MATERIAL BASIC PRICE IN DESTINATION REGION			
Iron / Bar			
(Rp.)	Integration (Rp.)	Increase (Rp.)	(%)
Rp 81.298,49	Rp 81.300,00	Rp 3.298,49	4,06%
Rp 81.332,32	Rp 81.400,00	Rp 3.332,32	4,09%
Rp 81.366,16	Rp 81.400,00	Rp 3.366,16	4,14%
Rp 81.400,00	Rp 81.400,00	Rp 3.400,00	4,18%
Rp 81.433,83	Rp 81.500,00	Rp 3.433,83	4,21%
Rp 81.569,18	Rp 81.600,00	Rp 3.569,18	4,37%
Rp 81.704,53	Rp 81.800,00	Rp 3.704,53	4,53%

Continuation of table 7

MATERIAL BASIC PRICE IN DESTINATION REGION			
Cement / Sack			
(Rp.)	Integration (Rp.)	Increase (Rp.)	(%)
Rp 72.278,50	Rp73.000,00	Rp22.278,50	30,52%
Rp 72.507,03	Rp73.000,00	Rp22.507,03	30,83%
Rp 72.735,57	Rp73.000,00	Rp22.735,57	31,14%
Rp 72.964,12	Rp73.000,00	Rp22.964,12	31,46%
Rp 73.192,66	Rp74.000,00	Rp23.192,66	31,34%
Rp 74.106,82	Rp75.000,00	Rp24.106,82	32,14%
Rp 75.020,99	Rp76.000,00	Rp25.020,99	32,92%

Based on table 7 by taking calculation of reinforcement iron material Ø10mm as an example, it is known that the basic price of reinforcement iron Ø10mm per bar in the destination region is Rp. 81.298,4 and its purchase price in Banjarmasin is Rp. 78.000,00. Thus there are price differences in amount of Rp. 3.298,49. The increasing percentage is caused by material transportation cost in amount of 4,06%.

For cement Gresik, its basic price in the destination area per sack is Rp. 72.278,50 and the purchase price in Banjarmasin is Rp. 50.000,00. Hence, there are price differences in amount of Rp. 22.278,50 and the increasing percentage is caused by transportation cost in amount of 30,52%.

5.4 The Influence of Operational Cost on Building Material

The influence of building material transportation VOC in route of Banjarmasin – Puruk Cahu upon the basic price in the destination area particularly for reinforcement iron material and Portland cement are represented in Figure 1 and 2 with correlation graphic for both of the factors.

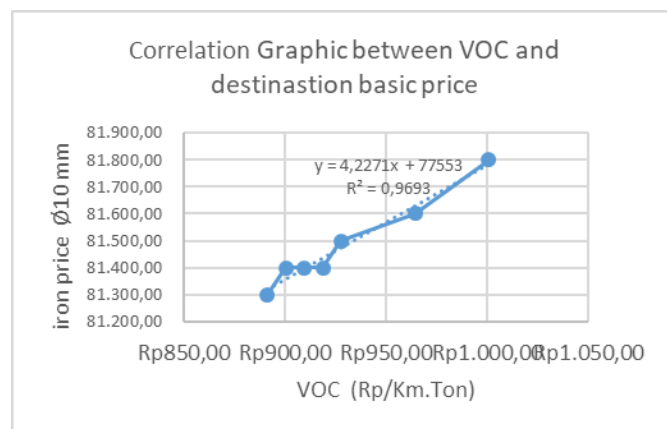


Fig.1: Correlation graphic between VOC and destination basic price of iron Ø10mm

Based on figure 1, it can be concluded that the influence of reinforcement iron price increase due to transportation cost is 96,93% and the rest of 3,07% is caused by another factor. Therefore, the equation correlation of those two factors is:

$$y = 4,2271x + 77553$$

Where:

y = Material iron price per bar (Rp.)

x = Vehicle operational cost (Rp./km.ton)

With R^2 value = 0,9693

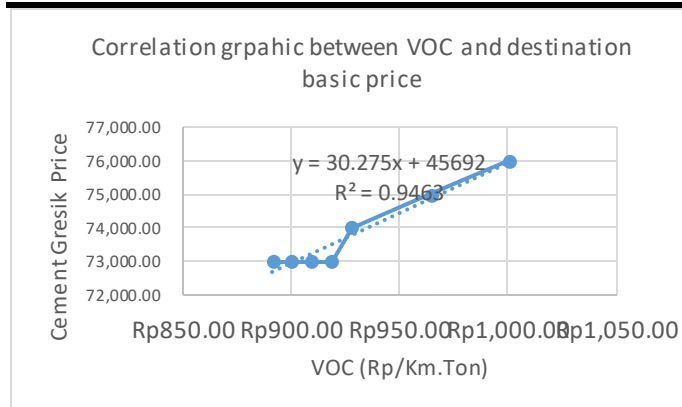


Fig.2: Correlation graphic of VOC and cement basic price in destination area

Based on the figure of 5.2, it can be concluded that the influence of portland cement price increase due to transportation cost is 94,63% and the rest of 5,37% is caused by another factor. Therefore, the correlation equation of those two factors is:

$$y = 30,275x + 45692$$

Where:

y = portland cement price per 50 kg (Rp./sak)

x = vehicle operational cost (Rp./km.ton)

with R^2 value = 0,9463

VI. CONCLUSION

According to the analysis and discussion in previous chapter, it can be concluded that:

1. Vehicle Operational Cost (VOC) Banjarmasin – Puruk Cahu route for building material transport especially reinforcement iron and cement are Rp. 8.744,31 /km and Rp. 891,14 /ton.km.
2. Building material transportation fare based on existing fare calculation from sample profil obtains minimum material transport fare in amount of Rp. 8.100,00 /km and Rp. 840,00 /ton.km with minimum capacity 9 ton, maximum fare transport in amount of Rp. 10.450,00 /km and Rp. 1000,00 /ton.km with maximum capacity 11 ton. The average material transport fare are Rp.8.848,44 /km and Rp. 902,81 /ton.km with average load in amount of 9,81 ton. In consequences, it is known that the average existing fare transportation is a little bit higher than the calculation of VOC for fare Rp./km and Rp./ton.km.
3. The influence of VOC increase for reinforcement iron material is 96,93% and portland cement is 94,63%. The rest 3,07% of reinforcement material and 5,37% of portland cement are caused by another factor.

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When Scientific Production Enters in Field: Bibliometrics Appointments about Soccer

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Abstract — Soccer is an exponent of Brazilian culture and identity, being discussed and analyzed in the most varied areas and segments of the academic world. In this sense, this work aims to measure and analyze the scientific production produced on the subject. The Scopus Platform, which is the largest database of scientific reference documents in the world, has been chosen to fulfill the proposed objective. In his theoretical framework, the work presents concepts about bibliometry, with the contribution of Rodrigues et al. (2016), Araújo and Alvarenga (2011), Tolves et al. (2016) and Krauskopf (2018), and on soccer, with the contributions of Giulianotti (2010), Rossi and Mendes Jr. (2014) and Silva (2006). At the end of the study, a scientific landscape was established that quantitatively demonstrated the production of areas, countries, universities, authors and periodicals.

Keywords — Scientific indicators. Quantitative research. World Cup.

I. INITIAL CONSIDERATIONS

In the field, 22 players. Outside him, a crowd accompanying the match with watchful eyes, watchful ears, and trembling hands. There is no more fascinating sport than soccer (DAMO, OLIVEN, 2013; GASTALDO, 2016). Therefore, as Guterman (2010) points out, sport can be understood as the largest social phenomenon in Brazil, since it represents the national identity and consolidates itself as the greatest expression of urban and mass popular culture in the country.

It is known, however, that sport is not only idolized by Brazilians. Soccer is consolidated as one of the most attractive and commented sports in the world (ROSSI; MENDES JR., 2014). Games involving large European clubs move millions of people around the globe, as there is now the possibility of seeing great stars parading their talent in a decision. The 2018 Champions League final, for example, had an audience of approximately 160 million people, surpassing even another major sporting event: the Super Bowl final. In Brazil it was no different: Globo, which has been broadcasting the competition since 2009, achieved its best result in 2018 (23 Ibope average

points, 10 points more than its traditional Saturday afternoon attractions).

In this sense, understanding soccer as a sport of collective interest, this work aims to measure and analyze the scientific production produced on the subject at a global level. Specifically, it is intended to establish a scientific landscape that demonstrates, quantitatively, the production of areas, countries, universities, authors and periodicals. In order to achieve the proposed objective, the Scopus Platform was chosen as the largest database and reference scientific documents in the world.

As for the work's disposition, the same is structured as follows: initially, the methodological procedures are presented with their selection criteria (RODRIGUES et al., 2016; ARAÚJO; ALVARENGA, 2011; TOLVES et al., 2016; KRAUSKOPF, 2018); after, it is discussed about the soccer (GIULIANOTTI, 2010; ROSSI; MENDES JR., 2014; SILVA, 2006); then the analyzes are presented; finally, the final considerations and the references are exposed.

II. METHODOLOGICAL PROCEDURES

This work, which aims to measure and analyze the scientific production produced on soccer at a global level, used bibliometrics. For Rodrigues et al. (2016), bibliometrics is an important tool that allows to analyze the progress on the intellectual production of certain subjects. In agreement, Araújo and Alvarenga (2011, p. 51) argue that bibliometrics as an area of study of information science “has a relevant role in the analysis of scientific production, since its indicators portray the degree of development of an area of the knowledge of a scientific field or of knowledge”. Still, for Tolves et al. (2016), the analysis of the scientific production allows a better understanding of the nature of the research activities carried out in the numerous areas of knowledge, from different countries, institutions and researchers. It is also understood that the propagation of research results can generate improvement for professionals in the field and, consequently, several social advances.

From this point of view, to reach the defined objective, we used, in this research, a query to the Scopus database. Considered the largest database of abstracts and citations

in the world's peer-reviewed literature (KRAUSKOPF, 2018), the platform offers a comprehensive overview of the production of global research in the areas of Science, Technology, Medicine, Social Sciences, Arts and Humanities. In addition, it provides tools that enable the monitoring, analysis and visualization of researches.

As a search criterion, only the filter-term Soccer was used. It was decided not to insert a second word or phrase because the proposal was precisely that the results to be returned were broad, thus establishing a vast landscape regarding the scientific construction on the subject. Obviously, it was understood that, in order for the research to verify adequate results, the term should be searched in English (the official language of the platform and of global scientific production). Thus, the final draft was Soccer, which, according to the designated parameters, returned 21,376 works, including articles, reviews, book chapters and event annals.

Among the preferences available for consultation, in addition to the key-term mentioned, the following particularizations were applied:

- in the place where the term soccer should appear, it was selected "Article title, Abstract, Keywords";
- on the date of publication, the marked option was "All years" - "Present";
- in the document type to be located, "All" was preferred;
- in the type of access, "All" was selected;
- after, it was clicked on "Search".

The following figure explains, in a particular way, the way the site search fields have been marked.

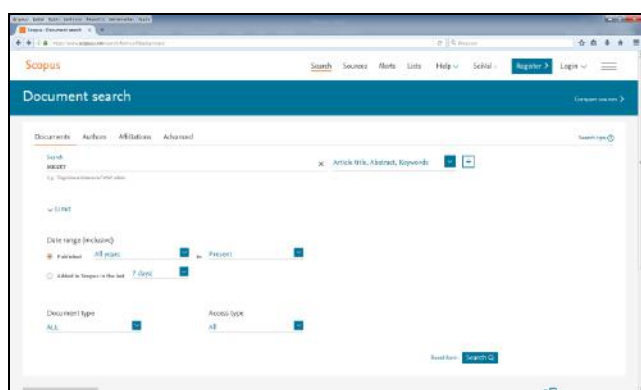


Fig. 1 – Scopus - Initial search

Source: Screenshot made by the authors

III. BRIEF NOTES ABOUT SOCCER

Soccer is the most popular sport in Brazil. However, this preference can also be perceived in other countries, that is, it is the most globalized of sports. Be it in rich English soccer or in precarious African soccer, the ball rolls and with it a series of sensations and emotions surround their spectators. It is the sport in which in the last moment a game that seemed defined can have a huge turnaround.

It's also on the 4 lawn lines that a galactic team, full of valuable players, is not sure of the victory, even playing against an infinitely smaller payroll team.

Another interesting element is that, mainly in Brazil, the players does not have a specific biotype. It can be high or low, fast or slow. This is usually explicit before the start of an important game, when the national anthem is played. Profiled, the players are presented by the camera and, there, we perceive the different physical characteristics of each one that translate the Brazilian cultural diversity. There is, perhaps, no other place in the world where this question is so clearly perceived. Brazil is, therefore, a country of many cultures, races, ethnicities.

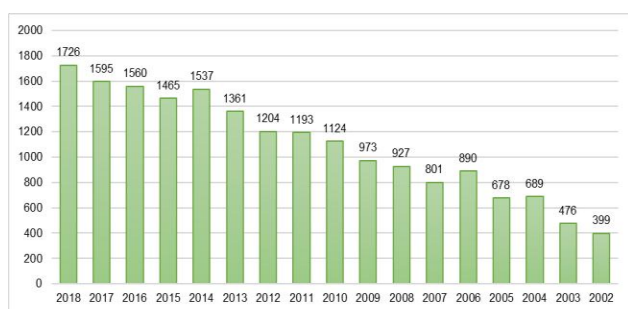
Giulianotti (2010, p. 07) mentions that, "although it may be increasingly outdated to say this, soccer is undeniably the world's leading sport." The author also seeks to uncover the characteristics that make the sport so popular: the simplicity of rules, equipment and body techniques. Roughly, it is enough that there are two teams, one ball and two goalies. The main purpose is to get the ball into the opponent's goal: it is the goal, the apogee, the maximum moment, whether on the European grassy slopes or in the muddy fields of the "gaucho countryside". However, although it seems a determining factor for the show, the goal is not fundamental, since there are anthological matches in which the score remained 0x0. What is worth is the emotion and the feeling that the sport provides.

In the current scenario, it is a consensus among fans and commentators that, in addition to enthusing the public, soccer also moves millionaire figures: contracts are made with players still adolescents, sponsorships are inserted in shirts and millions of products of the clubs are consumed. The sport has become an industry. However, from a different perspective, Rossi and Mendes Jr. (2014, 276) comment that, contrary to popular belief, soccer is a bad business: "the package of ideas that sees soccer as a great industry world to handle tens of billions of dollars is somewhat misleading". The authors cite examples of companies with millionaire billings and that, if they used the logic of the clubs, they would be bankrupt. About the games in Brazil, which occur during the week, close to the 10:00 a.m., the authors commented: "before complaining about the schedule, soccer needs to give more audience than the novel" (p. 282).

The point is that, generating losses or profits, or joys or sorrows, soccer is unanimous in the country and, as Silva (2006) argues, is understood as a symbol of national identity and an icon of Brazilian popular culture. Thus, in order to meet the proposed goal of this study, the bibliometric diagnoses are presented.

IV. REVIEWS AND RATINGS

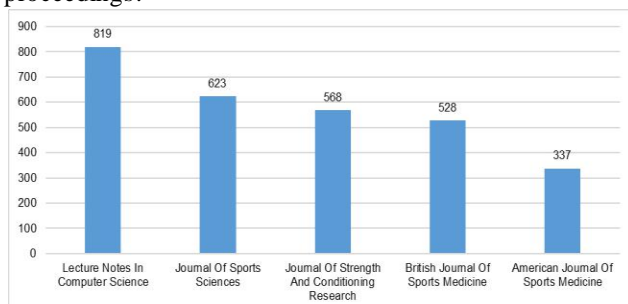
As a starting point for the discussions, we first sought to analyze the last 17 years of publications involving soccer. The respective time interval was selected with the intention of identifying the growth or decline of the number of publications year by year, since the FIFA World Cup, mega-event of the sport, occurs every 4 years. There was, therefore, the assumption that in the years in which the event occurs, the number of publications would increase considerably. Observing the following graph, we can see that, in the selected temporal section, this was not the occurrence, since it is noticed that the number of publications on the subject has been ignited, which expresses the growing interest of the scientific community in the subject.



Graph 1 - Number of annual publications

Source: Prepared by the authors

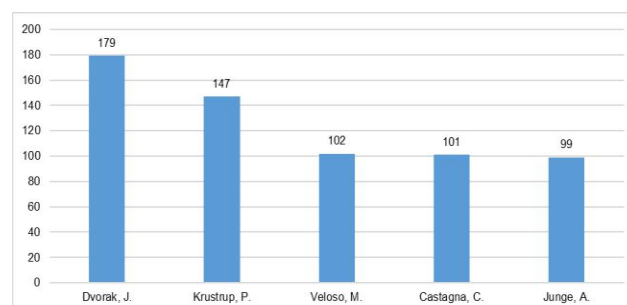
In order to identify the journals responsible for the greatest number of publications since the initial year of this survey (1932), the chart below shows that, with 819 publications, Lecture Notes in Computer Science has the lead. This, however, is not a journal that, in principle, is directly related to soccer: when we look at the themes that make up the total number (819), we notice that the works come from areas such as computer science, mathematics and biochemistry. The other journals that make up the chart - Journal of Sports Sciences, Journal of Strength and Conditioning Research, British Journal of Sports Medicine and American Journal of Sports Medicine - published in vast majority, work linked to the field of Medicine, dividing between articles and conference proceedings.



Graph 2 - Periodicals and number of publications

Source: Prepared by the authors

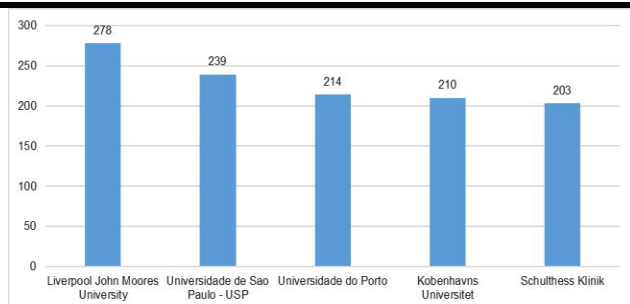
From the author's point of view, Jiri Dvorak leads the ranking with 179 publications. The author comes from Medicine, having published much of his work in periodicals related to the subject. This fact can be seen in the other members of Graph 3 who publish, substantially, in medical journals. It is also noted that the immense part of these publications are co-authored; there is rarely publication alone or even with few authors. The work with the greatest number of citations from Dvorak (476), for example, is "Summary and agreement statement of the 2nd International Conference on Concussion in Sport" and has 10 authors. His second paper, "Consensus statement on injury definitions and data collection in studies of soccer (soccer) injuries" (449 citations), has 9 and this shows a tendency among all the authors that integrate the graph.



Graph 3 - Authors and number of publications

Source: Prepared by the authors

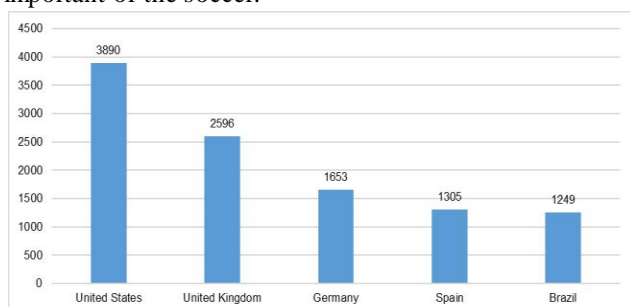
Graph 4 highlights the institutions with the largest number of publications. At the top, there is Liverpool John Moores University, a traditional english university founded in 1823. Among the most cited articles produced in the institution, the first three positions have Thomas P. Reilly as co-author: "Anthropometric and physiological predispositions for elite soccer" (468), "A multidisciplinary approach to talent identification in soccer" (418) and "Talent identification and development in soccer" (341). It is also worth noting the position of the University of São Paulo as the second institution that produced most works on soccer indexed in Scopus. Its most cited work, times 121, is "A model for the structural, functional, and deontic specification of organizations in multiagent systems", authored by J. Hübner, J. Sichman and O. Boissier, published, precisely, in the Lecture Notes in Computer Science. The high scientific production reinforces the idea that sport is of great interest in the country (GIULIANOTTI, 2010), even in the academic world.



Graph 4 - Institutions and number of publications

Source: Prepared by the authors

Although “within the four lines” the United States is not an exponent of soccer - the country has never won a FIFA World Cup, for example - in the academic field leads the ranking of nation with the largest number of publications¹. There are 3890 works, mostly from Medicine. Brazil, defined by Silva (2006) and Guterman (2010) as the country of soccer, ranks 5th with 1249 jobs. Between the two countries are the United Kingdom, Germany and Spain: nations known globally for their tradition in sport, possessing, in addition to world titles, national championships consolidated as the most important of the soccer.

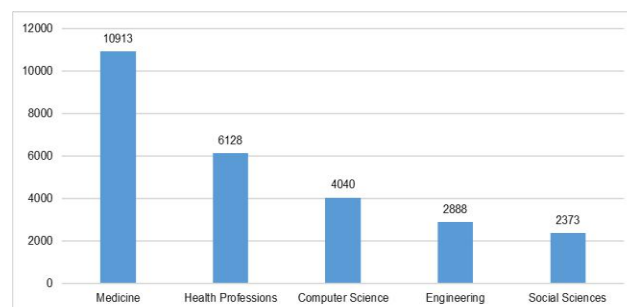


Graph 5 - Countries and number of publications Source:

Prepared by the authors

As already mentioned, Medicine has a remarkable production on soccer in the scientific world: it is, therefore, the area that most produced works indexed in Scopus (10913). The article “Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study”, published in the American Journal of Sports Medicine, has 1351 citations and is the most cited work in the field. The ranking also includes the areas of Health Sciences, Computer Science, Engineering and Social Sciences. We chose to demonstrate, graphically, only the 5 areas with the highest number of citations; however, it is important to mention that given the breadth of soccer, the subject is addressed in countless

other areas, such as Psychology, Marketing and Economy, for example.



Graph 6 - Area and number of publications Source:

Prepared by the authors

The synthesis-table presented below presents the main quantitative results highlighted by the research.

Table.2 - Summary table of results

Quantitative highlights of the search for the term soccer		
Year	2017	1726 publications
Journal	Lecture Notes In Computer Science	819 publications
Author	J. Dvorak	179 publications
Higher education institutions	Liverpool John Moores University	279 publications
Country	United States	3890 publications
Area	Medicine	10913 posts

Source: Prepared by the authors

The conclusions drawn for this work are presented below.

V. CONCLUSIONS

The present work, including soccer as a sport of global interest, aimed to measure and analyze the scientific production produced on the theme. The priority was to build a scientific landscape that quantitatively demonstrated the production of areas, countries, universities, authors and periodicals. Therefore, in order to achieve the desired objective, the Scopus Platform, which is the largest database and scientific documents in the world, was chosen.

In this sense, some observations can be pointed out:

- It was assumed that in the years in which the FIFA World Cup takes place scientific production on soccer would increase considerably. This did not occur, since the number of publications increased year by year, regardless of the event;
- The newspaper that has more texts on soccer indexed in Scopus is Lecture Notes In Computer Science, that has no

¹ Data refer to the nationality of journals and not to authors who have published. In this way, it is important to mention the interest about soccer in periodicals, coming from a country where sport is not a reference.

direct relation with soccer. In addition, the works that make up the total number (819) come from areas such as Computer Science, Mathematics and Biochemistry;

- From the author's point of view, one can see that, among the quantitative highlights, the vast majority of publications are co-authored; there is rarely a solitary publication or even a few authors;

- Among the universities that most published works is Liverpool John Moores University (278). However, it is considered fundamental to highlight the University of São Paulo in the second position (239);

- The United States, a country without a tradition in soccer, ranks first in the ranking of nations with the largest number of publications. After, appear the United Kingdom, Germany, Spain and Brazil, countries where soccer has high popular appreciation;

- Medicine is the area with the most works indexed in Scopus, followed by Health Sciences, Computer Science, Engineering and Social Sciences. It is also evidenced that the subject is approached by countless other areas, such as Psychology, Marketing and Economy, for example.

At the end of the study, it is understood that the proposed goal has been achieved, while at the same time projecting its continuity. It is possible, for example, to carry out this landscape on other platforms, such as Redalyc, Scielo and Web of Science. There is also the prospect of joining the word Soccer with other filter-terms in order to acquire a greater delimitation in the presented results.

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Origin and Distribution of the Lumbosacral Plexus in *Sus scrofa* (Mammalia:Suidae)

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Abstract— The aim of the present study was describe the origin and distribution of the lumbosacral plexus of *Sus scrofa*. Thirty specimens were fixed in 10% formalin solution and prepared according to the macroscopic dissection procedures. The *Sus scrofa* presented five (40%) or six (60%) lumbar vertebrae and the plexus was derived from L2 to S4 spinal nerves. Eight nerves were originated from the plexus and distributed to the pelvic limb: (1) lateral femoral cutaneous, from L2-L4, branched in the psoas minor, psoas major and internal abdominal oblique muscles; (2) femoral, from L3-L6, supplied the psoas major, psoas minor, iliacus, pectineus and quadriceps femoris muscles; emitted the saphenous nerve that innervates the sartorius muscle; (3) obturator, from L3-L6, distributed to the gracilis, obturator externus, pectineus and adductor muscles; (4) cranial gluteal, from L4-S1, branched the middle gluteal and piriformis muscles; (5) caudal gluteal, from L6-S2, supplied the superficial gluteal muscle; (6) sciatic, from L4-S2, innervated the tensor fasciae latae, middle, accessory and deep gluteal, semitendinosus, semimembranosus, biceps femoris, piriformis, gemelli and quadratus femoris muscles; emitted the (a) tibial nerve, that innervates the caudal muscles of the leg and divided into medial and lateral plantar nerves, terminating as plantar digital nerves; (b) common fibular nerve, divided into superficial and deep fibular nerves, that supplied the cranial and lateral muscles of the leg, terminating as dorsal digital nerves; (7) pudendal, from S2-S4, distributed to perineal muscles; emitted the dorsal nerves of clitoris and penis; (8) caudal rectal, from S2-S4, branched to perineal muscles.

Keywords— Anatomy, Artiodactyla, Pelvic limb, Spinal nerves, Wild boar.

I. INTRODUCTION

Wild boars (*Sus scrofa* Linnaeus, 1758) are mammals belonging to the Suidae family, originating in Europe, Asia and North Africa, but they can now be found in several oceanic islands and on all continents, except Antarctica [1]. Although belonging to the same family, there are several differences between the domesticated pig and the wild boar. The latter possesses the horsehair and long hairs, the length of the thoracic limbs is slightly larger than pelvic limbs, in addition to be a taller and shorter animal [2].

The lumbosacral plexus consists of the ventral branches of the spinal lumbar and sacral nerves [3]. Dyce et al. (2010) [4] described that the lumbosacral plexus in dogs is responsible for the innervations of the pelvic limbs and is formed from the ventral branches of the fourth (L4), fifth (L5), sixth (L6) and seventh (L7) lumbar spinal nerves, and from the ventral branches of the first (S1) and second (S2) sacral spinal nerves, whereas in the swine the nerves of this plexus are originated from the ventral branches of the third lumbar spinal nerve (L3) to the third sacral spinal nerve (S4) [5].

The knowledge of the formation and composition of this plexus is important to understand anatomical, physiological, and postural aspects as well as to contribute with other studies of Comparative Anatomy, providing important data for anesthetic, surgical and clinical procedures. Therefore, the aim of this study is to

describe the origin and distribution of the lumbosacral plexus nerves of *Sus scrofa*.

II. MATERIAL AND METHODS

Thirty specimens of *Sus scrofa*, 13 female and 17 male, belonging to the Laboratory of Animal Anatomy, Faculty of Veterinary Medicine, Federal University of Uberlandia, Minas Gerais state, Brazil, were used in this study. The animals were hybrids and derived from the crossing of different wild boar subspecies [6].

The specimens were fixed in 10% formalin solution through the aorta artery and stored in containers containing this same solution. The animals were prepared according to the macroscopic dissection procedures [3]. Initially, a longitudinal incision was made along the ventral midline, from the xiphoid cartilage of the sternum xiphoid process to the caudal margin of the pubic symphysis. Two other transverse incisions were made parallel to the cranial margin of each antimer until reaching the dorsal median line; a longitudinal section was made on the pubic symphysis, which was then disarticulated, and the abdominal and pelvic viscera as well as adipose tissue of these regions were removed for the visualization of the ventral branches of the lumbar and sacral spinal nerves of both antimeres. After identifying the spinal nerves of the lumbosacral plexus on both the right and left antimeres, the skin and subcutaneous fascia of the gluteal region, medial and lateral regions of the thigh and leg, and dorsal and plantar regions of the foot, were rebounded in order to analyze the distributions and ramifications of the nerves.

For the visualization of structures, a magnifying glass of eight times was used when necessary, and the nomenclature adopted for descriptions of the anatomical structures was according to the Nomina Anatomica Veterinaria [7]. The documentation was done by means of photographic camera (Nikon 18 mega pixels) and schemes, illustrating the origins and distribution of nerves.

For statistical analysis, the data concerning the origins of nerves in both antimeres were analyzed in a descriptive way in terms of simple percentage. This study was approved by the Ethics Committee on the Use of Animals (CEUA) of the Federal University of Uberlandia, under the protocol CEUA /UFU 103/13.

III. RESULTS

There were variations in the number of lumbar vertebrae in *Sus scrofa*, showing six lumbar vertebrae in 18 specimens and five ones in 12 animals. In all animals, four sacral vertebrae were found. The formation of the lumbosacral plexus in all specimens occurred through the connections between the ventral branches of the lateral

cutaneous femoral, femoral, obturator, cranial gluteal, caudal gluteal, sciatic, pudendal and caudal rectal nerves (Figs. 1 and 2).

The variations in the number of lumbar vertebrae were determinant for the diversification of the origins of the nerves that constitute the lumbosacral plexus and consequently for its disposition. In animals with six lumbar vertebrae, the ventral branches of L3 to S3 spinal nerves contributed to the formation of the lumbosacral plexus, whereas in animals with five lumbar vertebrae this formation was originated from L2 to S3. However, there was participation of S4 in two specimens (6.7%), one female and one male, presenting five lumbar vertebrae (Fig. 1).

The lateral cutaneous femoral nerve fibers were originated from L3/L4 in 17 (56.7%), L2/L3 in 11 (36.7%), and L2/L3/L4 in two (6.7%) specimens (Figs. 1A and 2). Thus, there was participation of L3 in 60 (100%), L4 in 38 (63.3%) and L2 in 26 (43.3%) antimeres in the lateral cutaneous femoral nerve composition. Regarding its distribution, branches were sent to the psoas minor, psoas major and internal abdominal oblique muscles, subiliac lymphnodes, fascia and skin of the knee joint region in all animals.

The femoral nerve was originated from L4/L5 in 21 (70%), L3/L4 in six (20%), L3/L4/L5 in two (6.6%) and from L4/L5/L6 in just one (3.3%) specimens (Figs. 1C, 2 and 7B). Therefore, the femoral nerve was derived from L3 to L6, with predominance of L4 and L5; there was participation of L4 in 60 (100%), L5 in 48 (80%), L3 in 16 (26.7%) and L6 in two (3.3%) antimeres in its composition. In all specimens, the femoral nerve sent branches to the psoas major, psoas minor, iliacus and pectineus muscles; then, emitted the saphenous nerve and finally distributed to the quadriceps femoris muscle (rectus femoris, vastus intermedius, vastus medialis and vastus lateralis muscles) (Fig. 3A). The saphenous nerve sent branches to the sartorius muscle and continued distally and medially to the thigh and the leg; at the level of the middle third of the leg, it was divided into medial and lateral branches. The medial branch distributed to the fascia of the caudal region of the leg, while the lateral branch accompanied the extension of the leg to the tarsal joint, dividing into medial, intermediate and lateral branches. The medial branch reached the fascia and skin on the metatarsal bone II; the intermediate branch innervated the dorsal region of the tarsal and metatarsal joints; and the lateral branch sent terminal branches to the fascia and skin of these joints.

The obturator nerve was originated from L4/L5 in 18 (60%), L3/L4/L5 in 10 (33.3%), L3/L4 in one (3.3%) and L4/L5/L6 in one (3.3%) specimens (Figs. 1D, 2 and 7B). In this way, the roots that constituted the obturator nerve

were derived from L3 to L6, with predominance of L4 and L5; on rare occasions, from L3 and L4 or with contributions of L3 or L6. Therefore, there was participation of L4 in 60 (100%), L5 in 58 (96.7%), L3 in 22 (36.7%) and L6 in two (3.3%) antimeres in the obturator nerve composition. About the distribution, the obturator nerve supplied the gracilis, obturator externus and adductor muscles in all animals (100%), whereas branches were sent to the pectineus muscle in 72% of the cases (Fig. 3A).

The cranial gluteal nerve fibers were originated from L5/L6 in 16 (53.3%), L5/S1 in eight (26.7%), L4/L5 in four (13.3%) and L6 in two (6.7%) specimens (Figs. 1B). In this manner, there was participation of L5 in 56 (93.3%), L6 in 36 (60%), S1 in 16 (26.7%) and L4 in eight (13.3%) antimeres in the cranial gluteal nerve composition. Concerning the distribution, in a short course, the cranial gluteal nerve leaved the pelvic cavity through the sciatic foramen and sent branches to the middle gluteal and piriformis muscles in 100% of the cases.

The caudal gluteal nerve was originated from S1/S2 in 20 (66.7%), L6/S1 in five (16.7%) and S1 in five (16.7%) animals (Figs. 1G). Thus, there was participation of S1 in 60 (100%), S2 in 40 (66.7%), and L6 in 10 (16.7%) antimeres in the caudal gluteal nerve composition and its distribution was verified only to the superficial gluteal muscle (Fig. 3B).

The sciatic nerve fibers were originated from L5/L6/S1/S2 in 17 (56.7%), L4/L5/S1/S2 in eight (26.7%), L5/S1/S2 in four (13.3%) and L5/L6/S1 in one (3.3%) animals (Figs. 1F, 2 and 7B). Therefore, there was participation of L5 and S1 in 60 (100%), S2 in 58 (96.7%), L6 in 36 (60%) and L4 in 16 (26.7%) antimeres in the sciatic nerve composition. Regarding the distribution, the sciatic nerve, along its course, emitted branches to the tensor fasciae latae, middle gluteal, accessory gluteal, deep gluteal, semitendinosus, semimembranosus, biceps femoris and piriformis muscles in all antimeres (100%) (Fig. 3A). At the level of the greater trochanter of the femur bone, the sciatic nerve curved ventrally and emitted a branch to the gemelli and quadratus femoris muscles. In 100% of the animals, a thin branch was originated from the caudal margin of the sciatic nerve, named caudal cutaneous femoral nerve, which was distributed in the skin of the caudal region of the thigh over the origin of the semitendinosus and biceps femoris muscles (Fig. 3B). It is noteworthy the presence of a branch communicating of the sciatic nerve with the pudendal nerve in all the specimens.

Distally in the caudomedial part and middle third of the thigh, the sciatic nerve divided into tibial and common fibular nerves (Fig. 3B). In all specimens, the tibial nerve

gave off branches to the gastrocnemius, soleus, popliteus, superficial digital flexor, tibialis caudalis, lateral flexor, and medial flexor (deep digital flexor) muscles (Fig. 4A). In the distal part of the leg, it divided into the medial and lateral plantar nerves. The medial plantar nerve followed in the plantar region, and divided into medial and lateral branches at the level of the tarsal joint. The first branch is called the common plantar digital nerve II, which emitted the proper plantar digital nerve II and continued as the abaxial proper plantar digital nerve III; the second branch is the common plantar digital nerve III, which before dividing into axial proper plantar digital nerves III and IV, emitted a branch communicating with the proper plantar digital nerve V (Figs. 4B and C). The lateral plantar nerve, in an oblique course, passed under the plantar ligament of the tarsus and accompanied the lateral margin of the superficial muscles of the digits; in the distal third of the tarsus, sent branches to the interosseous muscles, continued as common plantar digital nerve IV, and near the metatarsophalangeal joint, emitted the proper plantar digital nerve V, continuing as the abaxial proper plantar digital nerve IV (Figs. 4B and C).

The tibial nerve originated the lateral sural cutaneous nerve in 27% of the cases, whereas this latter nerve was derived from the common trunk of the sciatic nerve in 73% of the cases. The lateral cutaneous sural nerve descended in the lateral middle direction along the caudal surface of the gastrocnemius muscle, and in the lateral region of the tarsus it gave off branches to the skin (Fig. 5A).

The common fibular nerve crossed the lateral head of the gastrocnemius muscle, perforated the soleus muscle, and on the proximal part of the tibia divided into the superficial and deep fibular nerves (Fig. 5A). At the level of the tarsal joint, the superficial fibular nerve, relatively thicker than the deep fibular nerve, gave off several branches to fascia and skin of this region and then divided into medial, intermediate and lateral branches. The medial branch continued as the common dorsal digital nerve II, which emitted the proper dorsal digital nerve II and followed distally as abaxial proper dorsal digital nerve III (Figs. 5B and C). The intermediate branch followed along the dorsal region of the foot; at the level of the metatarsophalangeal joint, it communicated with the dorsal metatarsal nerve III to constitute the common dorsal digital nerve III and then divided into axial proper dorsal digital nerves III and IV (Fig. 5B). The lateral branch, called the common dorsal digital nerve IV, emitted the proper dorsal digital nerve V and continued as abaxial proper dorsal digital nerve IV (Figs. 5B and D). At the proximal third of the leg, the deep fibular nerve sent branches to the tibialis cranialis, fibularis tertius, extensor digitorum longus, fibularis longus and lateral digital

extensor muscles. The deep fibular nerve went through the sulcus between the fibularis longus and the lateral digital extensor muscles (Fig. 5A); at the metatarsal region continued as dorsal metatarsal nerve III, which after emerging between the tendons of the flexor digitorum longus muscle, joined the common dorsal digital nerve III (Fig. 5B). In 5 antimeres (8.33%) a communicating branch between the deep fibular nerve and the common dorsal digital nerve II was found (Figs. 6A and B).

The pudendal nerve was originated from S2/S3 in 28 (93.3%), and S2/S3/S4 in two (6.7%) specimens (Figs. 1E and 2). In this way, there was participation of S2 and S3 in 60 (100%) and S4 in four (6.7%) antimeres in the pudendal nerve composition. The pudendal nerve emitted perineal branches to the external anal sphincter, levator ani, constrictor vulvae, ischiocavernosus and bulbospongiosus muscles (Figs. 7A and B). In addition, the pudendal nerve originated the dorsal nerve of clitoris and mammary

branches, which innervate the clitoris and skin of the vulvar region, respectively, and the dorsal nerve of the penis that was distributed in the penis glans, foreskin, and scrotum in all animals (Figs. 7A and B).

The caudal rectal nerve was originated from S2/S3 in 28 (93.3%), and S2/S3/S4 in two (6.7%) animals (Fig. 1E). Thus, there was participation of S2 and S3 in 60 (100%) and S4 in four (6.7%) antimeres in the caudal rectal nerve composition. In its course, the caudal rectal nerve sent branches to the levator ani, coccygeus and external anal sphincter muscles in 100% of the animals (Fig. 7B).

Table 1 summarizes the origin, participation and distribution of the ventral branches of spinal nerves that constitute the lumbosacral plexus in *Sus scrofa* and Table 2 summarizes the branches of these nerves and its distribution to muscles and organs.

Table 1. Origin, participation and distribution of the ventral branches of spinal nerves that constitute the lumbosacral plexus in *Sus scrofa*.

Nerves	Origin N (%) animals	Participation N (%) antimeres	Distribution to muscles and organs
Lateral femoral cutaneous	L3/L4 – 17 (56.7%)	L3 – 60 (100%)	psoas minor, psoas major and internal abdominal oblique muscles; subiliac lymph nodes, fascia and skin of the knee joint region
	L2/L3 – 11 (36.7%)	L4 – 38 (63.3%)	
	L3/L4 – 2 (6.6%)	L2 – 26 (43.3%)	
Femoral	L4/L5 – 21 (70%)	L4 – 60 (100%)	psoas major, psoas minor, iliacus, quadriceps femoris, pectineus muscles
	L3/L4 – 6 (20%)	L5 – 48 (80%)	
	L3/L4/L5 – 2 (6.6%)	L3 – 16 (26.7%)	
	L4/L5/L6 – 1 (3.3%)	L6 – 2 (3.3%)	
Obturator	L4/L5 – 18 (60%)	L4 – 60 (100%)	gracilis, obturator externus and adductor muscles (100%); pectineus muscle (72%)
	L3/L4/L5 – 10 (33.3%)	L5 – 58 (96.7%)	
	L3/L4 – 1 (3.3%)	L3 – 22 (36.7%)	
	L4/L5/L6 – 1 (3.3%)	L6 – 2 (3.3%)	
Cranial gluteal	L5/L6 – 16 (53.3%)	L5 – 56 (93.3%)	middle gluteal and piriformis muscles
	L5/S1 – 8 (26.7%)	L6 – 36 (60%)	
	L4/L5 – 4 (13.3%)	S1 – 16 (26.7%)	
	L6 – 2 (6.7%)	L4 – 8 (13.3%)	
Caudal gluteal	S1/S2 – 20 (66.7%)	S1 – 60 (100%)	superficial gluteal muscle
	L6/S1 – 5 (16.7%)	S2 – 40 (66.7%)	
	S1 – 5 (16.7%)	L6 – 10 (16.7%)	
Sciatic	L5/L6/S1/S2 – 17 (56.7%)	L5/S1 – 60 (100%)	tensor fasciae latae, middle gluteal, accessory gluteal, deep gluteal, gemelli, quadratus femoris, piriformis, semitendinosus, semimembranosus, biceps femoris muscles
	L4/L5/S1/S2 – 8 (26.7%)	S2 – 58 (96.7%)	
	L5/S1/S2 – 4 (13.3%)	L6 – 36 (60%)	
	L5/L6/S1 – 1 (3.3%)	L4 – 16 (26.7%)	
Pudendal	S2/S3 – 28 (93.3%)	S2/S3 – 60 (100%)	external anal sphincter, levator ani, constrictor vulvae, ischiocavernosus and bulbospongiosus muscles
	S2/S3/S4 – 2 (6.7%)	S4 – 4 (6.7%)	
Caudal rectal	S2/S3 – 28 (93.3%)	S2/S3 – 60 (100%)	levator ani, coccygeus, external anal sphincter muscles
	S2/S3/S4 – 2 (6.7%)	S4 – 4 (6.7%)	

Table 2. Branches of the nerves that constitute the lumbosacral plexus in *Sus scrofa* and its distribution to muscles e organs.

Nerves	Branches	Distribution to muscles e organs
Lateral femoral cutaneous	None	-
Femoral	Saphenous: <ul style="list-style-type: none"> • medial branch • lateral branch: <ul style="list-style-type: none"> ▪ medial branch ▪ intermediate branch ▪ lateral branch 	Sartorius muscle <ul style="list-style-type: none"> • fascia of the caudal region of the leg ▪ fascia and skin on the metatarsal bone II ▪ dorsal region of the tarsal and metatarsal joints ▪ fascia and skin of the tarsal and metatarsal joints
Obturator	None	-
Cranial gluteal	None	-
Caudal gluteal	None	-
	Caudal cutaneous femoral	Skin of the caudal region of the thigh
	Lateral sural cutaneous	Skin of the leg caudal surface and lateral region of the tarsus
	Tibial: <ul style="list-style-type: none"> • medial plantar <ul style="list-style-type: none"> ▪ common plantar digital II <ul style="list-style-type: none"> - proper plantar digital II <ul style="list-style-type: none"> ○ abaxial proper plantar digital III ▪ common plantar digital III <ul style="list-style-type: none"> - axial proper plantar digital III - axial proper plantar digital IV • lateral plantar <ul style="list-style-type: none"> ▪ common plantar digital IV <ul style="list-style-type: none"> - proper plantar digital V <ul style="list-style-type: none"> ○ abaxial proper plantar digital IV 	Gastrocnemius, soleus, popliteus, superficial digital flexor, tibialis caudalis, lateral flexor, and medial flexor (deep digital flexor) muscles <ul style="list-style-type: none"> • interosseous muscles
Sciatic	Common Fibular: <ul style="list-style-type: none"> • superficial fibular <ul style="list-style-type: none"> ▪ medial branch <ul style="list-style-type: none"> - common dorsal digital II <ul style="list-style-type: none"> ○ proper dorsal digital II <ul style="list-style-type: none"> ➢ abaxial proper dorsal digital III ▪ intermediate branch <ul style="list-style-type: none"> - common dorsal digital III <ul style="list-style-type: none"> ○ axial proper dorsal digital III ○ axial proper dorsal digital IV ▪ lateral branch <ul style="list-style-type: none"> - common dorsal digital IV <ul style="list-style-type: none"> ○ proper dorsal digital V ○ abaxial proper dorsal digital IV • deep fibular <ul style="list-style-type: none"> ▪ dorsal metatarsal III 	<ul style="list-style-type: none"> • fascia and skin of the tarsal region • tibialis cranialis, fibularis tertius, extensor digitorum longus, fibularis longus and lateral digital extensor muscles

	Dorsal nerve of the clitoris	Clitoris and skin of the vulvar region
Pudendal	Dorsal nerve of the penis	Penis glans, foreskin and scrotum
	Mammary branches	
Caudal rectal	None	-

IV. DISCUSSION

Origin of the lumbosacral plexus

There was a wide variation in the origin of the nerves constituting the lumbosacral plexus in *Sus scrofa*. One of the determining factors was the inconstancy in the number of lumbar vertebrae, as reported in swine [8], domestic pig of the AG-1050 lineage[9], Zebu-crossed bovine fetuses[10] and wild boar[11].

In the present study, the findings of six lumbar vertebrae in 18 (60%) specimens of *Sus scrofa* were similar to the reports in swine [12, 13], whereas the results of five lumbar vertebrae found in 12 specimens (40%) were also described by Ghoshal (1986c)[14] in swine and Rosa (2012)[15] in Pen Ar Lan swine. However, no variations of these structures were found in wild boar [16, 17]. Thus, the composition of the lumbosacral plexus in *Sus scrofa* specimens that presented six lumbar vertebrae occurs from L3 to L6 and from S1 to S3, similarly to the reports in swine [5], whereas in animals with five lumbar vertebrae it occurs from L2 to S3. However, in two (6.6%) specimens with five lumbar vertebrae there was participation of S4, findings that agreed in part with Ghoshal (1986a,c)[14, 18] in equine and swine, who described that this plexus extended from L3 to S4 and not referring to the participation of L2. Frandson (1979)[19] reported that the lumbosacral plexus formation in swine occurs from the last three lumbar spinal nerves and the first sacral spinal nerve, whereas Godinho et al. (1987) [3] mentioned its composition from L4 to S4 in ruminants.

Lateral femoral cutaneous nerve

The origin of the lateral femoral cutaneous nerve from L3 and L4 in 56.7% of *Sus scrofa* specimens was in agreement with reports in ruminants [5], equine[18] and swine [14]. According to Könige et al. (2011)[20], the main contribution to the formation of this nerve in equine was from L4, but in animals with five lumbar vertebrae, its formation occurred from L2 and L3 and from L2 to L4. In contrast, L5 fibers may be present in the composition of this nerve in ruminants [3] and are the main contribution to its formation in swine [5].

The distribution of the lateral femoral cutaneous nerve to the psoas minor, psoas major and internal abdominal oblique muscles was in accordance with descriptions in swine[14]. In ruminants, however, this nerve sends branches to the quadratus femoris and

iliacus muscles[3], whose distribution was not found in the specimens of the present study.

Femoral nerve

The femoral nerve in *Sus scrofa* showed varied origins: from L4 and L5 in 70% of animals as described in ruminants[12], swine[8], Zebu-crossed bovine fetuses[21] and Saanen goats[22]; from L3 and L4 in 20% of animals, in partial concordance with reports of Sisson and Grossman (1975)[12] in ruminants, Ghoshal (1986c)[14] in swine and Moraes et al. (2008)[23] in equine, who mentioned its origin from L3 to L6; from L3 to L5 in 6.6% of animals as reported by Moraes et al. (2008)[23] in equine; from L4 to L6 in 3.3% of animals, as described in ruminants [4, 5, 24], dogs[25], swine [8], equine [23], Zebu-crossed bovine fetuses[21] and Pen Ar Lan swine[15].

It is noteworthy that the femoral nerve rarely presented contribution of L3 or L6 in ruminants [12], equine[12, 18], dogs [26] and swine [14]; these data were in agreement with the findings of *Sus Scrofa* specimens studied, which showed a minor contribution of L3 (26.6%) and a minimal of L6 (3.3%) in the femoral nerve composition. On the other hand, Mihelic et al. (2004)[8] mentioned that this nerve may have origin from L6 and L7 in swine.

The distribution of the femoral nerve in *Sus scrofa* to the psoas major, psoas minor, iliacus and quadriceps femoris muscles was similar to that seen in ruminants[3-5, 24]. Branches of this nerve to the pectineus muscle in all the studied specimens were also found in Zebu-crossed bovine fetuses[21].

The saphenous nerve, a branch of the femoral nerve, showed distribution to the sartorius muscle as described in swine [14]. Conversely, the branch of saphenous nerve that joins to the medial branch of the superficial fibular nerve to constitute the common dorsal digital II nerve as described in swine [14] was not found in *Sus scrofa*. The distribution of the saphenous nerve terminal branches to the metatarsal bone II, tarsal and metatarsal joint regions were equivalent to those described in swine[14].

Obturator nerve

The origin of the obturator nerve in *Sus scrofa* showed four variations: (1) from L4 and L5 in 60% of specimens, in agreement with reports of Schwarze and Schröder (1970) [5] in ruminants, Sisson and Grossman (1975) [12] and Ghoshal (1986a)[18] in equine, Ghoshal

(1986c)[14] in swine, and Chagas et al. (2006)[9] in domestic pig of the AG-1050 lineage; (2) from L3 to L5 in 33.3% of animals, similar to ruminants [27] and swine [14]; (3) from L3 and L4 in 3.3% of specimens, in accordance with descriptions of Bruni and Zimmerl (1977)[27] in donkey; (4) from L4 to L6 in 3.3% of animals as described in ruminants [24], dogs [25], swine[8], and domestic pig of the AG-1050 lineage [9].

Godinho et al. (1987)[3] described fibers originating only from L5 and L6 in the composition of the obturator nerve in ruminants, but in the studied specimens of *Sus scrofa* there was additional contribution of L4. Miranda et al. (2007) [10] reported that the formation of the obturator nerve occurs from L5 and S1, L5, L6 and S1, and L6 and S1 in Zebu-crossed bovine fetuses; however, these descriptions were not observed in the animals of present study.

Altogether, the origin of the obturator nerve in *Sus scrofa* occurred mainly from L4 and L5 in disagreement with Mihelic et al. (2004)[8] who evidenced a greater involvement of L5 and L6 in swine. The second major contribution in the composition of this nerve in *Sus scrofa* occurred from L3 (36.6%) as described in equine [12, 18]. It should be noted that these diversifications in the composition of the obturator nerve are related to the animals presenting five lumbar vertebrae.

The distribution of the obturator nerve to the obturator externus, gracilis, adductor and pectineus muscles was in agreement with reports of Ghoshal (1986a,c)[14, 18] in equine and swine, Evans and De Lahunta (2001)[25] in dogs and Nascimento et al. (2013)[22] in Saanen goats. In contrast, Chagas et al. (2006)[9], in a study with domestic pig of the AG 1050 lineage, described branches to the sartorius, quadratus femoris and semimembranosus muscles, whose distribution was not observed in any *Sus scrofa* specimens analyzed.

Cranial gluteal nerve

The origin of the cranial gluteal nerve in *Sus scrofa* predominantly from L5 and L6 (53.3% of specimens) was in accord with reports of Godinho et al. (1987) [3] in ruminants, in which this nerve was derived principally from L6. On the other hand, Ghoshal (1986b)[24] has found contribution of L6 and S1 in the formation of the cranial gluteal nerve in ruminants, whereas some authors have described a occasional participation of L5 in addition to L6 and S1 in ruminants[5] and equine [18]. In dogs and cats, the cranial gluteal nerve has arisen from L6 and L7[28], findings not evidenced in this study. Ghoshal (1986c)[14] has described the cranial gluteal nerve as a branch of the sciatic nerve in swine, but the Nomina Anatomica Veterinaria (2017)[7] mentions it separately.

In *Sus scrofa*, the cranial gluteal nerve sent branches to the middle gluteal and piriformis muscles, as reported

by Ghoshal (1986c)[14] in swine and Godinho et al. (1987)[3] in ruminants. However, cranial gluteal nerve fibers to the tensor fasciae latae and deep gluteal muscles were not verified in *Sus scrofa* as described by Ghoshal (1986b)[24] in ruminants.

Caudal gluteal nerve

The origin the caudal gluteal nerve in *Sus scrofa* from S1 and S2 in 66.7% of specimens was comparable to the reports of Ghoshal (1986b) [24] in ruminants. The contribution of S1 was observed in all specimens analyzed in agreement with Evans and De Lahunta (2001)[25] in dogs. The contribution of S3, as mentioned by Ghoshal (1986d) [28] in dogs, L6, L7 and S1 or L6 and L7 by Evans and De Lahunta (2001)[25] in dogs, was not found in *Sus scrofa* specimens. There are no reports in the literature about the participation of L6 and S1 in the composition of this nerve, as observed in 16.7% of *Sus scrofa* specimens of this research.

The supply of the caudal gluteal nerve to the superficial gluteal muscle was similar reported by Ghoshal (1986b,d) [24, 28] in ruminants and dogs. However, branches of this nerve to the piriformis and middle gluteal muscles as seen in dogs [28] and to the middle gluteal and biceps femoris muscles as described in ruminants [3] were not found in *Sus scrofa* specimens.

Sciatic nerve

The fibers of the sciatic nerve in *Sus scrofa* originated from L5, L6, S1 and S2 in 56.7% of specimens were also observed in ruminants [27], swine [14], Zebu-crossed bovine fetuses [29], equine [4] and Pen Ar Lan swine fetuses [30]. Another composition of this nerve with fibers originating from L5, L6 and S1 in only 3.3% of specimens was also reported in ruminants[27] and Pen Ar Lan swine fetuses [30]. In animals with five lumbar vertebrae, the contribution of L4 was seen in 26.7% of *Sus scrofa* specimens, similar to that described in swine [14].

In contrast, there are reports describing that S3 fibers contributed to sciatic nerve formation in swine [14] and Zebu-crossed bovine fetuses[31, 32], but this description did not occur in the animals of this study. Several studies have reported that the fibers of the sciatic nerve can originate from L6, S1 and S2 in equine[12], ruminants [3, 5, 20, 27], Zebu-crossed bovine fetuses [29]; this arrangement, however, was not found in *Sus scrofa* specimens studied, but from L5, S1 and S2 in 13.3% of animals.

When analyzing the participation of the ventral branches of the spinal nerves in the sciatic nerve formation in *Sus scrofa*, the greater contribution was essentially from the last lumbar spinal nerve and first sacral spinal nerve in 100% of specimens, similar to that

seen in ruminants [5, 24] and Zebu-crossed bovine fetuses [29].

Regarding the distribution of the sciatic nerve, branches to the semitendinosus, semimembranosus and biceps femoris muscles found in all *Sus scrofa* specimens were also reported in ruminants [3, 5, 12], equine and swine [14, 18], dogs [25] and Zebu-crossed bovine fetuses [32]. Also, branches to the gemelli and quadratus femoris muscles were seen in ruminants [3, 5, 12], dogs [24-26], cats [33] and equine [4], whereas branches to the middle gluteal and deep gluteal muscles were described in ruminants [24] and Zebu-crossed bovine fetuses [32], corresponding to the findings in all *Sus scrofa* specimens. Finally, branches to the piriformis and tensor fasciae latae muscles found in all studied specimens were reported respectively in cats [33] and ruminants [3].

Divergent from the findings in *Sus scrofa*, sciatic nerve fibers were sent to the adductor muscle in ruminants [3, 12], swine [14] and Zebu-crossed bovine fetuses [32]; this muscle was supplied by the obturator nerve in *Sus scrofa* specimens studied. In addition, branches of the sciatic nerve were sent to the pectineus muscle in swine [14] whereas this muscle was supplied by the femoral and obturator nerves in *Sus scrofa* specimens.

In *Sus scrofa*, the sciatic nerve emitted two cutaneous branches during its course: the caudal cutaneous femoral nerve in 100% of specimens analyzed, similar to the citations of Ghoshal (1986b) [24] in ruminants and ovine; and the lateral sural cutaneous nerve in 73% of the animals studied, differently from the findings in dogs [26], ruminants [24] and equine [18, 20]. A communicating branch of the sciatic nerve with the pudendal nerve was also observed in all *Sus scrofa* specimens, in agreement with the findings in swine [14] and cats [28, 33].

As terminal branches of the sciatic nerve, the tibial and common fibular nerves were observed in all *Sus scrofa* specimens studied. The distribution of the tibial nerve to the gastrocnemius, soleus, popliteus, and superficial and deep digital flexor muscles as well as its division in medial and lateral plantar nerves are in concordance with those reported in ruminants and swine [14, 24]. The medial plantar nerve and its division in medial branch – continuing as the common plantar digital II, proper plantar digital II and abaxial proper plantar digital III – and lateral branch – continuing as common plantar digital III, axial proper plantar digital III and IV – were similar to the reports in swine [14]. Likewise, the lateral plantar nerve and its division in common plantar digital IV, proper plantar digital V and abaxial proper plantar digital V were also seen in swine [14]. The presence of a communicating branch between the medial and lateral plantar nerves observed in *Sus scrofa* specimens was also described in ruminants and swine [14, 24].

The division of the common fibular nerve of *Sus scrofa* in superficial and deep fibular nerves was comparable to those found in swine [14]. The superficial fibular nerve and its division in medial branch – continuing as the common dorsal digital II, proper dorsal digital II and abaxial proper dorsal digital III – intermediate branch – continuing as common dorsal digital III, axial proper dorsal digital III and IV – and lateral branch – continuing as common dorsal digital IV, proper dorsal digital V and abaxial proper dorsal digital IV – were similar to the reports in swine [14]. In contrast, Ghoshal [14] described in swine a communicating branch between the saphenous nerve and the common dorsal digital nerve II as well as a nerve originated from the lateral branch of the superficial fibular nerve, namely the lateral dorsal digital nerve V, which were not found in the *Sus scrofa* specimens analyzed.

The distribution of the deep fibular nerve to the tibialis cranialis, fibularis tertius, fibularis longus and lateral digital extensor muscles was also observed in ruminants [24] and equine [34]. Its continuation at the metatarsal region as dorsal metatarsal nerve III and its junction with the common dorsal digital nerve III were equivalent to those found in ruminants [24] and swine [14]. In addition, the communicating branch between the deep fibular nerve and the common dorsal digital nerve II seen in 8.3% of *Sus scrofa* specimens was also observed in swine [14].

Pudendal nerve

The origin of the pudendal nerve from S2 and S3 in 93.3% of *Sus scrofa* specimens analyzed was concordant with that described in swine [5, 14], dogs [28] and goats [35]. Likewise, Ghoshal (1986b) [24] and König et al. (2011) [20] reported that S3 is the main branch that participates in the formation of this nerve in ruminants. Another ventral branch of spinal nerve involved in the formation of the pudendal nerve was S4 in only 6.7% of specimens in agreement with reported in ruminants [3, 4] and Zebu-crossed bovine fetuses [31]. The origin from S1, S2 and S3 described in dogs [4, 25] was not observed in *Sus scrofa* specimens analyzed.

The distribution of the pudendal nerve to the external anal sphincter, levator ani, constrictor vulvae, ischiocavernosus and bulbospongiosus muscles in *Sus scrofa* was accord with the findings in swine [14] and ruminants [20]. Also, the distribution of the pudendal nerve branches, namely the dorsal nerve of the clitoris, the dorsal nerve of the penis and mammary branches, was similar to that described in ruminants [5].

Caudal rectal nerve

The origin of the caudal rectal nerve from S2 and S3 in 93.3% of *Sus scrofa* specimens was concordant with

the data reported by Chagas et al. (2010)[36] in Pen Ar Lan swine. The contribution of S4 in the formation of the caudal rectal nerve seen in only 6.7% of specimens was also observed in Pen Ar Lan swine [36]. However, Schwarze and Schröder (1970)[5] and Ghoshal (1986c)[14] reported that this nerve originated from S4 with an inconstant contribution of S3 in swine. Other studies have reported the participation of S3 and S4 in the composition of this nerve in equine [37] and S4 and S5 in ruminants [3]. In ruminants, Ghoshal (1986b)[24] described that this nerve was mostly originated from S4, but it can be originated from S4 and S5.

The distribution of the caudal rectal nerve to the levator ani and external anal sphincter muscles in *Sus scrofa* was similar to that described in swine [14] whereas the fibers to the coccygeus muscle were also observed in ruminants [24] and equine [37].

V. CONCLUSIONS

In this study, the morphological analyze of the *Sus scrofa* lumbosacral plexus was describe, emphasizing the origin and distribution of its nerves. Summing up, considering the observations in all specimens studied, it can be conclude that the lumbosacral plexus of *Sus scrofa* is originated from L3 to S3 in animals with six lumbar vertebrae and from L2 to S4 in animals with five lumbar vertebrae. Also, eight nerves are originated from lumbosacral plexus, namely the lateral femoral cutaneous, femoral, obturator, cranial gluteal, caudal gluteal, sciatic, pudendal and caudal rectal nerves. They distribute to structures of the wall and abdominal and pelvic cavities as well as regions of the pelvic limb.

CONTRIBUTORS

Lázaro Antônio dos Santos, Lorena Tannus Maneses and Lucas Assis Ribeiro were responsible for acquisition, analysis and interpretation of data. Frederico Ozanam Carneiro e Silva and Frederico Balbino Lizardo were responsible for preparation and revision of the manuscript. Zenon Silva, Roseâmely Angélica de Carvalho Barros and Daniela Cristina de Oliveira Silva were responsible for concept and design, and for preparation of the manuscript. All authors read and approved the final version of manuscript.

CONFLITS OF INTERESTS

The authors declare no conflicts of interest associated with this manuscript.

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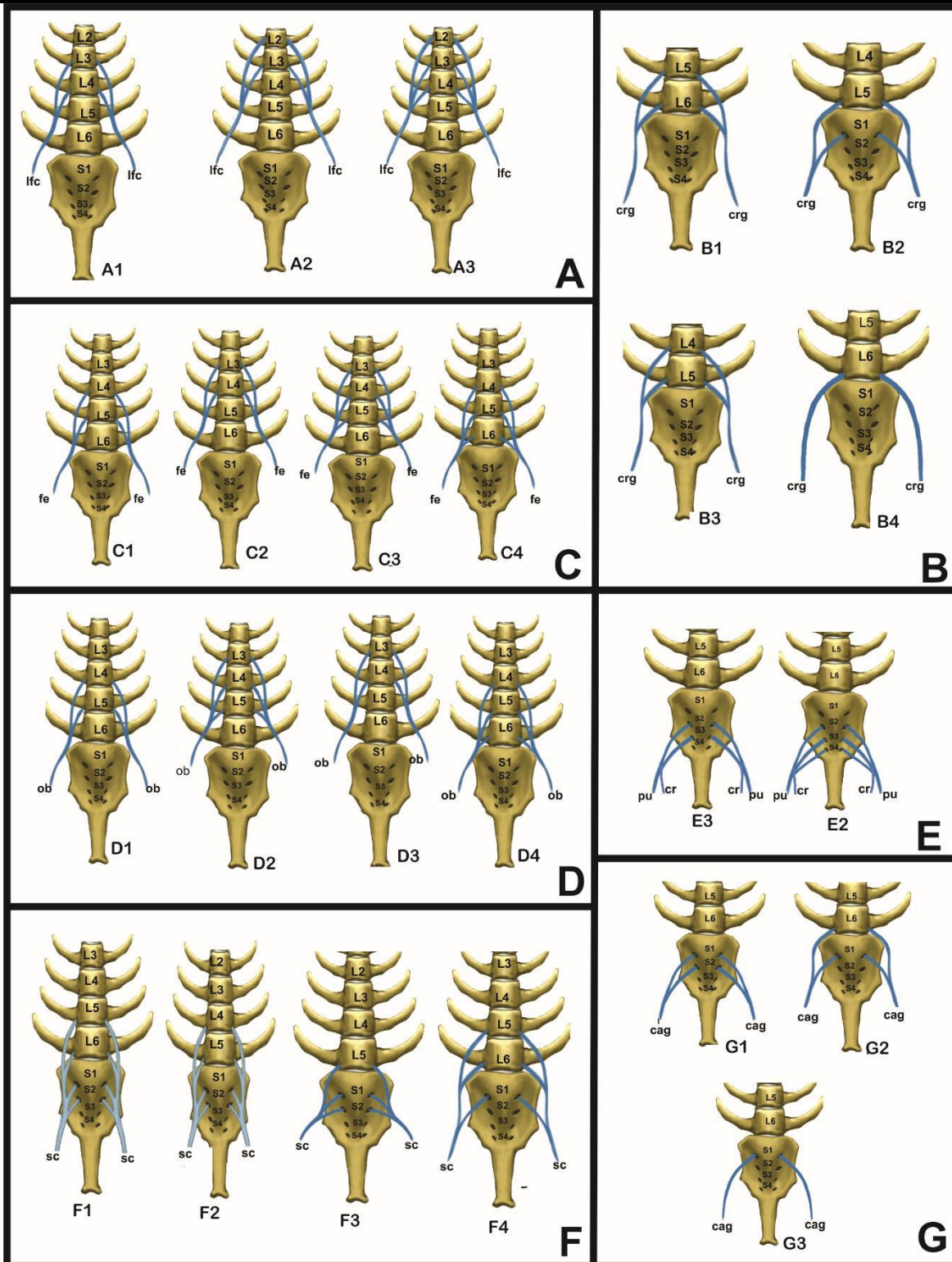


Fig. 1 Schematic drawing representing the lumbar and sacral regions and the variations of the origins of the component nerves of the lumbosacral plexus of *Sus scrofa*. (A) lfc, lateral femoral cutaneous nerve; A1, from L3 and L4; A2, from L2 and L3; A3, from L2, L3 and L4; (B) crg, cranial gluteal nerve; B1, from L5 and L6; B2, from L5 and S1; B3, from L4 and L5; B4, from L6; (C) fe, femoral nerve; C1, from L4 and L5; C2, from L3 and L4; C3, from L3, L4 and L5; C4, from L4, L5 and L6; (D) ob, obturator nerve; D1, from L4 and L5; D2, from L3, L4 and L5; D3, from L3 and L4; D4, from L4, L5 and L6; (E) pu, pudendal nerve; E1, from S2 and S3; E2, from S2, S3 and S4; (F) sc, sciatic nerve; F1, from L5, L6, S1 and S2; F2, from L4, L5, S1 and S2; F3, from L5, S1 and S2; F4, from L5, L6 and S1; (G) cag, caudal gluteal; G1, from S1 and S2; G2, from L6 and S1; G3 from S1. Nerves: cag, caudal gluteal nerve; crg, cranial gluteal nerve; fe, femoral nerve; lfc, lateral femoral cutaneous nerve; ob, obturator nerve; pu, pudendal nerve; sc, sciatic nerve.

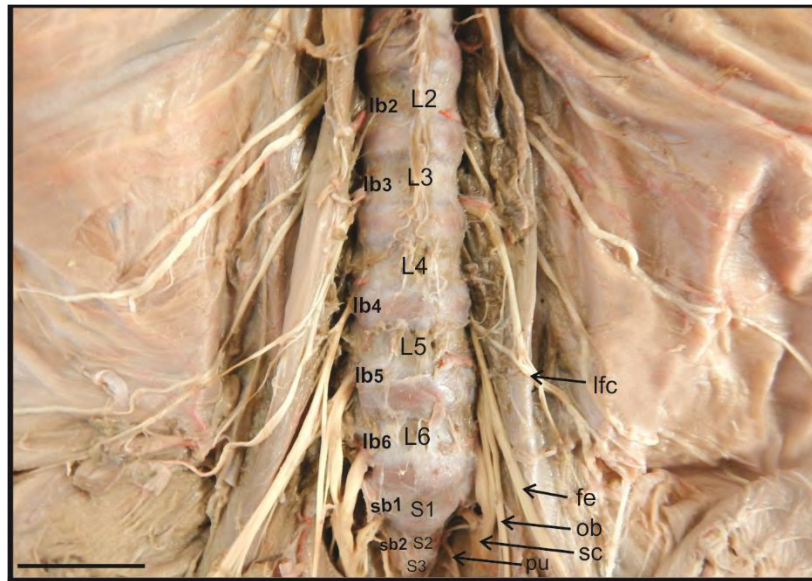


Fig. 2 Ventral view of the lumbar and sacral regions of *Sus scrofa*. L2-L6, second to sixth lumbar vertebrae; S1-S3, first to third sacral vertebrae; lb2 to lb6, second to sixth ventral branches of the lumbar spinal nerves; sb1 and sb2, first and second ventral branches of the sacral spinal nerves; Nerves: fe, femoral; lfc, lateral femoral cutaneous; ob, obturator; pu, pudendal; sc, sciatic. Scale bar 3 cm.

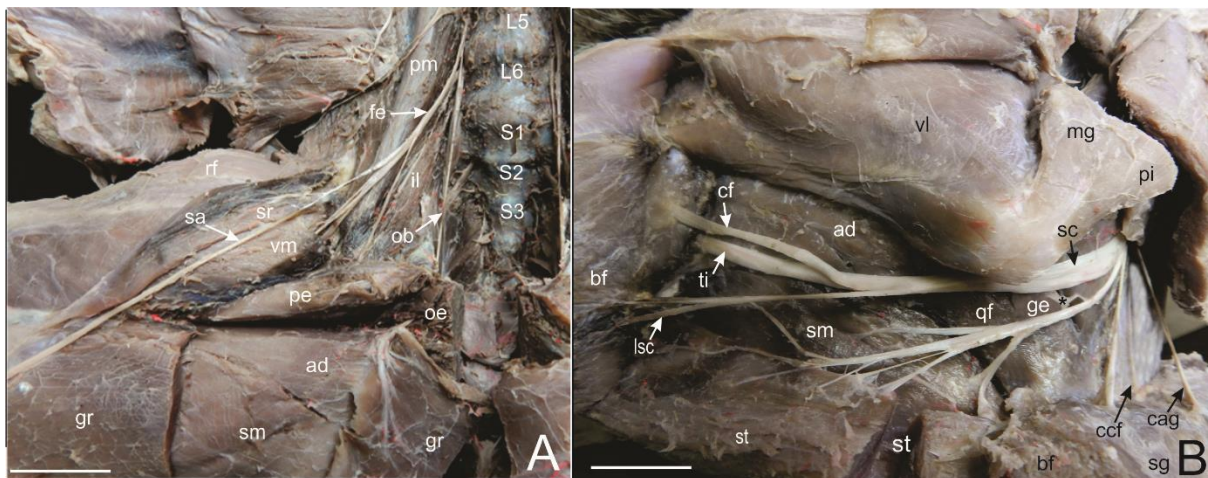


Fig. 3 (A) Ventral view of the lumbar and sacral regions of *Sus scrofa*. (B) Caudolateral view of the gluteal and thigh regions of the left antimer of *Sus scrofa*. L5 and L6, fifth and sixth lumbar vertebrae; S1-S3, first to third sacral vertebrae. Nerves: cag, caudal gluteal; ccf, caudal cutaneous femoral; cf, common fibular; fe, femoral; lsc, lateral sural cutaneous; ob, obturator; sa, saphenous; sc, sciatic; ti, tibial. Muscles: ad, adductor; bf, biceps femoris; ge, gemelli; gr, gracilis; il, iliacus; mg, middle gluteal; oe, obturator externus; pe, pectineus; pi, piriformis; pm, psoas major; qf, quadratus femoris; rf, rectus femoris; sa, sartorius; sg, superficial gluteal; sm, semimembranosus; st, semitendinosus; vl, vastus lateralis; vm, vastus medialis. (*) branches to gemelli and quadratus femoris muscles. Scale bar: 3 cm.

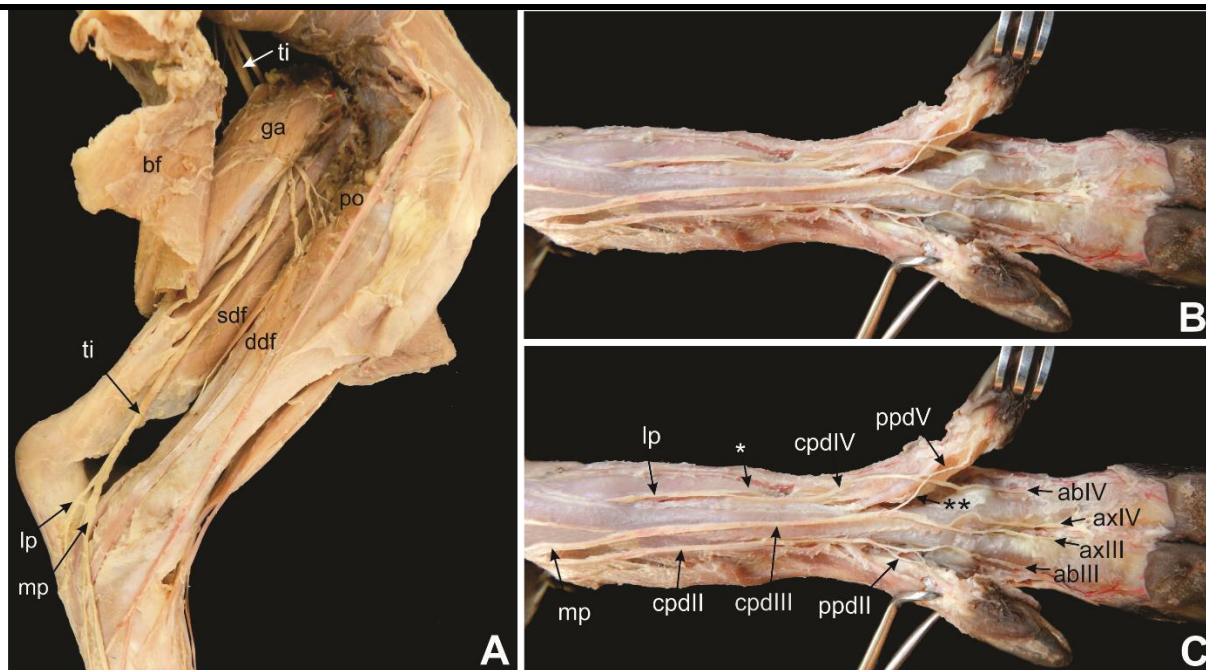


Fig. 4 Pelvic limb of *Sus scrofa*. (A) Medial view of the left leg and tarsal joint. (B) and (C) Plantar view of right foot. Nerves: abIII, abaxial proper plantar digital III; abIV, abaxial proper plantar digital IV; axIII, axial proper plantar digital III; axIV, axial proper plantar digital IV; cpdII, common plantar digital II; cpdIII, common plantar digital III; cpdIV, common plantar digital IV; lp, lateral plantar; mp, medial plantar; ppdII, proper plantar digital II; ppdV, proper plantar digital V; ti, tibial; * branches to the interosseous muscles; ** branch communicating with proper plantar digital nerve V. Muscles: bf, biceps femoris; ddf, deep digital flexor; ga, gastrocnemius; po, popliteus; sdf, superficial digital flexor. Scale bar 3cm.

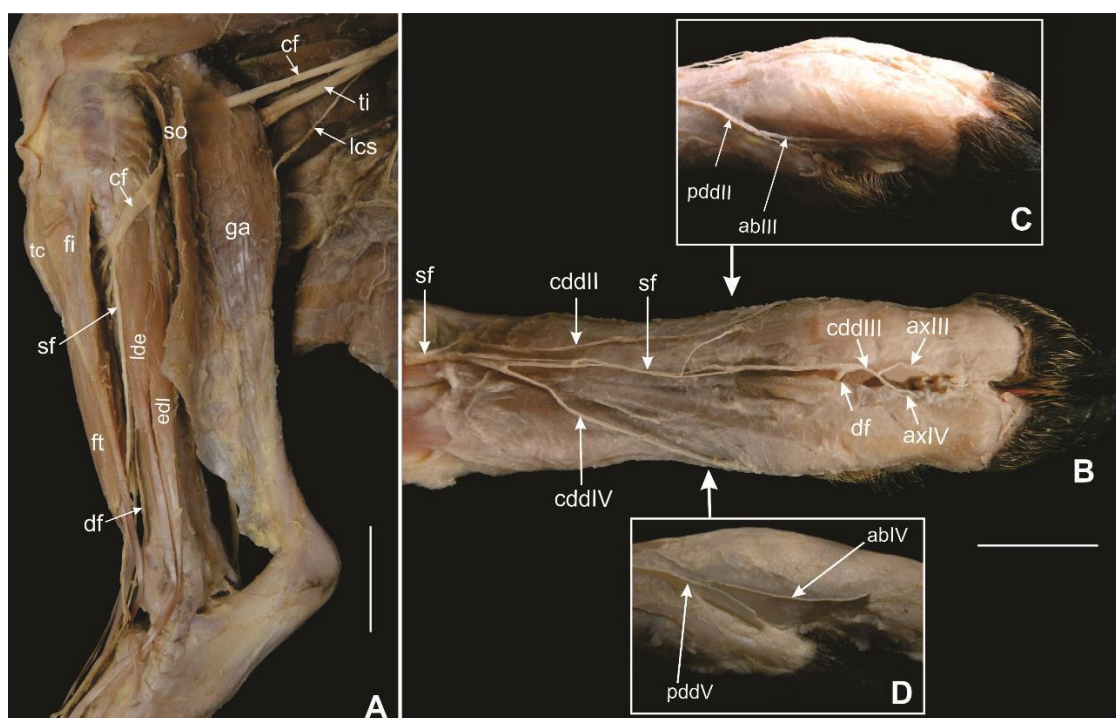


Fig. 5 Pelvic limb of *Sus scrofa*. (A) Lateral view of the left leg and tarsal joint. (B) Dorsal view of right foot. (C) Medial view of the metatarsophalangeal joint. (D) Lateral view of the metatarsophalangeal joint. Nerves: abpddIII, abaxial proper dorsal digital III; abpddIV, abaxial proper dorsal digital IV; axpddIII, axial proper dorsal digital III; axpddIV, axial proper dorsal digital IV; cddII, common dorsal digital II; cddIII, common dorsal digital III; cddIV, common dorsal digital IV; cf, common fibular; df, deep fibular; lcs, lateral cutaneous sural; pddII, proper dorsal digital II; ppdV, proper dorsal digital V; sf, superficial fibular; ti, tibial. Muscles: edl, extensor digitorum longus; fl,

fibularis longus; ft, fibularis tertius; ga, gastrocnemius; lde, lateral digital extensor; so, soleus; tc, tibialis cranialis.

Scale bar 3 cm.

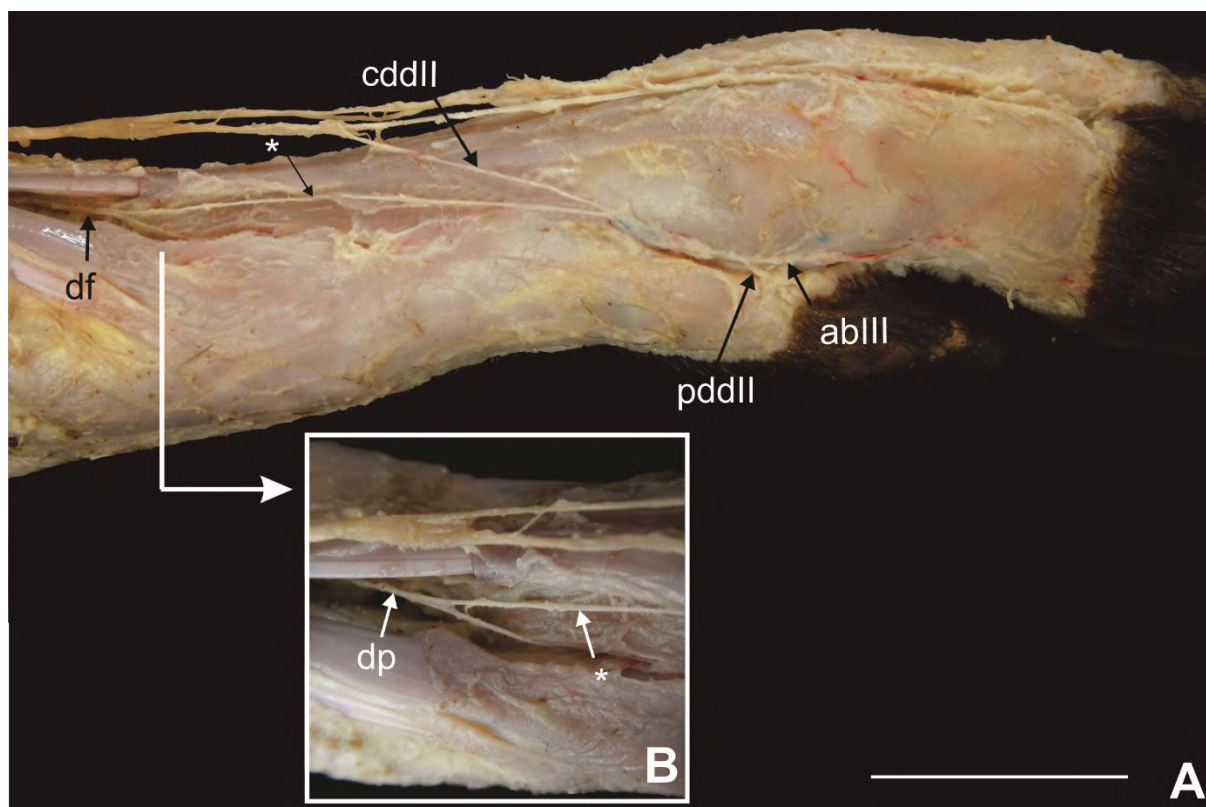


Fig. 6 Left foot of *Sus scrofa*. (A) Dorsomedial view. (B) Extended view of the metatarsal region. Nerves: abpddIII, abaxial proper dorsal digital III; cddII, common dorsal digital II; df, deep fibular; pddII, proper dorsal digital II; * branch communicating with common dorsal digital nerve II. Scale bar 3 cm.

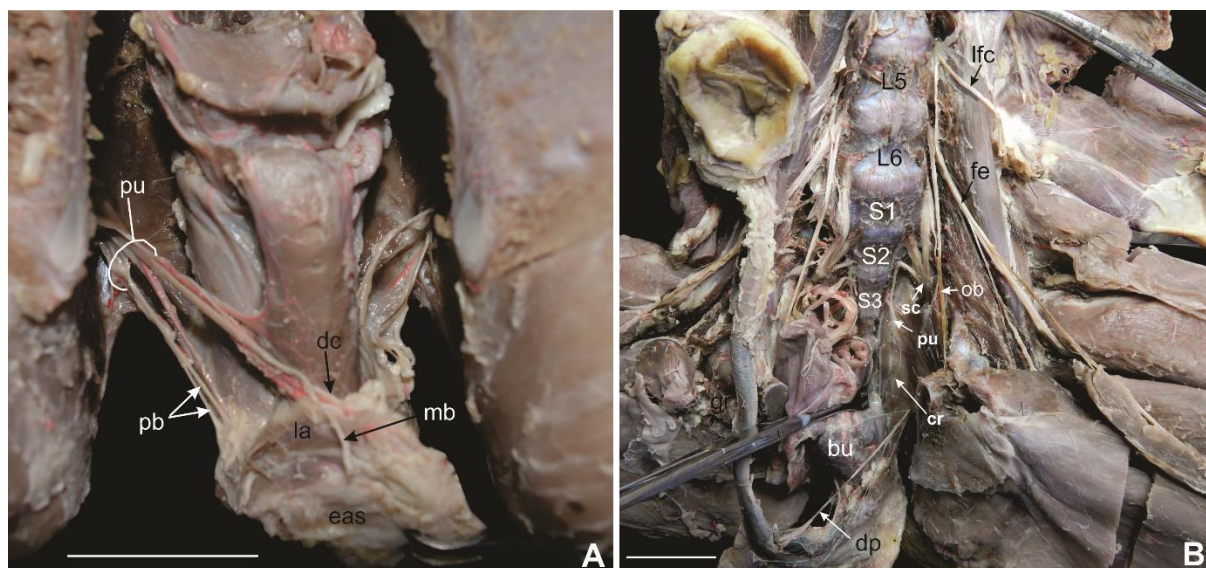


Fig. 7 Ventral view of pelvic cavity of *Sus scrofa*. (A) female and (B) male. L2 and L6, second and sixth lumbar vertebrae; S1 - S3, first to third sacral vertebrae. Nerves: cr, caudal rectal; dc, dorsal nerve of clitoris; dp, dorsal nerve of the penis; fe, femoral; lfc, lateral femoral cutaneous; mb, mammary branches; ob, obturator; pb, perineal branches; pu, pudendal; sc, sciatic. Muscles: bu, bulbospongiosus; eas, external anal sphincter; la, levator ani. Scale bar 3 cm.

Evaluation of HadGEM2-ES and MIROC5 Models to simulate average Temperatures in the last Agricultural Frontier of the Brazilian Savannah

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Abstract— *The climate models adopted by the Intergovernmental Panel on Climate Change are capable of reproducing the current climate well on a continental scale, but need to be validated on a smaller scale. The objective of this study was to evaluate the performance of the regional models MarkSim-HadGEM2-ES and MarkSim-MIROC5 to estimate average temperatures in the last frontier of agricultural expansion of the Brazilian savannah. For this purpose, the data generated by the models were compared with those recorded by the National Institute of Meteorology and evaluated by statistical measures of correlation, bias and performance. The results revealed low bias and very good agreement, but high relative error and unsatisfactory performance in micro-regional and regional scales. Thus, the data generated by these models need correction to reproduce the current climate and enable reliable projections on these spatial scales.*

Keywords— *evaluation, climate, modelling, savannah, temperature.*

I. INTRODUCTION

The processes of climate change are part of the natural dynamics of the climate on the planet. However, the compilation of scientific studies conducted by the Intergovernmental Panel on Climate Change – IPCC (2014) attests to a probability above 95% that these changes are being accelerated and intensified by the increased concentration of greenhouse gases – GHGs coming mainly from the burning of fossil fuels and changes in land use and coverage to meet the growing needs of civilizations (Nkhonjera, 2017; Hsiang; Burke, 2014; IPCC, 2014; Marengo et al., 2011).

According to Broecker (2017), GHGs have increased their concentrations in the Earth's atmosphere to unprecedented levels since the beginning of the 20th

century and, as a result, global warming has become unequivocal, affecting the evapotranspiration and precipitation system. In this sense, several researchers (O'Neill et al., 2017; Lesnikowski et al., 2015; Hsiang; Burke, 2014; IPCC, 2014; Huang et al., 2012; Marengo et al., 2012) state that the increase in average annual temperatures, at a global level, will increase the monthly and interannual variability of rainfall in many locations and these events, in turn, may generate various impacts on plantations and livestock, such as lack or excess of water, outbreaks of pests and diseases, flooding of productive lands, forest fires, among others that threaten the health and well-being of populations.

Climate change predictions are the result of scientific understanding of the interrelationships between the physical, chemical and biological processes that govern the functioning of the atmosphere, the oceans and the Earth's surface (Steinke, 2012; Riahi et al., 2011). This knowledge is used to create global climate models that estimate the future behaviour of rainfall, temperature, pressure, cloud cover, humidity and a series of other climate variables for a day, a month or a year (Riahi et al., 2011; Thomson et al., 2011). Currently, there are numerous climate models that integrate information on demographic and socio-economic trends in different temporal and spatial scales, but only seventeen of them were used in studies selected by phase five of the intercomparison of coupled models project – CMIP5 (Mach et al., 2016; IPCC, 2014). These models are considered the most reliable according to a set of criteria that include the effectiveness to reproduce the past and current climate within a given region, because if a model can perform simulations that are very similar to the known data, there is greater confidence that this model can project the future climate (Lewis, 2014; Moss, 2010). Therefore, the Global Climate Models – GCMs adopted

by the IPCC (2014) are those that have demonstrated convincing ability to reproduce observed characteristics of the current climate and its changes in the past.

The GCMs provide reliable quantitative estimates of future climate change, particularly at continental scales in the order of 300 x 300 km (IPCC, 2014). However, the use of GCMs is limited in projecting climate change at the regional and sub-regional levels because significant differences in climate occur at a scale below the resolution of the GCMs. So, to expand the spatial resolution of the set of climate data produced by a GCM it is necessary to convert and validate them through downscaling methods (Silva, 2018; Lyra et al., 2017; Chou et al., 2012).

Feng et al. (2015) analysed ten models of the CMIP5 and demonstrated that none of them alone can capture long-term trends. This is due to a failure to simulate the difference between the interhemispheric sea surface temperature. Therefore, it is important to analyse the interannual variability of the simulations of the annual averages of the interesting variables in order to validate them through downscaling methods.

The need to validate the data generated in the downscaling process of a given GCM, through comparison with the data observed in different parts of the globe, makes it essential to select a period representative of local time to calculate a Climate Normal of interest (IPCC, 2013). A Climatic Normal (NC) is defined by the World Meteorological Organization (WMO, 2011) as the average of the atmospheric variables recorded in 30-year periods, starting on the first day of January of the years ending with digit one. For example, the average rainfall of a region in the period from January 1st, 1981 to December 31st, 2010 is an NC. However, the scarcity of meteorological records with such long historical series is a common problem in numerous regions of the planet. Therefore, the WMO (2011) recommends the adoption of the Provisional Climatological Normals (NCP) that should be calculated from periods of ten years of observations recorded data following the other criteria of the NC.

Among the models evaluated in CMIP5, MIROC5 (*Model for Interdisciplinary Research on Climate 5*) and HadGEM2-ES (*Hadley Centre Global Environmental Model 2 – Earth System*) are the ones that obtained the best results in simulating the present and past climate of South America (Lyra et al., 2017; Chou et al., 2012; Jones et al., 2011; Watanabe et al., 2011).

In the Brazilian savannah, the water cycle and temperatures are strongly influenced by vegetation characteristics (Strassburg et al., 2017), so it is highly vulnerable to global climate change. Therefore, the rapid expansion of natural areas converted into pastures and

plantations can accelerate local climate change processes (Ayala et al., 2016; Imaflora, 2018).

The strategic importance of this biome for the preservation of the country's water resources is undeniable, since it absorbs and flows into it the waters that supply three important aquifers and six large Brazilian hydrographic basins, including the Amazon and the Tocantins. Additionally, this biome hosts large ecologically sensitive areas due to the great biodiversity of fauna and flora, with hundreds of endemic species and a mosaic of soils vulnerable to erosion and acidification processes (Strassburg et al., 2017; PBMC, 2014; Da Silva, 2013).

In this context, the objective of this study was to evaluate the performance of the simulations generated in the regional climate models MarkSim-HadGEM2-ES and MarkSim-MIROC5, based on data observed in conventional INMET weather stations located in the micro-regions that make up the last frontier of agricultural expansion of the Brazilian savannah.

II. MATERIAL AND METHODS

The territorial delimitation followed the proposal of Miranda et al. (2014) and was composed of 31 micro-regions of four federal units (UF) in Brazil, which encompass 139 municipalities in Tocantins, 135 in Maranhão, 33 in Piauí and 30 in Bahia distributed in an area of 73,848,967 hectares (Figure 1).

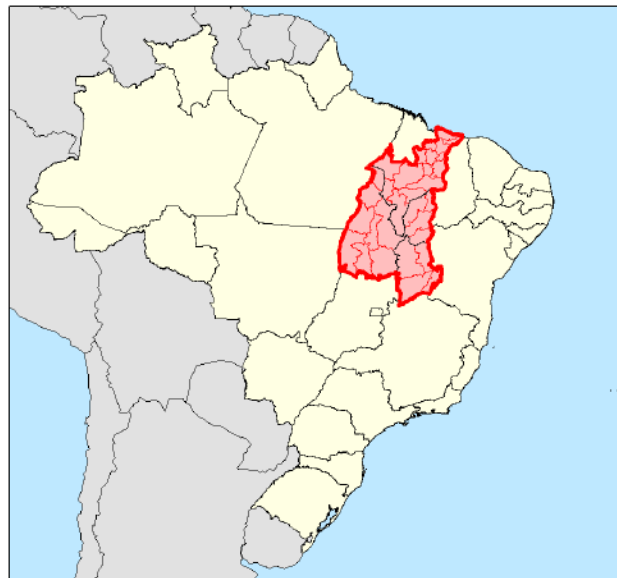


Fig. 1: Location of the study area.

This territory is composed predominantly of savannah formations (63.6%), but also presents transition areas between different types of flowers (15%) and seasonal forest (10.7%) on the borders with the Amazon biome and Caatinga to the west and east, respectively. The relief is characterized by large areas of slopes (39%) and depressions (56%), with altitudes ranging from 1 to

1200m above sea level. In the central extension, the semi-humid tropical climate is dominant and corresponds to about 78% of the territory, being characterized by periods of seven to eight months of scarce precipitation and average air temperature above 18°C in all the months of the year. On the eastern border, the semi-arid climate is characterised by the absence of rainfall for six months and high temperatures all year round. Four large hydrographic regions are contained within these limits, they are: Tocantins-Araguaia, Atlantic-North/Northeast stretch, Parnaíba and São Francisco (Magalhães et al., 2014; Mingonti et al., 2014).

The monthly averages of maximum, minimum and average temperatures were extracted from the records of the stations of the National Institute of Meteorology – INMET, available on the institution's website (<http://www.inmet.gov.br/portal/>).

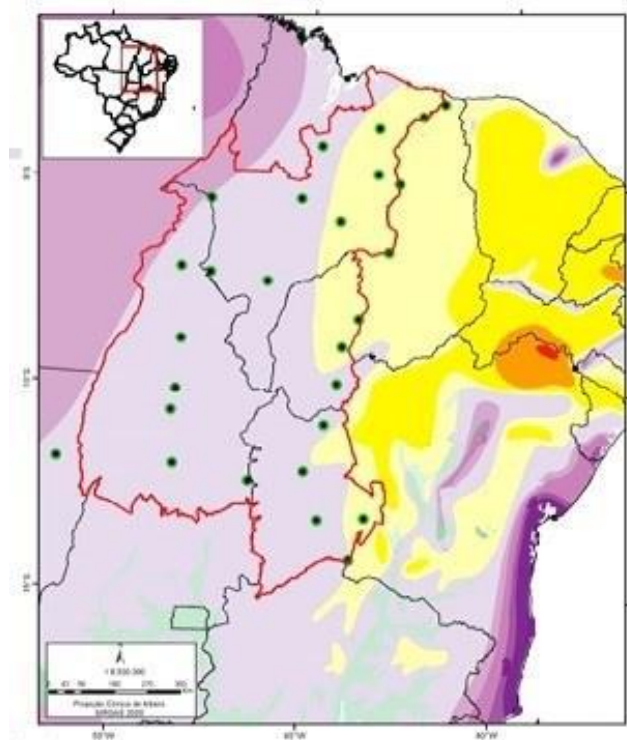


Fig. 2: Location of the 27 weather stations.

Historical records of observations made in 27 meteorological stations in the last ten years were used, referring to the period from January 2010 to December 2018. These records were associated with each micro-region (Table 1) which, according to information from the Municipal Agricultural Survey of the Brazilian Institute of Geography and Statistics (IBGE, 2018), has experienced an agricultural area growth of over 40% since 2009.

The daily climate data simulation was generated in the MarkSim-GCM. The MarkSim is a 3rd order Markov generator designed to estimate precipitation and daily temperatures that, according to Jones and Thornton

(2013), has been used efficiently as a temporal and spatial downscaling, with resolutions up to 50 km (<http://gisweb.ciat.cgiar.org/MarkSimGCM/>). Therefore, temporal and spatial downscaling was used on the coordinates of the INMET stations from the HadGEM2-ES (Hadley Centre Global Environmental Model 2 – Earth System) models with resolution data of 1,2414°x1,875° (Jones et al., 2011) and MIROC5 (Model for Interdisciplinary Research on Climate 5) produced by the Climate System Research Center of the University of Tokyo, with resolution data of 1,4063°x1,4063° (Watanabe et al., 2010). Thus, data on precipitation, solar radiation and maximum and minimum temperatures were generated for the period from January 2010 to December 2018.

Table 1: Identification codes (ID) of the Micro-regions contained in the study area and their states.

Micro-region	ID	Micro-region	ID
Alto Mearim e Grajaú – MA ¹	01	Cotegipe - BA	17
Alto Médio Gurguéia – PI ²	02	Dianópolis - TO	18
Alto Parnaíba Piauiense - PI	03	Gerais de Balsas - MA	19
Araguaína – TO ³	04	Gurupi - TO	20
Baixo Parnaíba Maranhense - MA	05	Imperatriz - MA	21
Barreiras – BA ⁴	06	Itapecuru Mirim - MA	22
Bertolínia – PI	07	Jalapão - TO	23
Bico do Papagaio – TO	08	Lençóis Maranhenses - MA	24
Bom Jesus da Lapa – BA	09	Médio Mearim - MA	25
Caxias – MA	10	Miracema do Tocantins - TO	26
Chapadas das Mangabeiras - MA	11	Porto Franco - MA	27
Chapadas do Alto Itapecuru - MA	12	Porto Nacional - TO	28
Chapadas do Extremo Sul - PI	13	Presidente Dutra - MA	29
Chapadinha – MA	14	Rio Formoso - TO	30
Codó – MA	15	Sta Maria da Vitória - BA	31
Coelho Neto – MA	16		

States: Bahia⁴, Maranhão¹, Piauí² e Tocantins³

Descriptive statistics tools (mean, coefficient of variation, Student's t test and Pearson's correlation coefficient) were used in the *Paleontological Statistics Software Package for Education and Data Analysis* – PAST and used to analyse the results, adopting a significance level of 95% to test the possible interannual differences and relationships between the variables obtained and simulated.

To assess the accuracy of climate models, the percentage of bias (Pbias), mean absolute percentage error (EMPA) and mean absolute error (EMA) was used together with Willmott's agreement index (Willmott et al., 2012). On the other hand, the adapted performance index (C') of the models was evaluated by the product of Pearson's correlation coefficient (r) and Willmott's index (d), as proposed by Camargo and Sentelhas (1997).

The zero value for Pbias (Equation 1) indicates the absence of bias, while different values indicate overestimation, when negative, and underestimation, when positive (Van Liew et al., 2007). Considering that the observed data present a small margin of error, Pbias between -0.5% and +0.5% were considered null.

Equation 1:

$$P_{BIAS} = \left[\frac{\sum Obs_i - Est_i}{\sum Obs_i} \right] 100$$

Where:

Est_i – Estimated value of the variable for point i ;

Obs_i – Observed value of the variable for point i .

The EMA measures the magnitude of the weighted average of absolute errors. For Willmott and Matsuura (2005), the EMA is a natural and more accurate measure of the mean magnitude of the error as can be seen in equation 2.

Equation 2:

$$EMA = \frac{1}{n} \sum_{i=1}^n |O_i - E_i|$$

Where:

E_i – Estimated value of the variable for point i ;

O_i – Observed value of the variable for the point i ;

n – Sample size.

The mean absolute percentage error – EMPA (Equation 3) is a precision statistic that prevents the error from being decreased by the sum of values with opposite signs and can be classified according to Table 2 (Lewis, 1997).

Equation 3:

$$EMPA = \frac{1}{n} \sum \left| \frac{Obs_i - Est_i}{Obs_i} \right| 100$$

Where:

Est_i – Estimated value of the variable for point i ;

Obs_i – Observed value of the variable for point i ;

n – Sample size.

Willmott's index reveals the degree of agreement between observed and simulated measurements, ranging from 0 to 1, where the first value represents the total disagreement and the second the perfect agreement. Thus, the higher the result of equation 4, the better the performance of the model.

Equation 4:

$$d = 1 - \frac{\sum_{i=1}^n (O_i - E_i)^2}{\sum_{i=1}^n (|E_i - \bar{O}| + |O_i - \bar{O}|)^2}$$

Where:

E_i – Estimated value of the variable for point i ;

O_i – Observed value of the variable for the point i ;

\bar{O} – Average value of the observed variable

n – Sample size.

Table.2: Proposed classification for Pbias and performance index (C').

Pbias ¹	(C') ²	EMPA ³	Classification
<10%	> 0,75	< 10%	Very Good
10% - 14%	0,75 - 0,64	10% - 19%	Good
15% - 24%	0,65 - 0,60	20% - 29%	Satisfactory
≥25%	< 0,60	≥30%	Unsatisfactory

¹Van Liew et al. (2007); ²Camargo e Sentelhas (1997);

³Lewis (1997)

The adjustment of the models was performed by testing multiple regression models, and sinusoidal regression was selected because it better represents the cyclic regime of the temperature oscillations in the region.

III. RESULTS AND DISCUSSION

Figure 3 shows the behaviour of the quarterly averages of observed temperatures simulated by the HadGEM2-ES and MIROC5 climate models. The typical seasonality of the region (Lahsen et al., 2016; Curado et al., 2014) is satisfactorily reproduced in the model, but with a marked tendency to overestimate temperatures in the fourth quarter (October, November and December) and

underestimate them in the second quarter (April, May and June). The same pattern of error was found, with small differences, in both models, and the largest errors recorded occurred in the second and third trimester, where the observed temperatures were much higher than those simulated. These quarters correspond to the post-harvest

period in monoculture plantations, where the soil of large areas is uncovered and there is a sharp drop in air humidity due to low vegetation cover and, consequently, reduced evapotranspiration (Balduino et al., 2018; Imaflora, 2018; Ayala et al., 2016; Curado et al., 2014; Da Silva, 2013).

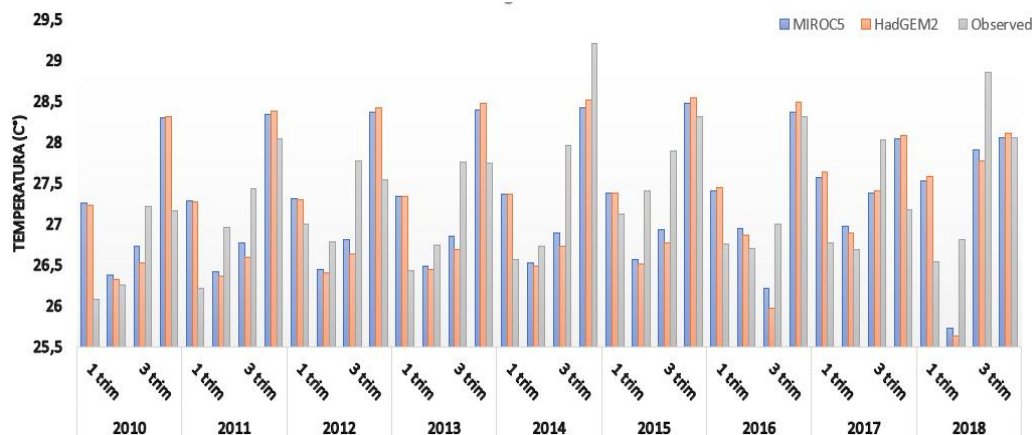


Fig. 3: Quarterly averages of Simulated and Observed Temperatures in the period from 2010 to 2018.

Table 3 presents the descriptive statistics of the simulated and observed data, on a monthly basis, in the studied area. It is possible to see that the models simulate measures of central tendency and interannual variability very similar to those observed, so that no significant difference between the variables was detected, at the minimum level of $p \leq 0,05$ in the Student's t test, in this time scale. There is also a low intra and interannual variability of mean temperature in this region, which according to Strassburg et al. (2017) represents an indication of greater vulnerability to environmental changes, since the functioning of almost all ecological services is adapted to low temperature ranges.

Table 3: Descriptive statistics of the studied period.

Statistical indicators	MIROC5	HadGEM2	Observed
Mean (°C)	27,267	27,231	27,277
Standard Deviation	1,012	1,104	0,950
Variation Coefficient (%)	3,710	4,056	3,481

Figure 4 shows the bias, or the absence of it, in the simulation of the two models in relation to the average monthly temperatures observed in each micro-region that presented expansion of agricultural areas in the last 10 years. This special view shows that the models provided overestimated data for most micro-regions.

The MIROC5 model had better results in this indicator, since it did not present bias in eight micro-regions (Fig 4B), while the HadGEM2-ES model did not have bias in only five micro-regions (Fig 4A). Five micro-regions had their temperatures underestimated in both models, being

two central ones where savannahs predominate and three in the eastern border, in the transition from the Cerrado to the Semiárido. It is noticed that the absence of bias is concentrated in the micro-regions near the Amazon biome (IBGE, 2012), where there is also a higher frequency of classification divergence between the two models.

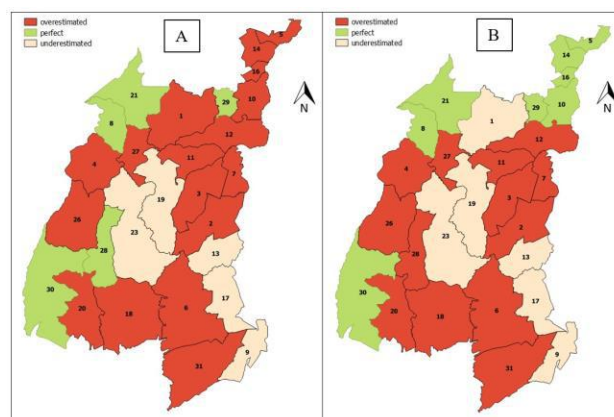


Fig. 4: Bias of over or underestimation of monthly mean temperatures in the simulations of the HadGEM2-ES (A) and MIROC5 (B) climate models in the period from 2010 to 2018.

Table 4 shows that the percentage of bias was classified as "very good" for both models and in all micro-regions analysed. However, it was found that in 11 micro-regions the HadGEM2-ES error is higher, while in other 10, the MIROC5 shows a higher error. For the others, the difference in errors between the two models is irrelevant. The same occurred with the Willmott index, with the

smallest values located in micro-regions 02, 04, 17 and 18.

Average errors above 1.5°C, in at least one of the models, were found in 33.3% of the micro-regions. It is noteworthy that, given the low variability ($VC < 4.1\%$) of the interannual mean temperatures observed in the study area (Table 2) and in others (Batlle-Bayer et al., 2010; INPE, 2013), errors of this magnitude can be considered substantial, even though the agreement of the variables' behaviour is high ($d > 0.80$). It was also observed that the MIROC5 model obtained greater errors than the HadGEM2-ES in most (57%) of the micro-regions.

Table 5 shows that the values obtained for each model in the statistical indicators, at a regional scale (study area unit), are similar in relation to precision (d), correlation (r) and the percentage of mean error (EMPA), these being classified as from moderate to very good. However, there are significant differences in relation to the bias (Pbias) and the performance indicator (C). Although the results of both models are classified as very good for the bias (Van Liew et al., 2007), they show unsatisfactory performance (Camargo and Sentelhas, 1997). In this sense, the MIROC5 model underestimates, while the HadGEM2 model overestimates the average temperatures. Both are considered very good, but the MIROC5 model is the one with the lowest bias. Part of these results are similar to those found by Sales et al. (2015). However, Torres (2014) also found many uncertainties in the validation of climate models, even with dynamic downscaling techniques.

Table 4: Model performance indicators in each micro-region of agricultural expansion.

ID	(d)		EMA		Pbias	
	Had	Miroc	Had	Miroc	Had	Miroc
1	0,94	0,92	1,22	1,35	-0,74	0,73
2	0,50	0,48	1,94	2,16	-3,54	-4,19
3	0,93	0,90	0,88	1,21	-1,41	-3,06
4	0,62	0,63	1,67	1,36	-5,64	-4,14
5	0,94	0,92	0,87	1,14	-1,25	0,00
6	0,83	0,89	0,71	0,95	-0,87	-2,17
7	0,94	0,92	1,29	1,39	-1,74	-0,56
8	0,93	0,94	1,15	1,04	0,25	0,20
9	0,83	0,88	1,43	1,12	1,15	0,54
10	0,96	0,94	1,13	1,27	-0,97	0,50
11	0,93	0,90	0,88	1,21	-1,41	-3,06
12	0,93	0,92	1,10	1,15	-2,26	-1,83
13	0,82	0,85	1,51	1,44	3,01	2,98
14	0,94	0,92	1,07	1,14	-1,25	0,00

16	0,94	0,92	0,97	1,14	-1,25	0,00
17	0,70	0,78	1,64	1,38	2,75	1,65
18	0,61	0,63	2,07	2,28	-3,64	-5,49
19	0,93	0,90	1,29	1,45	1,17	1,66
20	0,87	0,84	1,36	1,72	-4,02	-5,81
21	0,93	0,94	1,15	1,04	0,25	0,20
23	0,81	0,86	2,13	1,87	4,45	3,55
26	0,90	0,90	1,12	1,24	-3,17	-3,08
27	0,92	0,92	1,33	1,22	-1,40	-0,58
28	0,87	0,90	1,61	1,47	-0,01	-0,67
29	0,97	0,97	0,90	0,93	0,16	0,40
30	0,83	0,83	1,62	1,64	-0,01	-0,14
31	0,82	0,79	0,25	1,32	-1,34	-2,88

Table 5: Model performance indicators in relation to the total delimited area for the study.

Indicators	MIROC5	HadGEM2	Performance
(d) ¹	0,744	0,729	Very High
EMPA	3,054	3,079	Very Good
(r) ²	0,526	0,561	Moderate
Pbias*	0,107	-0,854	Very Good
(C')*	0,392	0,409	Unsatisfactory

¹Stork et al. (2016); ²Levine et al. (2008); *significant ($p \leq 0,05$)

The analysis of the behaviour of the time series (Figure 2), composed by the observed data and estimated by downscaling of the models, revealed that the forecast errors present a cyclic pattern. Therefore, the adjustment of the models was performed by sinusoidal regression of four phases, that is, considering the averages of quarterly periods. The models were adjusted by Equation 5 and the coefficients generated for each model are expressed in Table 6.

Equation 5:

$$Y = (X_{\max} - X_{\min}) * \cos(2\pi (X_i - X_{\min}) / (T - p))$$

Where:

Y – Adjusted estimated value;

X – Gross value estimated by the model;

X_{\max} – Estimated maximum gross value;

X_{\min} – Estimated minimum gross value;

T – Estimation period;

p – Number of phase of the sinusoidal model.

Table 6: Sinusoidal adjustment coefficients.

Phase	MIROC5		HadGEM2	
	Range	Period	Range	Period
1	-0,697	3,590	-0,7572	3,673
2	-0,282	0,572	-0,3334	0,567
3	-0,447	0,152	0,3469	0,092
4	0,247	0,143	-0,3547	0,166

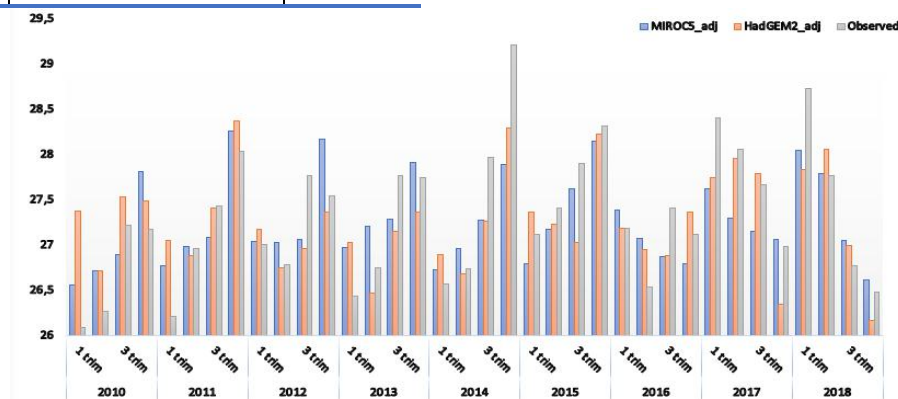


Fig. 5: Quarterly averages of Simulated and Observed Temperatures, with sinusoidal adjustment, throughout the studied period.

Table 7: Model performance indicators after sinusoidal adjustment.

Indicators	MIROC5	HadGEM2	Performance
(d) ¹	0,999	0,999	Very High
EMPA	1,976	1,997	Very Good
(r) ²	0,50	0,52	Moderate
Pbias	0,002	-0,001	Very Good
(C')	0,707	0,721	Good

¹Stork et al. (2016); ²Levine et al. (2008).

IV. CONCLUSION

1 – Both models are accurate in reproducing the average annual and interannual temperatures, as well as their variability. However, they present difficulties in temporally synchronizing the typical monthly seasonality of the studied region, even though they reproduce them satisfactorily on an intra-annual scale;

2 – Both models present high levels of agreement in relation to the temperatures observed in the micro-regional scale, except in the micro-regions 02, 04, 17 and 18, where the level of agreement is classified as moderate;

3 – The bias of both models is less than 1% on a regional scale and varies from 0 to 5.64% on a micro-regional scale, being classified as "Very Good" in the two scales analysed. However, the models present biases in opposite directions in several micro-regions, and in the regional scale the MIROC5 tends to underestimate while the HadGEM2 tends to overestimate the interannual and micro-regional mean temperatures;

The adjustment results can be seen in Figure 5 and Table 7. It was confirmed that the adjustment generated an increase in agreement between the simulations and the observed data, which intensified the model's performance level and provided better temporal adjustments in the seasonal oscillations.

4 – The opposing biases in many micro-regions and in the studied region determined only a moderate correlation between the data simulated by both models in relation to the observed data. This affected the coefficient of performance of the models, which was classified as unsatisfactory in all spatial scales analysed;

5 – This is reinforced by the values presented in the mean absolute error, since, even with a reduced variability of intra- and interannual temperatures in all micro-regions, the error was higher than 1.5° C in several of them. Although the percentage of regional mean error was approximately 3%, the low variability of mean temperatures in the region makes this percentage high for the local reality, although classified in the literature as "very good";

6 – Despite the great balance in the performance of the two models, the MIROC5 was slightly higher on a regional scale. On the micro-regional scale, the superiority of one over the other is a result of the lowest bias and is divided similarly among micro-regions;

7 – Temperature simulation is important to estimate the other climate variables and make projections for the future (Balduino et al., 2018; Bocchiola et al., 2013). Therefore, the results of this study show that the data generated in the regional climate models MarkSim-HadGEM2-ES and MarkSim-MIROC5 require correction of systematic errors prior to the use of future projections aimed at multiple objectives, especially in the planning of public policies that require greater intra-annual precision. However, for studies requiring only annual averages, it is sufficient to choose the model with the least bias in

micro-regional scales.

8 - The method of adjustment of the simulations, by means of sinusoidal regression, substantially increased the performance index of the estimates by improving the level of agreement between the simulated and observed data.

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Economic Development Analysis for Smart Cities: A New Approach for Management and Innovation Practices

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Abstract — *Urban planning is the process of idealization, creation and development of solutions to improve or revitalize certain aspects within a given urban area or planning a new urban area in a given region, with the main objective to provide people with an improvement in life quality. The objective of this article is to point out ways to possible scenarios and solutions to facilitate the use of best management practices and innovation to overcome the future challenges for public managers of Porto Alegre City, Brazil. Observing the growth rates of public investment in infrastructure and non-infrastructure, as well as the quantitative results we have that the city of Port Alegre is targeting public investments in a contrary way to what refers conceptually to Smart Cities. Low investments in infrastructure and non-infrastructure followed by the rise in law enforcement expenditure inhibit the entry of private investment and consequently economic growth for the city.*

Keywords— *PICAM, Smart City, Economic Development, Innovation, Cross Section Analysis, Monte Carlo Simulation.*

I. INTRODUCTION

Urban planning is the process of idealization, creation and development of solutions to improve or revitalize certain aspects within a given urban area or planning a new urban area in a given region, with the main objective to provide people with an improvement in life quality.

According to Aoun (2013), in less than 40 years, 70 % of the world's population will be living in cities. The rapid migration will cause pressures not only on urban planners, but also on public administrators, as these should expand the infrastructure for industrial and residential areas beyond the break-even point. Thus,

increasing the population's expectations for a smarter city.

Smart cities are the paradigm of proper planning not only to the field of urban development, but also to innovation management. According to Komnino (2009), in the urban development field, intelligent cities supports the growth of local knowledge and in the field of innovation management ensures the sustainability of global innovation network. These two serves as connection to turn public institutions into innovative institutions to face the challenges of regional and global competition.

The last decade has seen the rapid conceptual evolution of what used to be called "technological cities" for now "digital or smart". The concept evolution correspond to the cities development with strategic mission focused not only on innovation and creativity, but also with economic focus and opportunities for society. The concept leads to an integrated and sustainable city (Yigitcanlar, 2007; Martinez- Fernandez and Yigitcanlar, 2007).

Smart cities essentially allow and encourage all citizens to become more active and participative as community members through a strong technological infrastructure. For that there are four key aspects with strong informational driver as: a) modern digital infrastructure that combines an open and transparent public database; b) intelligent systems to generate services based on data for the user to make strategic analysis of investments in the city; c) systems that allow the user to compare the results and performance generated by the data; d) openness to learning and exchange of experiences through new arrangements and simulation of mathematical models available to society .

Thus, the purpose of this article is to point out ways to possible scenarios and solutions to facilitate the use of best management practices and innovation to overcome the future challenges for public managers of Porto Alegre City, Brazil. The results will help to assist for a better investment strategic assessment by the local government, as well as to help users to compare better macroeconomic variables performance for the given period.

Therefore, a quantitative research was used which consisted of two steps as the first being the analysis of growth rates behavior for the variables considered relevant to ensure competitiveness, followed by a macroeconomic analysis using the *Private Investment Cross Analysis Methodology (PICAM)*.

This study is the result of a research conducted by the Entrepreneurship and Innovation Center of Fundação Dom Cabral with the support of IBM and participation of representatives of Porto Alegre's municipal government using the competitiveness data, which were based on the nations competitiveness methodology used by the World Economic Forum, for the period 2004-2014.

This paper is structured initially with an introduction followed by methods and materials. The third section shows the main results discussed on the topics listed above and then the conclusions.

II. MATERIALS AND METHODS

Private Investment Cross Analysis Methodology (PICAM) provides a cross section analysis among the variables determining the public / private investment with the macro and microeconomic variables that affects the sectors, as well as the intersection between the sector and analyzed subsectors (Tadeu & Silva, 2014a), Tadeu & Silva, 2014b ; Tadeu & Silva, 2013a, Tadeu & Silva, 2013b).

The quantitative data were obtained through DATAPOA and public database available based on IBGE (Brazilian Institute of Geography and Statistics), IPEA (Institute of Applied Economic Research) and Brazilian Central Bank Reports for the 2004-2014 period. This period was used because of the city's data base availability. The obtained data are in millions of Real and were deflated at 1995 prices.

Three questions were used to approach the quantitative research:

- What is the current economic environment for a short-term assessment for public management?
- What are the determinants for investment in the public sector?
- What are the short and long term challenges for the public administrators of Porto Alegre to the level of investment to achieve the standard of Smart Cities?

The competitiveness data used for the city of Porto Alegre were: Public Investment; Municipal GDP; Investment in Infrastructure (Environmental Management, Energy and Urban Planning, Communication and Sanitation); Investments in non-infrastructure (health, culture, sports and leisure); Public Budget; Subsidies; Expenditure on education; Expenditure on criminality; Expenditure on Justice; Expenditure on Urban Mobility; Expenditure on R & D and training.

2.1 Analytical model: Private Investment Cross Analysis Methodology (PICAM) and Fixed Effects Coefficients for Porto Alegre City Public Investments

The proposed econometric model is directed towards the city of Porto Alegre public investment and combines the use of a set of data associated with economic performance observing the variables behavior related to competitiveness.

The methodology presented here is divided into two sections with the presentation of the theoretical model describing the econometric model for panel data and the second presenting the Analytical Model with application of the cross-section model and fixed coefficients for the city's public investment.

2.2 Cross Section Model and Variables Definition

This section initially refers to the use of cross section model and longitudinal data. The first used econometric model is intended to test the macroeconomic data that may have an inhibitor impact on Porto Alegre's public investment.

In order to explain the effects of economic variables on public investment in the city of Porto Alegre the following variables to the functional model were chosen:

- $Invest_pub = f(r, GDP, PIB, Invinfra, Invninfra, Inflation)$ (1)
where:
- R = Real Interest Rate
- GDP = Gross Domestic Product.
- $INVPUBINFRA$ = Public Infrastructure Investments; investments in electricity and urban planning, environmental management, telecommunications and sanitation.
- $INVPUBNINFRA$ = Public Investments in non Infrastructure; investments that are not related to infrastructure, such as health, sport and recreation and culture.
- $Inflation$ = inflation in the city of Porto Alegre.

From the general econometric model, we propose a natural logarithm model for public investments for the period 2004 - 2014, so to review the elasticities in the

long-run, in other words the values will be transformed into rates:

$$\begin{aligned} \text{LogInvest_pub}_t = & \beta_0 + \beta_1 \text{LogR} + \beta_2 \text{LogGDP}_{it} + \\ & \beta_3 \text{LogINVPUBINFRA}_{it} + \beta_4 \text{LogINVPUBNINFRA}_{it} + \\ & \beta_1 \text{LogInflation} + \varepsilon_t \end{aligned} \quad (2)$$

2.3 Growth Rates

With the data generated by EQ. 2 it is possible to analyze the growth rates behavior of the selected variables for the competitiveness variables of Porto Alegre, as these are expressed in natural logarithm.

For this step will be generated 12 graphics for the city of Porto Alegre, these being:

- Public Investments Growth Rates;
- GDP Growth Rates;
- Investment in Infrastructure Growth Rates;
- Investment in Non-Infrastructure Growth Rates;
- Public Budget Growth Rates;
- Subsidies Growth Rates;
- Expenditure on Education Growth Rates;
- Expenditure on Criminality Growth Rates;
- Expenditure on Justice Growth Rates;
- Expenditure on Urban Mobility Growth Rates;
- Expenditure R&D Growth Rates;
- Expenditure on Training Growth Rates.

2.4 Cross-Section between public investment variable and macro variables.

The following four equations will be estimated to evaluate the impacts of the proposed variables for public investments.

The four estimated questions are determined as follows:

- Equation 1: $\text{LnInvest_pub} = f(\text{LnInfra}, \text{LnnInfra}, \text{LnGDP}, \text{LnR}, \text{LnInflation})$
- Equation 2: $\text{LnInvest_Infra} = f(\text{Ln environmental management}, \text{LnEnergy_Urbanism}, \text{Ln telecommunications and sanitation})$
- Equation 3: $\text{LnInvest_nInfra} = f(\text{LnHealth}, \text{LnCulture}, \text{LnDesporto_Lazer})$
- Equation 4: $\text{LnInvest_nInfra} = f(\text{LnHealth}, \text{LnCultura}, \text{LnSport_Recreation}, \text{LnCriminality}, \text{LnJustice}, \text{LnEducation}, \text{LnR\&D}, \text{LnTraining})$

III. RESULTS

This session presents the results analysis of the growth rates competitiveness variables, as well as the econometric analysis for the PICAM.

The results are divided into three stages in order to analyze the behavior of the studied parameters as follows:

I. Analyze the growth rates for the competitiveness variables:

- i. Macroeconomic variables for Porto Alegre: Public Investment; GDP, Infrastructure; No Infrastructure; and
- ii. Government Variables for Porto Alegre: Budget, Subsidies, Criminality, Justice, Education, Research and Development, Training and Urban Mobility.

II. Analyze Public Investment Cross-Section results for the city of Porto Alegre.

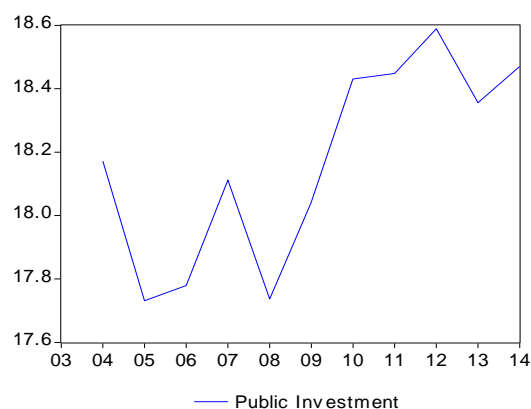
III. Analyze the Cross-Section of the Public Investment for the sustainability variables such as environmental management, energy and urban planning and communication and sanitation.

3.1 Stage 1: Growth Rates Variables Behavior of Porto Alegre's Cross Section Model

This stage is divided into two parts as the first being the analysis of macroeconomic variables and the second the public administration variables for the city of Porto Alegre.

3.2 Porto Alegre's Macroeconomic Analysis

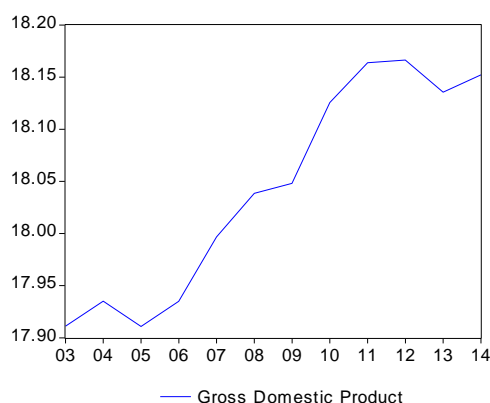
Graph 1, below, shows the behavior of the public investment growth rate for the city of Porto Alegre. It is observed that public investment showed high growth rates over time highlighting the period 2008-2012.



Graph 1: Public Investment Growth Rate.

The period shown above refers to the global financial crisis that demanded an increase in government investments to ensure life quality and secure municipal economy at appropriate levels.

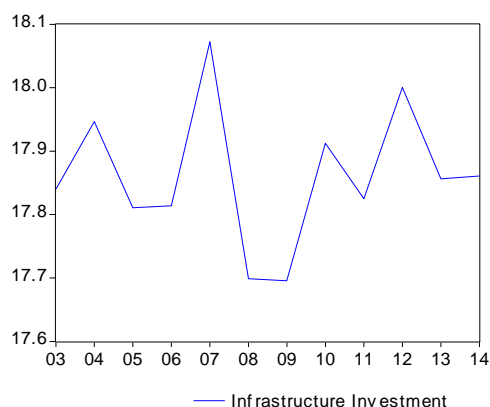
Graph 2 shows the Gross Domestic Product (GDP) growth rate generated by the city of Porto Alegre. The results indicate that there was an increase in GDP through the period 2005-2012.



Graph 2: Gross Domestic Product (GDP) growth rate.

The growth in GDP in the period can be explained by the increase in public investment presented in Graph 1. However, it is observed that the GDP growth rate has a smoother behavior compared with the behavior of public investment growth rate. It is suggested that public investment had to be higher to generate a reaction in GDP growth.

Graph 3 shows the growth rates for investments in infrastructure in the city of Porto Alegre. The results show variations in the growth rates for investments in infrastructure over the analysis period.



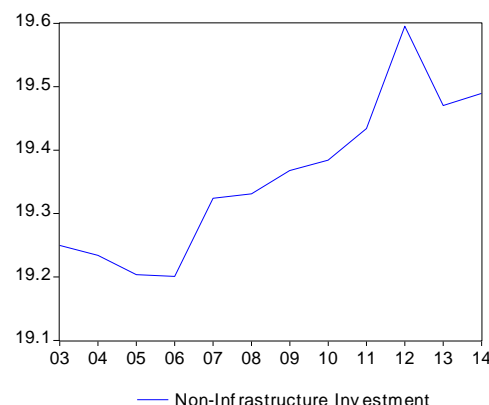
Graph 3: Infrastructure Investments Growth Rates.

The period with the highest drop in infrastructure investment was in 2007 to 2009. After 2009 investments grew, but with new fall in 2011.

As mentioned before, infrastructure is seen as the pillar to ensure competitiveness and attract private investment to the cities. But, what worries is that investment levels are lower than necessary reaching, in 2014, similar levels to 2003.

Graph 4 shows the results for the public investment in non-infrastructure growth rate. The graph shows two stages where the first one represents a decrease in the level of investments throughout the period from 2003 to

2006 and the second that shows a constant growth after the year 2006 to 2012.

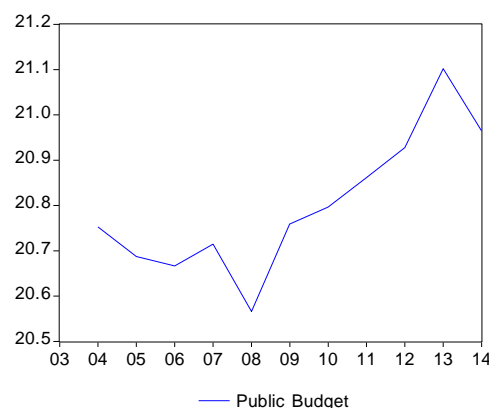


Graph 4: Public Investment in Non-Infrastructure Growth Rate.

The graph shows a peak over the period 2011-2012, but lowered investments right after reaching levels close to 2011.

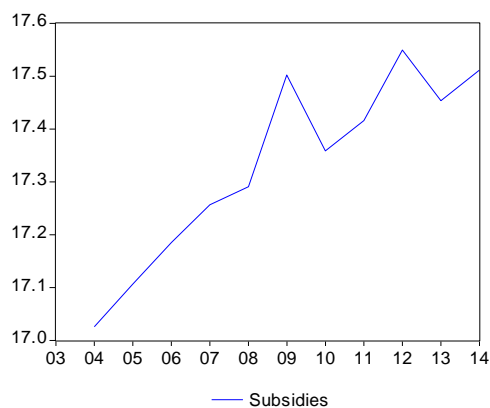
3.3 Porto Alegre's Public Administration Variables Analysis

Graph 5, below, represents the growth rate behavior for Porto Alegre's public budget variable. The graph shows that the public budget growth rate reached its lowest level in 2008. After 2008 the growth rate rises considerably over time, reaching the highest level in 2013. The results are explained because of the increase in public investment and GDP growth presented in Graphs 1 and 2, respectively.



Graph 5: Public Budget Growth Rate

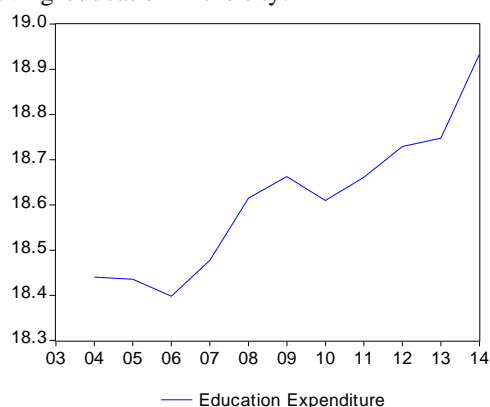
Graph 6 shows the growth rate for subsidies. The results show a variation in growth rate over the period analyzed and compared with other rates it is perceived that such behavior does not follow a pattern if compared to other variables.



Graph 6. Subsidies Growth Rate.

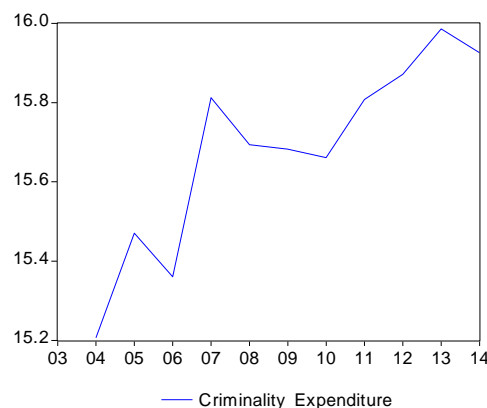
The subsidies growth rate is increasing and constant over the period 2004-2008. The two fallen moments occurred in 2009 and 2012. The period 2010-2012 may represent an increase in subsidies because of the strategy to attract the private sector based on private-public-partnership (PPPs) and as a result raised the GDP growth rate.

Graph 7 shows the expenditure on education variable behavior for Porto Alegre. It is observed that over the 10 years analysis the growth rate has been increasing representing the public managers political commitment in improving education in the city.



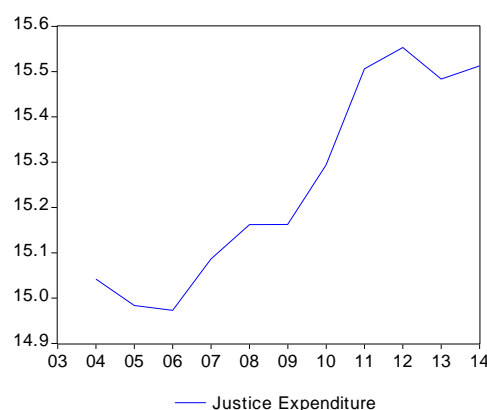
Graph 7. Education Expenditure Growth Rate.

Graph 8 shows the growth rate for the variable expenses with crime. The graph shows higher growth rates if compared to the growth rate on education expenditure. This is a chronic problem for the Brazilian cities, where the expenditure with police enforcement (expenditure with criminality) become the political platform for current and future public managers.



Graph 8. Expenditure with Criminality Growth rate.

Comparing Graphs 8 and 9 we observed the amount of money that the city of Porto Alegre has spent with law enforcement. Graph 8 and 9 have shown abrupt increase on expenditures over time.



Graph 9. Justice expenditure growth rate

The concept of smart city presented in the introduction shows that smart cities begins with intelligent systems that work for the populations benefit and environmental sustainability. Infrastructure, as well as public and private transport systems, health, research and development, and training are critical points to promote the city's efficiency. These critical points should be improved and integrated to the city's system transforming it into a real model to increase the population's life quality.

Analyzing the Porto Alegre's critical points, we observed that due to a political commitment public budget is mainly directed to expenditure on law enforcement, therefore, there has been a fight for scarce financial resources assessment among the other areas with worried reflexes according to Graphs 10, 11 and 12.

Graph 10 shows the growth rate of expenditure on urban mobility. The graph shows an inefficient urban transportation system with little public investment and that can discourage private investment to installing industries and businesses in the city, as well as hinders the

mobility of society to schools, training centers, hospitals and medical clinics.



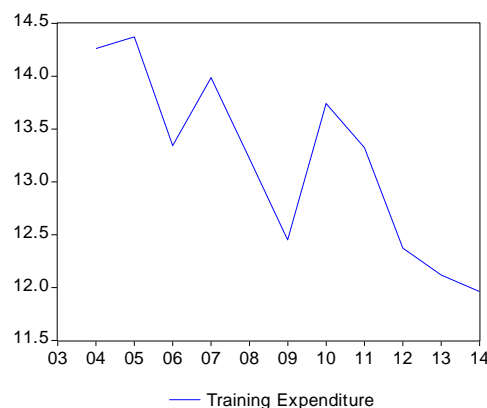
Graph 10. Urban Mobility Growth Rates

Contrary to what is understood as a smart city the results indicate low growth rates in Research & Development (R & D), as shown in Figure 11. The R&D investments results are seen as long-term, and this should be increasing over time rather than abrupt investments as shown in the years 2010-2011.



Graph 11. R&D Growth Rates

The most concerned graph analyzed up to now is Graph 12.



Graph 12. Training Expenditure Growth Rate

The results indicate a decrease on training expenditure, which in the long-run can have serious consequences as to public personnel with low productivity and a society unprepared for a possible expansion on private sector investment as in general. This, without considering the green belt that supplies the city of Porto Alegre.

3.4 Macroeconomic analysis for the city of Porto Alegre

This section is divided into 3 parts with an initial analysis of Porto Alegre's government investment equations, using the Cross-Section with Fixed Effects Method for the period of 2004-2014, followed by the government investments in infrastructure equations analysis and finally, the government investment equations in non-infrastructure analysis.

The results in Table 1 indicate a positive relationship between public investment in infrastructure (LogINVPUBINFRA) and public investment, that is, if there is a 1% increase in public investment in infrastructure will cause an increase in public investment of 1.27%. This behavior is maintained throughout the tested equations.

Table 1: Government Investments Equations for the city of Porto Alegre, RS, using the Cross Section Model with Fixed Effects for 2004-2014 period.

Explained Variables ⁽¹⁾	EQ1	EQ2	EQ3	EQ4	EQ5
C	-4.6962 [-2.0690] (0.0499)	-27.9184 [-14.9949] (0.0000)	-37.7259 [-18.3178] (0.0000)	-52.4049 [-11.9593] (0.0000)	-54.7938 [-11.9278] (0.0000)
LnINVINFR	1.2775 [10.0742] (0.0000)	0.6451 [7.6807] (0.0000)	0.8044 [10.5428] (0.0000)	0.8276 [11.1698] (0.0000)	0.8582 [11.2877] (0.0000)
LnINVNINFRA		1.7835 [18.4623] (0.0000)	0.0446 [0.1868] (0.8520)	0.3448 [1.4102] (0.1601)	0.3817 [1.5619] (0.1199)

LnGDP		2.2505 [7.7858] (0.0000)	2.7085 [8.8780] (0.0000)	2.7732 [9.0568] (0.0000)
R			0.0279 [3.7615] (0.0002)	0.0299 [3.9941] (0.0001)
Inflation				-0.0096 [-1.6586] (0.0988)
R ²	0.3411	0.7602	0.8173	0.8298
Adjusted R ²	0.3377	0.7577	0.8145	0.8262
S.E.R.	0.2457	0.1486	0.1300	0.1258
DW stat	0.8294	1.5456	1.8457	2.0168

Obs: (1) Statistics-t in brackets, followed by p-values in parenthesis.

Equation 2 shows the results with the inclusion of the variable public investment in non-infrastructure, which suggests a positive relationship regarding the impact on public investment in the city of Porto Alegre. This behavior is maintained throughout the tested equations. The Equation 2 showed an overall satisfactory degree of explicability with $R^2 = 0.76$.

In the case of Equation 3 it is observed that the Porto Alegre's Gross Domestic Product has a positive effect on the increase in public investment once the GDP allows to estimate the generated wealth and identify their specific composition contributing to public policy formulation.

The real interest rate (R) showed a positive signal in Equation 4 meaning the use of own resources for public investment, despite the value estimated to be close to zero. Another understanding lies in the fact that the interest rate does not interfere with public investment resources. Equation 4 shows an overall satisfactory degree of explicability with $R^2 = 0.82$.

Finally, Equation 5 estimates the influence of inflation on public investment and consequently the result of a complete macroeconomic model for the city of Porto Alegre. The results show that there was no change in the signs on the estimated variables indicating the importance of public investment in infrastructure and non-infrastructure, as well as GDP. On the other hand, despite the relatively insignificance interest rate and inflation that do not influence public investments. Equation 5 shows an overall satisfactory degree of explicability with $R^2 = 0.83$.

Table 2 shows the behavior of Environmental Management, Energy and Urbanization, and Communication and Sanitation expenditures for public-sector investment in infrastructure in the city of Porto Alegre.

Table 2: Government Investment Equations in Infrastructure in the city of Porto Alegre, RS, by the Cross-Section Method with Fixed Effects for the period 2004-2014.

Variáveis Explicativas ⁽¹⁾	EQ1
C	-0.8571 [-0.6203] (0.5385)
Ln_ Environmental Management	0.1359 [1.9213] (0.0618)
Ln_Energy_Urbanization	0.6779 [15.4690] (0.000)
Ln_Communication_Sanitation	0.2941 [14.0194] (0.0000)
R ²	0.8998
Adjusted R ²	0.8923
S.E.R.	0.0457
DW stat	2.0121

Obs: (1) Statistics-t in brackets, followed by p-values in parenthesis.

The results in Table 2 indicate a positive relationship between all variables that compound public investments in infrastructure. Investments in infrastructure promote improvements in the environment for private investment, urbanization, sanitation and environmental sustainability. Infrastructure promotes economic growth for the city, as

well as increase the personal wealth and the demand for a better and infrastructure quality. The results show an overall satisfactory degree of explicability with $R^2 = 0.89$.

Table 3 shows the behavior of health, culture, and sports and leisure expenditures in relation to public investment in non-infrastructure of Porto Alegre.

Table 3: Government Investment Equations in Non-Infrastructure in the city of Porto Alegre, RS, by the Cross-Section Method with Fixed Effects for the period 2004-2014.

Variáveis Explicativas ⁽¹⁾	EQ1
C	0.2573 [35.9173] (0.0000)
Ln_Health	0.9428 [2327.070] (0.0000)
Ln_Culture	0.0421 [66.6048] (0.000)
Ln_Sports_Leisure	0.0146 [[0.9488] (0.0000)
R ²	0.9999
Adjusted R ²	0.9999
S.E.R.	0.0001
DW stat	2.5559

Obs: (1) Statistics-t in brackets, followed by p-values in parenthesis.

The results in Table 3 indicate a positive relationship between all variables that compound public investments in non-infrastructure. Investments in non-infrastructure promote a better quality of life, citizenship concern and decreases criminality. The city of Porto Alegre do not invest the necessary amount of money to guarantee acceptable levels of services on health, culture and Sports and Leisure. The results show an overall satisfactory degree of explicability with $R^2 = 0.99$, despite the low coefficient values.

Table 4 presents the estimated complete model as to the behavior of public accounts in relation to public investment in non-infrastructure of Porto Alegre City. Therefore, we included, in addition to public expenditure contained in Table 3, the expenditures with law enforcement (police and justice), education, R&D and training for the 2004-2014 period.

The complete model presented in Table 4 indicates a clear disproportionality in public spending in the city of Porto Alegre, for expenses such as Health, Culture, Sports and R & D, despite showing a positive relationship, represents a small share values in public investment in non-infrastructure. On the other hand, expenditures Justice, Education and Training has shown significant and positive behavior. Expending on criminality has shown negative behavior represented with disinvestment in non-infrastructure. The results show an overall satisfactory degree of explicability with $R^2 = 0.99$.

Table 4: Complete Government Investment Equations in Non-Infrastructure in the city of Porto Alegre, RS, by the Cross-Section Method with Fixed Effects for the period 2004-2014.

Variáveis Explicativas ⁽¹⁾	EQ1
C	0.2359 [123.1218] (0.0000)
Ln_Health	0.9430 [6959.321] (0.0000)
Ln_Culture	0.0433 [382.6180] (0.000)
Ln_Sports_Leisure	0.0150 [140.5742] (0.0000)
Ln_Criminality	-0.0008 [-24.1831] (0.0000)
Ln_Justice	7.6135 [1.4029] (0.1645)
Ln_Education	7.6895 [1.4275] (0.1574)
Ln_P&D	0.0002 19.0165 (0.0000)
Ln_Training	9.4588 [13.3943] (0.0000)

Variáveis Explicativas ⁽¹⁾	EQ1
R ²	0.9999
Adjusted R ²	0.9999
S.E.R.	2.5689
DW stat	3.0438

Obs: (1) Statistics-t in brackets, followed by p-values in parenthesis.

Observing the growth rates of public investment in infrastructure and non-infrastructure shown in the first results session Step 1, as well as the quantitative results in the results presented in the second session we have that the city of Port Alegre is targeting public investments in a contrary way to what refers conceptually to Smart Cities. Low investments in infrastructure and non-infrastructure followed by the rise in law enforcement expenditure inhibit the entry of private investment and hence economic growth for the city.

IV. CONCLUSION

This paper suggests that there are possibilities to manage the cities with innovations in processes and consequently in technology. Much more than investor in intelligent systems, a city becomes intelligent from investments in infrastructure, non-infrastructure, education, justice and others. It is also suggested that the relationship between increases in subsidies and the quality of public spending, measured by the budget, would have a strong impact on improving the quality of life and economic growth.

The article's contribution is the use of an economic analysis model, evaluating the available data and impacts on public management, something not seen in the literature review on smart cities.

For future studies, we suggest to run a Monte Carlo Simulation which is a method that associates maximizing, minimizing and the risk calculation for the variables under study. In other words, searching up with the method, the simulation (historical attempts) quantities, the error can be predicted. The essential feature of Monte Carlo simulation is the use of sampling techniques through discrete variables and the search for solutions with the use of differential equations.

We also suggest obtaining data from other cities, seeking to achieve consistent analysis and their interpretation in search of improvements on public management, innovation and government intelligence.

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The Practice of the Dilution of Cleaning Solutions: Motivations and Risks

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Abstract— *The habit of diluting cleaning solutions is routinely practiced in many homes and facilities around the world every day. The aim of the present work was to analyze the antimicrobial effect on six pathogenic microorganisms transmitted by hand on the two most commonly diluted cleaning solutions used in the state of Paraíba (Brazil). This practice was identified by means of a questionnaire. The cleaning solutions were diluted in sterile water (1:2, 1:4, 1:8 and 1:16) and suspensions of *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli*, *Enterobacter aerogenes* and *Candida albicans* were exposed to each of these solutions for 20 minutes. The yeast remained viable when the solutions had the highest concentrations of water. More than two-thirds of the 395 respondents admitted to having diluted detergent solutions because it was cheaper while believing that the dilution promoted antiseptic action, but not understanding the risk that this poses to health*

Keywords— *Household practices, Handwashing, Candida albicans, Paraíba.*

I. INTRODUCTION

Handwashing is an essential routine activity related to the reduction of cross-contamination of different human activities, such as meals, food handling, toilet use, and health care. However, this concept is relatively modern and coincides with the increased use of soaps in the early 20th century (Draeos 2018; Robinson et al. 2016).

Historically handwashing is related to soul purification, or ablution, to the detriment of simple hygiene practice (Allegranzi et al. 2009). Only in the 19th century, motivated by germ theory, the importance of transmission of infectious disease by hands was demonstrated and doctors began to accept handwashing as a global standard of health, considering it a crucial measure for the control of infectious diseases (Ataee; Mehrabi and Salesi 2017).

Handwashing is a procedure that promotes the removal of debris, chemicals and pathogens by using water and with soap or detergent, thereby reducing the risks of food poisoning and gastric and respiratory diseases (Rabie 2006). The simple habit of washing hands with soap is associated with the healthy growth of children under 5 years of age (Dangour 2013), reducing diarrhea and pneumonia mortality rates by up to 50% (Caimcross et al. 2010; Curtis and Caimcross 2003). Handwashing is considered to be the most efficient and cost-effective way to prevent diseases (Adams and Marie 1982), as well as reducing expenses for antibiotic treatments (Webster; Faoagali and Cartwright 1994).

Hand care products are used to enhance the efficiency of water in removing stains and dirt. The use of surfactants is based on the principle of reducing the surface tension between the debris and sebum on a contact surface, favoring its scattering and subsequent removal by friction (Bhamla et al. 2017).

Cleaning the hands using either warm or cold water is inefficient due to the insolubility of fats. Hot water is also uncomfortable for the hands and not suitable for the elimination of transient pathogenic microorganisms. Use of soaps or detergents together with hot water makes fat removal more efficient. The reduction of microbial concentration, however, is independent of temperature when soaps and detergents are used (Laestadius and Dimberg 2005; Michaels et al. 2002).

In different parts of the world, the habit of diluting cleaning solutions used for handwashing has been observed. This practice is disseminated informally through websites and blogs available on the world wide web and most webpages recommend the dilution of the original product with tap water, in a ratio of 1:3.

It is important to note that many cleaning products are formulated for use without prior dilution; moreover, it is a very subjective act for the consumer to perform the dilution with the correct proportion of water. In addition, the variability and lack of knowledge of the

microbial density present in the water does not guarantee the activity of the diluted components against the microbiota, and may indeed favor microbial development in the bottles, representing risk of infections to users. Given this, the present study aimed to evaluate the antimicrobial activity of the two diluted cleaning solutions most consumed in the state of Paraíba (Brazil) on six pathogens transmitted by hand. In addition, a questionnaire was developed to verify the practice of dilution and the main factors that encourage it.

II. MATERIAL AND METHODS

Microorganisms and cleaning solutions

Six representative pathogens of the resident and transient microbiota were used: *Acinetobacter baumannii*, *Enterobacter aerogenes*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida albicans*. A detergent dishwashing solution and a bathroom liquid soap were evaluated. The criteria used to select the tested brands were: popularity, market value and lack of recommendations or information concerning dilution. The products were tested to ensure absence of cultivable heterotrophs prior to being employed in the assays.

In vitro antimicrobial activity test

The test was based on the methodology described by Medeiros; Vasconcelos and Calazans (2007). Initially, the cleaning solutions were aseptically diluted in sterile distilled water in the following ratios: 1:2, 1:4, 1:8 and 1:16, making up to a final volume of 10 mL. Then, a suspension of each pathogen from fresh culture incubated at $37\pm 2^{\circ}\text{C}$ was standardized by the turbidity indicated on the McFarland scale tube #1 ($\approx 3 \times 10^8$ CFU/mL) and 1 mL of this suspension was transferred to the tube containing solution diluted 1:2. After a gentle mixing in a vortex mixer, aliquots of 1 mL were serially transferred up to the 1:16 dilution. The tubes were allowed to stand for 20 minutes at laboratory temperature and thereafter, aliquots of 1 mL of each tube containing the diluted solutions were transferred to tubes containing a nutrient broth. After incubation at $37\pm 2^{\circ}\text{C}$ for 48 hours, the viability of the microbial cells was determined by turbidity visualization and the addition of 1

mL of 1% resazurin solution. This assay is based on the reduction of the resazurin, observed by the color change, from blue to pink, in up to 2 hours, indicating the presence of products from microbial metabolism (O'Brien 2000).

Questionnaire on the dilution of household cleaning products

A multiple-choice questionnaire was developed with 10 questions, aiming to identify the habit of diluting cleaning solutions as well as the reasons why people do it. The questionnaire was published in Portuguese on the internet on March 16, 2018 and was available for a period of 15 days on three social networks: Facebook, Instagram and Twitter.

III. RESULTS

Cleaning solutions

Neither type of cleaning solution had instructions for use regarding dilution in large quantities of water. In the composition reported on the labels, both presented more than one surfactant and preservative solutions in their formulation.

In vitro antimicrobial activity test

The dilutions in water of the two cleaning solutions were efficient for all bacterial strains tested. In the other hand, *C. albicans* remained viable in the diluted solutions 1:8 and 1:16, as shown in Tab. 1.

Users profile on the cleaning solutions dilution

A total of 395 people answered the questionnaire. The practice of diluting dishwashing detergents with tap water was admitted by about 50% of respondents; less than 30% stated that they diluted bathroom liquid soap. Interestingly, when asked if they know someone who did this with both liquid soap and detergent, the percentage for the "yes" answers were higher.

Almost half of the respondents believed that dilution of dishwashing detergent (44.9%) or bathroom liquid soap (49.1%) could reduce their antiseptic action but surprisingly disagreed that this practice could increase the risk to the user's health for both products. The data are presented in Tab. 2.

Table. 1: Cell viability of hand pathogens (at least two replicates)

Pathogen	Cell viability							
	Dishwashing detergent				bathroom liquid soap			
	1:2	1:4	1:8	1:16	1:2	1:4	1:8	1:16
<i>Acinetobacter baumannii</i>	—	—	—	—	—	—	—	—
<i>Pseudomonas aeruginosa</i>	—	—	—	—	—	—	—	—
<i>Staphylococcus aureus</i>	—	—	—	—	—	—	—	—
<i>Escherichia coli</i>	—	—	—	—	—	—	—	—
<i>Enterobacter aerogenes</i>	—	—	—	—	—	—	—	—
<i>Candida albicans</i>	—	—	+	+	—	—	+	+

Table. 2: Percentage of user evaluation on the dilution of cleaning solutions (n = 395)

Responses	Dishwashing detergent			Bathroom liquid soap		
Have already practiced dilution	48.6			29.6		
Meet people who practice	Yes	No	Not sure	Yes	No	Not sure
	23.5	26.3	50.1	32.2	34.2	33.7
Believe in the anti-germ protection after the dilution of the product	Yes	No	Not sure	Yes	No	Not sure
	36.7	44.8	18.5	30.9	49.1	20.0
Believe that dilution may pose a health risk	Yes	No	Not sure	Yes	No	Not sure
	6.3	64.8	28.9	7.8	63.5	28.6

Tab. 3 reveals the desire to save on household expenses as the main motivation in all the declarations presented by the interviewees to justify the practice of the dilution of dishwashing detergents and bathroom liquid soaps. Other reasons also mentioned by the interviewees, especially with reference to the use of dishwashing detergents, included: avoiding damage to the skin, facilitating the cleaning of objects such as jewelry, the need to perceive the formation of foam and the desire to reduce viscosity of the product, making it easier to pour, as well as ensuring greater yield. In the bathroom liquid soap, the concern about damage to the skin was not mentioned, however foam formation was mentioned by the majority of the interviewees.

IV. DISCUSSION

In vitro antimicrobial activity test

Humans harbor more microorganisms than the total number of cells in their bodies. Most of this microbiota is beneficial, commensal or neutral, whereas a minor number is represented by pathogens (Rosenthal et al. 2011). On the hands, microbial populations occur that vary in concentration depending on their location. In the palm region, for example, the amount is approximately 10^3 CFU/cm², while under the nails they can reach about 10^5 CFU/cm² (Blaser and Falkow 2009).

Table. 3: Consumer reasons for diluting cleaning solutions (%)

Responses	Dishwashing detergent	Bathroom liquid soap
Reduce costs	64.8	69.9
Both savings and avoiding skin damage	18.5	0.0
Only to reduce skin damage	1.9	0.0
Other reasons	5.9	3.3
Not sure	8.9	26.8

The microbiota present on the hands may be classified as resident or transient, and may sometimes be composed of symbiotic organisms as well as pathogens.

So-called resident microbiota is installed from birth, existing in the deeper layers of the skin, more difficult to remove with water and soap, and may vary according to diet, lifestyle, environmental factors, age and gender (Schommer and Gallo 2013; Grice et al 2008). On the other hand, the transient microbiota varies in number and diversity as a function of time and generally constitute non-pathogenic or opportunistic microbes, originating from the contact of the hands with the environment. They rarely multiply on the skin and can be easily removed by washing and rubbing the hands using either liquid soap or an effective detergent (Mathur 2011).

The most critical periods during a day in the context of hand hygiene for the reduction of oro-fecal transmission of diseases are after defecation, before handling or preparation of food and before meals. For people with children at home, two critical periods can be added: feeding after a child who defecated and manipulating instruments related to infant feeding (Luby et al 2011).

The anionic surfactants present in formulations of dishwashing detergents and bathroom liquid soaps, such as sodium lauryl sulfate, attribute antimicrobial activity to these products, especially against bacteria. Although they may promote more skin irritations compared to similar cationic ones, the microbial density is significantly reduced during hand washing (Jensen; Rogers and Schaffner 2017).

The literature reports on some multidrug-resistant microorganisms as well as those resistant to preservatives present in health care and cosmetic products; however, most of these microorganisms are bacteria (Martins et al 2018). Few studies have also identified multidrug-resistant fungi (Elmorsy and Hafez 2016; Shaqra et al 2012). The present study highlights *Candida albicans* as the only resistant pathogen to the conditions applied in the in vitro assay.

Similar results were obtained by Bloomfield et al (1991). When testing different concentrations of active chlorine, 70% ethanol and 13 other sanitizing products, the authors observed sensitivity of *S. aureus* and *P. aeruginosa* and resistance of *C. albicans* under two

distinct contact times, 1 minute and 60 minutes for hands and surfaces, respectively.

C. albicans has been described as partially resistant to vinegar solution and some antiseptic agents (Lafleur; Kumamoto and Lewis 2006). Resistance can be attributed to the presence of lipid rafts, that is, membrane microdomains with amounts of saturated fatty acids and sterols larger than those present in the rest of the cell membrane (Insenser et al 2006). This arrangement also ensures greater resistance to detergent solutions, also contributing significantly to the formation of biofilms by the yeast (Lattif et al 2011).

On the other hand, in cases of the occurrence of mutant cells, with failure of ergosterol synthesis and consequent destabilization of microdomain membrane interactions, hypersensitivity to antiseptics has been observed, as well as sensitivity to fumisin, a mycotoxin that inhibits the synthesis of sphingolipids (Mukhopadhyat et al 2004). Proteomic analyzes suggest that polarization of domains rich in sphingolipids and cholesterol are involved in cellular processes for example cell signaling, cytokinesis, and morphogenesis, and have important proteins for the formation of hyphae that favor *C. albicans* adhesion on surfaces, increasing its virulence (Martin and Konopka 2004).

Although the results obtained by our work suggest that the practice of diluting dishwashing detergent or bathroom liquid soap does not alter the effectiveness of the products against about 85% of the tested pathogens, especially bacteria, it is noteworthy that the study was performed under limited laboratory conditions, not reflecting the use in a domestic routine, that is, dilution in water captured directly from the tap which may contain a certain microbial density, including the presence of pathogens. Aside from this, the volume of water used in the dilution of a given volume of cleaning solution may be even greater than that investigated in this study.

On the habit of diluting cleaning solutions

Personal opinion questionnaires guarantee a more accurate and close-to-the-scene result when respondents are asked to express the opinion of others and can reveal their own habits without running the risk of judgment (Graefe 2014; Rothschild and Wolfers 2012). Therefore, most interviewees assumed that they practiced or knew someone who dilutes cleaning solutions, especially dishwashing detergents. However, dilution with excess of water can compromise the product quality, reducing the activity of the active compounds as well as the preservatives, favoring the microbial development in the recipient washed, thus increasing the risk of dissemination of pathogens (Campana et al 2006).

Another reason for dilution that may reflect microbial proliferation concerns the consumer's desire to alter undesirable organoleptic characteristics such as high viscosity and non-foaming, characteristics of which the consumer associates with the quality of the product (Santa Bárbara et al 2007). The viscosity of detergents and liquid soaps is a result of the addition of salts which function as additives, having among them the prevention of liquid leakage during manufacturing, transportation and use processes. The addition of water may also generate a foaming effect because of the surfactants present in the formulation. The role of foam is a visual indicator of the need to rinse; however, foaming, for most consumers has a more stimulating effect of the feeling of cleanliness and freshness than a real antiseptic action (Tang et al 2015; Cobirman 2012).

Disregarding the economic factor, the practice of diluting cleaning solutions such as dishwashing detergent, bathroom liquid soap, and even shampoo was seen to be common when the product needed to be used but the container was nearly empty. More people resorted to dilution of the dishwashing detergent but preserving the bathroom liquid soap for some reason that was not investigated by the questionnaire but which seems to be answered by the preconceived notion that bathroom liquid soap is for cleaning hands rather than utensils. This status probably occurs due to certain organoleptic characteristics of the product, such as odor, foam and moisturizing sensation, which guarantees the hygienic sensation for the user by associating the product with beauty and cleanliness (Martins et al 2018).

Hand skin protection was also identified as a motivating factor for the practice of dilution. Kein; Gubauer and Fitsch (1992) demonstrated the correlation between the constant use of dishwash detergents and non-allergic skin lesions that remain for weeks. Some studies have already indicated that skin irritation when using soaps and detergents can be aggravated by dry climates and the influence of hard water as a rinse (Baranda et al 2002). They also reported that glycerinated soaps and other cosmetic products made from glycerin, vegetable oils and petrolatum prevent dehydration of the stratum corneum, i.e. the outer layer of keratin on the skin, minimizing irritation (Cornwell 2018; Wilson; Berardesca and Maibach 1988). However, the literature consulted contained no data that correlates the dilution of these products with the amelioration of skin damage. Ours was the first study reported in Brazil that sought to understand the practice of dilution by consulting users through a questionnaire. The results suggest that the label contain instructions on how to properly dilute dishwashing detergents and toilet liquid soaps when appropriate, however, the health risks related to the practice as well as

the number of dilutions permitted and the source of the water to be used for this purpose should be clear.

V. CONCLUSION

The habit of diluting cleaning products is disseminated and routinely worldwide practiced by a large number of consumers, especially motivated by the reduction of costs and the increase in the domestic consumption time of the product. Under the conditions used in this study, dilutions between 1:2 and 1:16 did not interfere with the antiseptic action of the active compounds against bacterial pathogens. However, the result was inefficient for *C. albicans* which remained viable when both solutions presented higher percentages of water.

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Women's Empowerment: Study with Angolan Women Accountants

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Abstract— Empowerment is the act of giving or empowering someone. Female empowerment is empowering women to have the capacity and willpower to fight for their rights, equality and their personal and professional emancipation. This work aims to understand the current context of the accountant by focusing on the phenomenon of empowerment. In the review of the literature, the focus was on gender (in) equality, empowerment and women's empowerment. This is a descriptive qualitative research. Data collection was done through interviews with twelve Angolan accountants. About the results, regarding the access to the profession, the interviewees had the support of their relatives; are in good working environment; but have had and have a difficult trajectory to be in the places in which they are; had and still have salary differences compared to male colleagues. Many of them have good financial autonomy and would like it to be better and say that there is little appreciation as a woman in companies. About training, they believe that the Accounting Course has helped them a great deal, even if they feel more competent in the execution of their activities.

Keywords— Angolan Accountants, Female Empowerment, Gender.

I. INTRODUCTION

According to Baquero [1], the term empowerment arose through emancipatory movements involving groups of women, also through black movements, homosexuals among others who fought for civil rights. This word had its basis in the Protestant Reformation highlighted by the religious leader Luther in the sixteenth century. Costa [2] states that the concept of empowerment arose in the United States in the 1970s through black power and was seen as a way of valuing the black race. According to Fialho et al. [3], empowerment is linked to social or political power, as it empowers the citizen both in the organization and in society itself.

Lisbon [4] conceptualizes empowerment as a means of reaching their own interests, allowing individuals and companies to be aware of their skills and abilities. The author states that this phenomenon causes people and society to break the barrier that women were born to be submissive. Empowerment sometimes materializes in the

movements of women who struggle for achievement in relation to gender and social position. But this term, in the feminist proposal, refers to a power or resistance to abuse and domination. In this way he values women and gives them access to their recognition. Female empowerment is a mechanism for achieving equity between the sexes. It is also seen as a cultural or traditional challenge because it "breaks" the barrier in which only man has the right to participate in decision making. The first step to be taken in relation to feminist empowerment is to recognize that there is inequality between men and women [4].

Silva [5] contends that one of the goals of female empowerment and empowerment is to empower women to access their rights, such as: health services, family planning, health education, equality in school and community and, finally, to have support in the social organization of women.

Mota and Souza [6] clarify which events approach the subject about women accountants, stimulating debates and presenting evolution of their careers. These conferences make society aware of the importance of the female accountant in the labor market. The growth of women in the accounting area tends to grow because they are very dedicated to the profession. The authors argue that, in order for accounting professionals to gain more recognition, it is necessary to create new laws that protect the rights of women in the labor market. However, in order for them to obtain these rights, it is necessary to eradicate the existing wage inequality between men and women, when women occupy the same positions.

In this way, the female presence in the accounting profession is quite relevant, since the number of women seeking training in the accounting area tends to grow quite a bit, even though it is still a little rare to find them in hierarchically high positions [7].

In this sense, according to Mota and Souza [6], the woman accountant is increasingly reaching recognition and, thus, has become stronger in the labor market. Although it encountered obstacles in the course of the profession, over the years these barriers were reduced. In this context, the research problem arises: What is the professional context of the Angolan accountants about empowerment?

The main objective of the study is to understand the current context of the accountant, focusing on the phenomenon of empowerment. It has specific objectives: to describe the working environment and the profile of the Angolan accountants; to know the circumstances that made them choose the profession; and highlight the impact of empowerment on accounting professionals.

According to Silva [5] in the Angolan rural environment, education converges between official education that is learned in school and the traditional one that is developed at home, preserving the customs. Thus, the initial rites are fortified, since the differences between woman and man are visible, lowering it. The author states that society views women as a symbol of marriage and motherhood, seeing them as the home educator, not deviating from the domestic context.

Education data also draws attention: 57% of out-of-school children are girls. In Brazil, the number of women who provide household support increased from 25% to 34%, but even with this new data, wage inequality prevails favoring men more.

At present, the status of women is worrying in countries with a low level of development, where poverty and the restriction of women's society are part of the range of gender discrimination, and violence against women is seen in all scales of society [9].

For Mota and Souza [6], the wage gap is one of the forms of discrimination that women find in the labor market, even though they already occupy equivalent positions with men. In Brazil, 40% of women earn less than men. The other problem is the cultural issue because the woman is a mother and a housewife, and what man does not have the capacity to assume the tasks performed by her with the same responsibility.

In the same sense, data from the United Nations Development Fund for Women are presented, which indicate that women still receive a lower remuneration of 17% compared to men, which contributes to the impossibility of professional development for women. Gender inequality has also been identified in the labor market where women sometimes perform the same function as men and are paid less. The wage differences reach 75%. Already in the education issue it was found that more than 57% of the female school-age age is out of the teaching aspect that can be identified as a cultural factor for some areas of the African continent [10].

For Oliveira, Gaio and Bonacim [11], there are already women working in positions that were previously dominated by men. But even in certain organizations women are placed in defined places, which are visible as feminized sectors, and the jobs they perform are called women's work. However, despite the appreciation of the

female sex many times and of the changes in social relations and in the companies, there is still a difference in relation to the salary between men and women, and this makes it difficult for them to enter the labor market.

In this decade, the number of women in the labor market is visible and, in this way, the challenges increase, since the world culture is traditionally sexist, however in the organizations the functions have always been well divided when talking about man and woman, being man as mentor of the house and woman with caretaker of the home [12].

In addition to what has been explained theoretically and with statistical data, this study is justified in accordance with Article 7 of the Universal Declaration of Human Rights, which states that everyone must be treated equally before the law, and everyone is granted the right to preservation in the face of a distinction that violates the Universal Declaration of Human Rights [13].

In this sense, the 5th objective of the 2030 sustainable development agenda, which aims to promote gender equality and empower women and girls, through the reduction of forms of discrimination against women and girls around the world, comes to end forced marriages mainly of children, giving women access to information systems and technology. Likewise, the 10th objective that addresses the reduction of inequality, as stated in the mentioned agenda, predicts that by 2030 the poverty index will be reduced and thus reach a 40% income for the poorest population, guaranteeing opportunity for all.

The practical contribution of the research focuses on understanding the real difficulties encountered by Angolan accountants and socializing the results of the research. As for social relevance, it is due to the contemporary nature of the subject, as well as to the relevance of the theme due to the history of gender inequality, focusing on female empowerment. Finally, the approach to empowerment is indispensable because it asserts equity between women and men in decision-making [14].

II. THEORETICAL FOUNDATION

In this section, we start by addressing broader gender issues in the context of the phenomenon of empowerment and, finally, focusing on women's empowerment.

2.1 Gender Equality

It begins by conceptualizing gender, because it understands that the literature review becomes more didactic. Gender is a term subject to both temporal and geographical significations, thus having consequences for both sexes. The social construction is based on the misconception transmitted as true, in which the feminine

and masculine sexes have unique characteristics, being able to influence in the positions. Gender is a human classification that influences relationships with society and, therefore, is directly linked to social issues [15].

Gender is understood as the set of cultural and social characteristics directed to individuals according to their sex. Soon it is an acquired identity that is learned, changes over time, varies widely among cultures. These are the behaviors, values and attitudes that society defines as belonging to men or women. On the other hand, the gender approach replaces the formulation of problems and solutions, since it involves changes in the positioning and behavior of men and women, in the search for the construction of more fair societies [16].

According to Oliveira, Gaio and Bonacim [11], societies are based on a masculine norm, and this norm can only be questioned when men and women reflect on it, only after that they will be able to formulate proposals for both individual and social relations. The authors state that there will be social change only when men and women are the main actors; however, gender relations are mostly unequal, but a change is possible in this regard. As for the gender issue, improvement solutions will be achieved when there is a common change between both sexes [11].

The educational inequality of women is so visible that they can not grow or be intellectuals. They had classes at home, or they were delivered to convents. It can be seen that until the last century, women were not prepared for public life, and the main objective was to prepare women for religious life or to be a good caretaker of the home [17].

In addressing the issue in the public sphere, Diniz [18] clarifies that, even with the problems women face, they have gained recognition and appreciation. Also, the insertion of women in the labor market has had a great impact on society, due to the fact of changing some cultural and family aspects, bringing significant achievements such as women's rights in relation to voting, reduction of children, levels of schooling equal to men, contraceptive use, among others. But, over time, they began to face double working hours in order to secure their places in society [19].

For Oliveira, Gaio and Bonacim [11], in organizations, successful women attract a lot of attention and are seen with arrogant or humble people. There is much to be done in relation to this dispute between men and women, and the advancement of women in the domination of men's space needs to be more and more urgent, as there must be more awareness of both sexes, in order to achieve a future best. Sousa and Melo [20] add that, with the development of globalization, there are

notable changes in the organizational context, among them, there is more equality in relation to work between men and women in certain areas of activity.

Mota and Souza [6] affirm that, even with the success that women have had in the fight against inequality, there are still many obstacles to overcome so that they can be included in the labor market. In the workplace, the relationships between men and women are still of gender inequality, thus creating a division between them, thereby fortifying the differences in power between them, disqualifying the tasks performed by women. Mota and Souza [6] recall that, since the emergence of humanity, in family relations, women have always been seen as submissive, because, with macho society, a pre-established profile already existed, though she was like someone who was there only to satisfy a man, since in the schools they were educated to be a mother and a wife, with the purpose of marrying and having children and to deal with household chores, since in the home she was seen as a key element for the education of children.

Mota and Souza [6] also clarify that, over time, women gained more of their rights and that, from the nineteenth century through a lot of struggle, the 8th of March was chosen to be an international day because on this day the American women, workers of a textile factory claimed their rights and demanded better conditions of work and salaries compatible with their functions and equal to those of men. Business sectors are noting the evolution of women and are recognizing their talents, abilities and their dynamism towards the economy, and are realizing how necessary it is to insert them into the public sphere. [22]

According to Gontijo and Melo [23], female submission only arose due to the overlapping of masculine power, thus bringing disadvantage to female will. The authors state that, after some educational reforms, women could already enter the classroom, but there was still that separation between the students. But there was still discrimination with women, since they were not entitled to the same content as men, since they were in school to learn household chores or to be teachers.

In organizations, usually the work that is imposed on women, the chore of tasks comes from the top down, and the company's policies, over time, have been drawn up by men within a male dimension and understanding without women's needs and what they seek. For this reason, the empowerment of women presents a competition of powers in the socio-institutional spaces, especially in the home, since man has the dominant power in the relationship. So this means empowerment means a change

in traditional domination in respect to man, where he is seen as the boss. [14]

Finally, according to Alves [22], for women, the path to their independence will only be possible, when they achieve their rights and equality of opportunity within the family and social environment.

2.2 Empowerment

According to Costa [2], the concept of empowerment emerged in the 1970s and is directly linked to the civil rights movements in the United States as a form of self-valorization, especially of the black race. Baquero [1] remarks that this phenomenon had its origins in the Protestant Reformation initiated by Martin Luther in the sixteenth century, when he advocated social justice.

Baquero [24] also clarifies that the term empowerment has the meaning of taking possession of something, assigning power to the individual. When this word is associated with the intransitive verb, the essence is directed to capable individuals, or interested in growing and expanding abilities, with enough effort at self-mastery ends up guaranteeing power, making them empowered.

According to the UN Women [16], empowerment is giving or acquiring power, that is, it is a form of freedom to choose or act and also an extension of power, because it makes the individual to have the power to resolve situations that affect his or her own life. An empowered person has the ability to define their life goals, acquiring competence and knowledge to solve their own problems, find solutions and create conditions for their own well-being, that is, the result of a process.

According to Romano and Antunes [25] the process of empowerment focuses on what is fundamental that is the study of the relations of power that exists in an already defined context. The authors state that this process is analyzed based on two perspectives: the first places individuals as a power center, thus showing the bases of conclusion that social action brings changes to individuals. And the second refers to a continuity in which individuals understand that in order to be competent and creative, they must have power over decision-making with regard to matters of their interest.

In Friedman's view [26], there are three such types of empowerment: as social, political and psychological. In the social sphere, it refers to the access that individuals have, in relation to social interests, being knowledge, information among others. In the political sphere, it refers to the individual's participation in decision making, that is, it is not only linked to voting power, but also in the right of the community to have a voice to speak, when it is a collective matter and has access to the occupation of

managerial positions. In the psychological sphere, empowerment begins at the moment when the individual awakens consciousness regarding autonomy, thus being able to have control, confidence and self-esteem about their safety.

Kleba and Wendausen [27] argue that the literature brings different definitions of the term empowerment which can be used individually or collectively. It is collective when there is a collective and social movement; empowerment is individual when only a person seeks his personal development, according to his interest. Thus the phenomenon is directly linked to authority or power. For Leon [28], empowerment contains fundamental contradictions, namely: in the individual perspective, the phenomenon focuses the individual on self-confers, in the domain of personal control, soon the individual does things only thinking about himself, has as priority the independent subjects, seeks to succeed without help from other people, thus separating the individual from daily life and groups; already the collective focuses on the concern with others and connect to the socio-political context representing a cooperation.

For Lisbon [14], there are three levels of empowerment: individual, group and structural. At the individual level, it would be when the individual can get out of that life to be that caregiver of the children and responsibilities of the house and can pursue their own interests. At the collective level, it would be when everyone will seek the same social interests. At the structural level, it arises when, after individuals achieve results for their interests, the needs arising from collective empowerment emerge.

The companies are seeking knowledge about the word empowerment, because, through this phenomenon, they see it as a form of management allowing the managers' focus and freedom within the company [29]. Resuming Oliveira and Krom [30], empowerment in organizations emerges as an instrument that has certain abilities and has the benefit of making the company a continuous advance and perspective of providing the members with responsibilities and autonomy regarding decision making within the company.

According to Baquero [24], empowerment has the consequences of awakening knowledge and mastery in individuals, thus increasing the individual's capacity to feel influence in the path of life. This capacity, when awakened, interferes in the way strategies are developed, in the resource domain in relation to the resolution of important issues that affect life and outcomes in the family and at work [31].

2.3 Female Empowerment

Female empowerment is a movement that is associated with society as a whole, as non-governmental institutions, and with states that come together to create laws that encourage gender equality.

Rubin [32] believes that this is an activity involving different global dimensions such as: civil society, States, non-governmental organizations, containing the necessary rules for the regulation of Public International Law, seeking the necessary mechanisms to support gender equality. The author also states that, in addition to being a female movement, the phenomenon focuses on both sexes, since it is aimed at society.

Sousa and Melo [20] affirm that care should be taken when it comes to women's empowerment not only in recognition or professional advancement and in their participation in decision making in the company, because female empowerment is much more than that, because these levels are only some forms of power that makes the woman have self-confidence and is strong enough to face some situation whether personal or social. For Lisbon [4], empowering women should improve their self-confidence, their control over decision-making, believing that they are capable of changing their own beliefs and showing that they are capable of breaking down barriers to submission and be alert to their rights.

The concept of female empowerment is a way of showing the competence and overcoming of women in relation to the inequality of power that they find in both private and public spheres [33].

For Lisbon [14], empowering women is a way of learning for men, since it empowers them in a material and psychological sense, thus giving women access to solve the issues that benefit the family, sharing responsibilities. This process of the woman comes to show an understanding of being able to build new paths of collective responsibilities, especially for decision making, and thus can provide well-being at a higher level to them.

In the process of empowering women, they have to face various barriers, whether in the public or family sphere, because over the years man has always been seen as the individual who had the power to decide. The authors also affirm that these barriers encountered during the walk are one of the main challenges of this phenomenon [20].

The empowerment of women thus symbolizes an affront to patriarchal systems, to the autonomy of man and to the preservation of the privileges given to him [24]. For Melo and Lopes [12], the empowerment of women from a gender perspective challenges the barrier that exists between men and women in relation to the

dominant power of men within the family, defies the traditional domination of men by giving women autonomy and security and Your rights. The empowerment of the woman then means the transformation of man's authority over woman, empowering her to decide about her own body, about her sexuality, and the assurance that she can decide on her own life. The recognition of the woman herself as an able agent needs to be done so that changes can be felt in the social context [35].

It should be noted that women, even of middle and upper classes, still go through prejudices when talking about work and studies, that is, at all levels they are seen as an object. However, the World Conferences on Women have played an important role in bringing the problems experienced by women to the public, as they encourage the creation of feminist institutions to promote feminist world growth, opening spaces for the women's empowerment movement, as it contributes to the creation of national and international laws for the protection of women [32].

For Bruschini and Puppini (2004), women, in order to be empowered, reduced their way of looking at life in regard to children. They have reduced the number of children because they are learning to be more economically emancipated, creating sociocultural changes. One of the aspects that made the woman be seen differently before society in relation to household chores is her professional career. For Sousa and Melo [20], the insertion of women in the labor market is increasingly increasing, opening up new horizons related to gender and power in organizations. In this way the phenomenon points to new changes and mechanisms of women's empowerment, which is associated with the achievement of well-being and the recognition of relations with society, as well as represent an affront to the respectable patterns regarding male gender. According to Melo and Lopes [12], from the perspective of women in the organizational space, female empowerment goes to the search for financial and personal emancipation, to achieve this perspective, women have sought specialized academic training, preparing and developing professionally for the labor market in order to meet their own needs.

Deere and Leon [36] argue that the empowerment of women confronts the traditional relationship as regards the family, disempowering a man, from the moment the woman assumes responsibilities that were previously taken by men. In this context, this process causes changes to all family members, as it contributes to certain choices in life, allowing the woman to have a voice in relation to decision making in the home.

The empowerment of women should appear as a form of autonomy, since it is to empower and have the capacity to organize, mobilizing in favor of social change, so this phenomenon can come from fraudulent situations, showing the family differences with regard to the day to day [37].

According to Prá [38], speaking of women's empowerment is talking about power and their relationship within society and their crossing with gender, race and social class, in which power is marked as equality of man and woman resources and advantages. The concept of power, in the social context, involves an authoritarian, oppressive being, as a form of independence or resistance, giving a new direction to power relations on gender relations [14]. In Malhotra's view [31], are (5) the dimensions of the analysis of female empowerment.

Dimensions	Features
Economic	It refers to the woman who has access to employment and control of family financial resources, holds leadership positions and is able to reach high levels.
Partner/ Cultural	It is the woman who has power in relation to her life, freedom and access to social spaces and to change patriarchal norms.
Family / Interpersonal	Refers to the autonomy of women in having access to the decision and making in relation to the affairs of the home, about having children or getting married, among others.
Laws/Politics	In the view of the laws, it seeks to show in women what their rights are, and in politics, it refers to the political system about voting.
Psychological	It covers the improvement of the woman's life, so she can be safer in relation to her own life, the woman has high self-esteem, self-confidence, that is, she is well psychologically.

Figura 1: Dimensions and characteristics of female empowerment

Source: Malhotra [31].

III. METHODOLOGICAL PROCEDURES

As for the methodological framework, the research was classified about the qualitative approach regarding typology, descriptive. About the form of bibliographic and field research. For Triviños [39], a qualitative approach is one that involves direct contact between the researcher and the researched in order to seek a better understanding of the subject to be investigated. According to Cervo, Bervian and da Silva [40], the descriptive

research aims to observe and analyze a fact or even a phenomenon and is well developed in the social sciences.

For this research, twelve women accountants residing in Angola / Luanda were surveyed in the period of July 2018, using as data collection technique the semi-structured interview, carried out and literally transcribed by the researcher. The choice of the counters surveyed was for accessibility.

IV. PRESENTATION AND ANALYSIS OF RESULTS

To ensure interview anonymity, after each interview fragment, the identification of C1 for first, C2 for second and so on is inserted.

4.1 Profile of Interviewees

In the data collected, it was verified that six of the surveyed individuals are between 31 and 40 years of age, the highest number being between 20 and 30 years old, and only 41-50 years old with two interviewees. According to the level of education of the respondents, only the interviewee C10 has a master's degree, the interviewee C2 has a graduate degree, and the other ten have undergraduate degrees. Regarding the marital status, eight of the interviewees are married, three of them are single and only the C5 is divorced. As for children, nine have children, and C4, C6 and C12 do not yet have children. It was found that they had their first work experiences between the ages of 16 and 31.

The accounting area is a vast area and is one of the fields that offers the most opportunities for action. It was observed that C1 currently works in a non-profit entity with the name "Order of Accountants and Experts of Angola", which is the body in which the accountants are registered in Angola, and the same holds the position of accountant. The respondents C2, C5 and C6 already work in accounting organizations. Being an accountant, C5 Accountant and C6 as accounting assistant. The C3 and C4 work in the private sector and work in bank accounts. The C8 and C12 work privately in supermarkets, where C8 holds the position of accounting assistant and C12 as a project analyst. The C7, C9, C10 and C11 work in a public company that is known as one of the best oil companies in the country, occupying the positions of accounting technician, accountant in the area of common and operational costs and the last one as accounts analyst.

Concerning the technical responsibilities, six of them stated that they are responsible for the technical area, five of which are not and only one said that sometimes. It was sought to identify the time performance that the interviewees are in the accounting sector. It was verified that seven of them have a minimum time of performance

that is 0 to 5 years, three of 6 to 10 years and that only two have more than 11 years. Respondents argued that, despite their working time, they are always on the lookout for information to keep up-to-date with the accounting industry. "I always read books and do courses the order of the accountants of Angolans is constantly giving courses of updates." (C2).

With regard to the ones they perform at home, it was verified that two do not perform any domestic activities, six do all the activities, four partially do the activities. "I do not do many household chores because I have not had much time. But from time to time I organize my bedroom, which is my office and sometimes I cook." (C12). It was raised that ten of them have a person specifically to perform household activities, although they have the assistance of husband and children. "My collaborator of the home, my daughter and my husband one time or another." (C1). Two have a son or a mother.

4.2 Occupation Block

According to the choice of profession, five interviewees chose the profession for the encouragement of family members, three of them out of curiosity, the other three of them chose the profession for taste and only one for opportunity. "As I grew up in a family of managers I was influenced, first when I was younger, then when I grew up I learned to like, I did an analysis and I saw that it was one of the professions that launched me fast into the job market" (C4). "In the 2nd company where I worked, I was in the billing area, the accountant provided the service twice a week, I like to always learn new things I asked her to teach, she taught me so I covered her work in the days in which she did not serve in the company [...], before I thought about doing it right when I went to this company I totally changed my thinking I fell in love with accounting" (C2).

Regarding the influence on the choice of profession, five of the interviewees said that their family members influenced their choice (such as parents, siblings, husband and cousins), three of them because of their curiosity about wanting to learn the other three had no influence except their love for numbers, only one had the opportunity to get an exchange and did not have many options. "I myself decided to do accounting because I like numbers." (C3).

About who contributes and continues to contribute to their careers, six of the interviewees affirm that they are their relatives, four of them were themselves and the other two by God and heads of the company. "My parents and my older brother contribute most to my career. My boyfriend also gives me a strength to take courses and we can not stop only in higher education." (C6).

Eleven of them positively evaluate the recognition and encouragement on the part of the family in its professional trajectory, only one of them says that it had no incentive nor recognition on the part of her family in the beginning. "First of all in my family I had no recognition, until when my brother opened his law firm and he invited me to be his accountant. And yes, my family did not believe I had the ability to control a company." (C12). For Landerdahl et al. [21], when the notion of equality and empowerment is familiar in the family context, behavioral changes are remarkable, which are, for women, encouragement and appreciation, thus showing how important family support is, parents, children and husbands who should always be linked to them as partners in order to assist in their growth and enhancement.

The interviewed women were quite sure about the activities they perform in the service from the accounting assistant to the fully-paid accountant, rather than in Angola it is considered as accounting technique having undergraduate. "The activities I currently carry out are: Enter all data in the accounting program (Spring) Ex Posting invoices (foreign and domestic suppliers), Cash, banks (payments)." (C9).

Within the organizational space of the interviewees - physical environment, relationship with co-workers and the boss, in principle all of them said that the environment is good and pleasant. However, following, some of them commented that they had to go over certain situations. "I had an extraordinary opportunity in my life that I always had with Christians, I had a boss at first ... but there was only one thing that ended up coming out, but it's a good environment. I had colleagues who were like that, I'm not going to do it, the person was prejudiced because I was a woman he did not accept, he could not stand to see me there and he gave up." (C5). Within the organizational environment one can already see the increase of female participation, with the qualification endowed with several improvements, and yet the woman still faces attitudes that evidence discrimination, causing some to think that inequality is the measurement parameter intelligence and capacity between the sexes. In order for a woman to have a professional career, access to business and positions must also be allowed, from the lowest to the highest level in the company [44].

Regarding the professional trajectory, eight of them said that the trajectory of the profession was very difficult, three of them said that it was a normal course not so difficult and only the (C6) still does not have formed opinion, since it is beginning now. "It was hard very hard, it was not easy, there was a time of tears, but there was also that I had to get up and said I can, I can. It

was a pula from here, but I did. "(C5). Regarding the trajectory of the professionals, Mota and Souza [6] affirm that women, in order to achieve gains and victories, have experienced challenges and prejudices and this is still visible today. Despite advances and struggles for social equality in the organizational environment, they still face several obstacles in the labor sphere.

Nine of the interviewees said that during the professional trajectory they had and still have salary differences compared to men in the same function-activities. Two of them said they had not lived or experienced such situations, one of them chose not to comment on the subject because it found it delicate. "I had my second job, taught the work to my colleague and he earned more." (C2). "I have a difference, the salary increase here is by wedge, because you are the boss's son or nephew they talk to each other and raise salary, but I have faith that someday everything will improve and there will be improvements. And when I have to earn more, it's because God wants to." (C10). "As for wages, it's a little delicate, because you can not go peeking. It's a question I can not specify." (C7). Difference in wages relative to male colleagues is still visible, according to

Mota and Souza (2013), and this is one of the most striking ways of discriminating women in the organizational context. Brito [41] states that the number of women currently in the labor market does not come from their ancestor, but from the current context called globalization. The author further clarifies that even today in more developed economies, it is notable the various forms of discrimination or inequality such as salary differences, access to educational instruction, the labor market, leadership positions, and household chores.

According to the interviewees in relation to male colleagues in the workplace the relationship is good, however with some indifference, with regard to the number of women in the workplace. "We are a much smaller number, in terms of climate ok, more in the financial area or accounting and management, in an area with more than 30 people have less than 10 women and does not have this equality." (C4). "Very well. There are not so many differences, we only have salary differences, but no professional differences." (C9). In Fig. 2, a summary of the results on access to the profession is presented.

ESCOLHA DA PROFISSÃO	CONTRIBUI NA CARREIRA	INCENTIVO / FAMILIARES	AMBIENTE DE TRABALHO	TRAJETÓRIA PROFISSIONAL	DIFERENÇA SALARIAL	EM RELAÇÃO COLEGAS
<ul style="list-style-type: none"> • 5 Familiares • 3 Curiosidade • 3 Gosto pelos números • 1 bolsa de intercâmbio 	<ul style="list-style-type: none"> • 6 Familiares • 4 Elas mesmas • 2 Deus e chefe da empresa 	<ul style="list-style-type: none"> • 11 tiveram incentivo positivo para a carreira • 1 Não teve no início da carreira 	<ul style="list-style-type: none"> • 9 consideraram bom • 3 entendem que é normal 	<ul style="list-style-type: none"> • 8 Difícil • 3 Meio difícil • 1 Não possui opinião 	<ul style="list-style-type: none"> • 9 Informaram que sim • 2 disseram que não • 1 não possui opinião sobre isso 	<ul style="list-style-type: none"> • Todas indicaram que há uma boa relação

Figura. 2: Synthesis results access to the profession

Source: Search data, 2018.

4.3 Block Autonomia

Regarding the financial autonomy of the interviewees, nine said they were good, but could be better and three said that it is not good. "Today better than before, it is not as good as I wanted, but it tends to improve." (C5). Machado [42] states that, years ago, woman was totally financially dependent on the father or husband. Nowadays, she seeks not only marrying or having children, but also building her own identity as in her way of being or acting, not interfering with what is imposed by society, so woman will seek her financial independence to be able to trace her way.

According to the interviewees seven of them are totally financially independent, and five of them depend

partly on their relatives as parents and husband. "I depend on this case, because I still live with my parents, but in personal terms no longer." (C12).

Regarding professional autonomy to decide on the course of their careers, ten of the interviewees evaluate positively, since woman have to be independent when it comes to her professional life. Two of them are dependent on the bosses to decide. "We have the choice of being where we want, no one can manage our career we can not expect someone to manage it" (C4). Bruschini and Puppini [43] women when the matter is career they do not measure effort, so they are increasingly intellectually instructed. They are also economically more active, more attentive to new family standards, being more accessible

and more capable of managing and planning their career. For Oliveira, Gaio and Bonacim [11], in many of the companies, women are in turn devalued, ignored, and systematically dispense knowledge and perspectives.

Regarding the institution that the accountants work, they evaluate it in a positive way, since they have already been less valued, but in relation to the valuation perspectives as a woman many of them affirm that it is almost null. "Valuation is almost nil, they can even get you into the boss because of the need, it's the kind I need it for, but do not think it's going to rise, in addition. Even the Portuguese, for them, black can not pass for him mainly woman, and in other companies it is not different, and if that happens it is because she has something with

the boss, and never by merit or competence." (C5). The presence of women in the organizational world is now visible. Perhaps this is because there is more appreciation of women in organizations [45].

Four of those surveyed see themselves in five years running their own business, two think of leading their own teams in the company, three say that in crisis, they want to stabilize and see if they can earn a good salary, another two expect to grow in the accounting profession, and one claims to expect health only. "I would like to be further, but looking at the moment that we are in the country the crisis all this thing my expectation is not very big, but if flowing better, better for me." (C8). In Fig. 3, the results of this section are summarized.

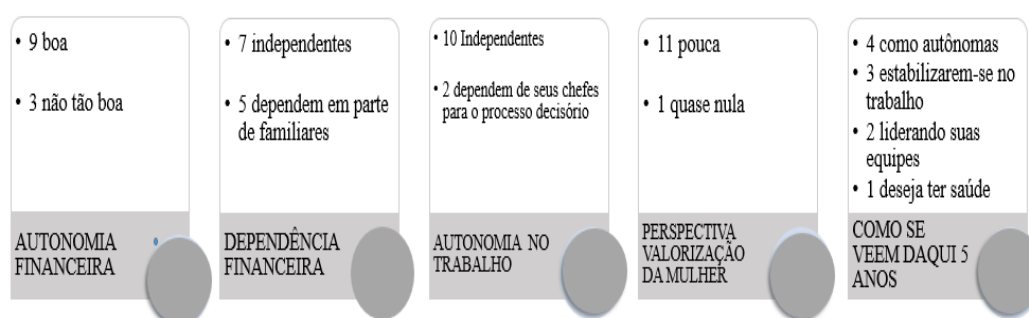


Figura 3: Synthesis results on autonomy

Source: Search data, 2018.

4.4 Block on Accounting Training

Regarding the results of this block, ten interviewees said that with the knowledge acquired in the course of accounting contributed a lot to the exercise of their professional activity, only two disagreed partly claiming some difference between what they learned in school with what they currently work. "It was based on what we apply today, we work with bank accounting, universities focus on business accounting, we had to learn everything from scratch. We only had one semester of bank accounting, bank accounting differed from business accounting. I today do not know how to work with the accounting of a company and I have never worked with business accounting, I have always worked with bank accounting." (C3). Women today have changed their behavior, not to be similar to men, but to compete with equality. In this sense, education has contributed considerably to this behavior change, since they seek adequate qualification to face the labor market [11].

It was perceived that there is a different point of view regarding the main competitive differential of women in relation to men in the area of accounting: five claim to be training, capacity for execution, seven the gender, knowledge, maternity factor, curiosity, autonomy, intelligence. "Autonomy, because we women are very autonomous, we fight because we want and we are always

looking for the best to the company" (C11). "Women are not to leave there, if something is happening they go back already men are more relaxed." (C6). "Curiosity and intelligence, we women are very cautious when it comes to work." (C2). Carneiro [46] affirms that women are seen in the labor market as competent, attentive, with sense of organization and with a lot of discipline.

From a perspective on their participation in the accounting profession, ten accountants claim that it is a positive outlook and that it tends to increase, since women are sufficiently competent enough to occupy prominent positions in organizations. "Angola opened up are already giving more access in women, you can already see women in leadership leading places. I think the perspective of women in the accounting profession is good, with limitations, but it is already notable women managers, business leaders." (C5). "We women are capable and really competent and we can do what men can do." (C6).

For Boniatti et al. [47], the male gender always predominated in the accounting area, but, over the years, the woman was occupying space in this area. One reason is that she always finds it difficult to reconcile her time with work and with the family: children, parents and husbands. This being one of the main obstacles they face,

it creates unfair competition in the labor market. The main results stand out.

- Ten of them believe that the Accounting course contributed greatly to the development of their professional activities
- They claimed as a competitive differential in the accounting profession: training, ability to execute, knowledge, curiosity, autonomy, intelligence make them.
- Ten of them believe that their participation in the accounting profession is positive and are competent to occupy prominent positions.

Figura 4: main results on accounting training

Source: Search data, 2018.

V. CONCLUSION

The feminine empowerment phenomenon for Angolan society is still a somewhat new subject and is in the process of being accepted because of the cultural standards found there. But Angolan women today are already in search of equal power in business. And, in order to achieve this, many go in search of specialized professional training in the area, to enable them to work.

With regard to the main objective of this study, to understand the current context of the accounting professional focusing on the phenomenon of empowerment, it was understood that, although the women object of this study had support from the family, there is still gender inequality there.

Regarding the work environment and the profile of Angolan accountants, the data indicated that their environments are good, but some claim that they have to go through uncomfortable situations in the work dimension. About the respondents' profile, they are in the age range of 25 to 47 years old, eight married, three single and only one single, nine with children and three without children.

With regard to knowing the circumstances that made them choose the profession, it was noticed that many accountants chose the profession by encouragement of relatives, curiosity and tastes by numbers. On the impact of empowerment on accountants, they believe that this phenomenon has brought many positive things, as they are increasingly seeking their independence, both personal and professional, and the pursuit of equality.

The main contributions of this study was to reflect on the phenomenon of female empowerment in the Angolan context, both for the literature and for the researcher who is an accounting student and is Angolan.

The delimitation of the work was due to the number of women interviewed, because some of them were a little afraid of the research, because in Angola this is not very common and also in some companies that I passed many

of them did not feel free to speak because they were in an environment with colleagues. For future work, be sure to enlarge the sample searched and also with professionals from other areas of knowledge.

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Organizational practices in the context of innovation to improve organizational competitiveness under the light of Complexity Theory

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Abstract— The rapid and constant changes in the environment influence individuals and organizations. Under these pressures, organizations need continually to learn how to cope with fierce competition at both global and local level, which represents constant challenges to organizations and those working in them. In this context, the question is: How can organizational practices impact the innovation process to enable organizations to compete more effectively? In order to answer this question, our general objective is to study the organizational practices in the face of innovation concepts aimed at organizational competitiveness (1) to raise the conceptual meanings of innovation that contribute to the organization's competitiveness; (2) to characterize organizational practices in an institutional locus; and to make a confrontation between the meanings of innovation and practices (3). The theoretical basis chosen for this essay lies in Complexity Theory, considering the antagonistic concepts and, at the same time, complementary to the perspective proposed here. The research has a qualitative approach and was elaborated through the method of Content Analysis, aiming to analyze the core of innovation by focusing on organizational practices, observing the dynamic relationship between the organization's many

interdependent levels, assuming that this serves as a lens for understanding the phenomenon under review, how organizational practices can interfere in the process of innovation in organizations intended to improve organizational competitiveness.

Keywords— Organizational Practices, Innovation, Organizational Competitiveness, Complexity Theory.

I. INTRODUCTION

In the nineteenth century, from the Industrial Revolution onwards, organizational practices and structures demanded a change linear technical and paradigmatic formation, due to the economic development and the consequent demand of labour for the industries, nowadays this ingrained form of observing the practices organizational structure is obsolete and precarious, since the highly competitive market requires new models that lead to innovation and constant evolution.

The simplistic view of the world was replaced by another with more complex foundations, where mechanistic thinking through Cartesian science believed that in any complex system the behaviour of the whole could be analyzed through its parts, it was replaced by systemic science where the parts need to be understood

within the context of their totality. Thus, for Teece, Pisano and Shuen (1997) capacities become dynamic, they represent the company's ability to integrate, build and reconfigure internal and external skills to address rapidly changing environments. Therefore, new organizational practices require dynamic capabilities that constitute new and innovative forms of competitive advantage.

In this context, the digital revolution reached a climax with the emergence of the Internet, which created a profound transformation in society. People are now widely connected by systems, which allow virtual interactivity. These changes reach organizational models by fostering rationality in processes at the same time as they allowed large-scale production, resulting in maximization of profit. These occurrences were not enough to satisfy the highly complex market; such internal and external intervention measures require knowledge in a surprising dynamic, which seems to be the main factor in the future generation of wealth, following the new rhythm of organizational learning.

The survey in Schwab (2016) allows us to interpret the new industrial revolution as a continuation of the third revolution driven at the speed of unprecedented discoveries, characterized by their transformational impact on integrated structures of governance. Schwab points out that this revolution empowers billions of people once they are interconnected through mobile devices, in processing, storing and accessing unlimited knowledge. They are operational cognitive models that can be multiplied by the merging technological additives, through artificial or robotic intelligence, by the Internet of Things or by autonomous vehicles, as well as 3D printing, nanotechnology, biotechnology, materials science, energy storage, quantum computing and other forms that will surely emerge at great speed. It is in this scenery that the main challenges facing modern and complex organizations emerge as the ideal vehicles for achieving competitive advantage, to an extent that ensures the survival of business in the market driven by the dynamics of the time. Managers then seek to develop competencies whereby others can be trained in collaborative innovation by which these advantages can be ensured.

Organizational practices are supported by new ideas and concepts which enable businesses, processes or products to innovate. These fundamental assumptions provide the basis for this task and the answer to the following question: How can organizational practices impact the innovation process to enable organizations to compete more effectively? In order to address this question, this study aims to study organizational practices and their relationship with innovation for competitiveness. Its specific objectives are (1) to examine the conceptual meanings of innovation that contribute to the

competitiveness of the organization; (2) to characterize organizational practices in an institutional locus; and (3), to make a confrontation between the meanings of innovation and practices. This task demands the construction of topics and subtopics; after this introduction the paper contains a theoretical-conceptual review, an account of the methodology treatment, the results of the research and a conclusion. This task demands the construction of topics and subtopics; after this introduction the paper contains a theoretical-conceptual review, an account of the methodology treatment, the results of the research and a conclusion.

II. THEORETICAL AND CONCEPTUAL REVISION

The theoretical basis chosen for this essay lies in the Complexity Theory as a way of exploring the concepts of innovation that make it possible to offer an understanding of the perspective of organizational practices that lead to the improvement of organizational competitiveness.

2.1 The complexity of systems

The systemic approach is based on the general theory of systems. The emergence of this new approach has received several denominations such as systemic analysis, systems analysis, systemic approach, structural analysis, functional analysis (Le Moigne, 1990).

This new perspective in the field of administration started from the study of the German biologist Ludwig Von Bertalanffy in the late 1940s but began to have repercussions only in the 1950s when the scientific community sought to intensify greater consistency for studies, thus observing the benefits of each branch of knowledge, began to structure a common theoretical conception, in order to counteract the tendency of fractionation of the sciences in specialties isolated from each other, a new way of observing and understanding the behaviour of the man arises.

For Bertalanffy (2008), a system would be a complex of interacting elements, where the whole is larger than its parts, and its integration cannot be reduced in parts, as that would destroy it. In the context of open systems, for this author, these would be a complex of elements in interaction and in continuous interchange with the environment, forming an activity to reach a goal, operating on inputs (information, energy, matter) and providing outputs (information, energy, matter) processed. For Bertalanffy (2010), a system is a set of mutually connected parts, from which emanate two concepts, namely: (a) purpose, when the units direct an order that always intends a goal and (b) globalism, action that it generates change in one of the units of the system propitiating modifications in all its other units. For the author, a systems approach is

necessary, when aiming to reach a certain goal, and for this, the systems specialist needs to find ways or means to reach it, considering as a choice between possible solutions, those that promise optimization of resources, with maximum efficiency and minimum cost, in a network of tremendously complex interactions. Considering the elements of analysis of systems theory, it is noted that its logic was developed based on the concepts of the biological sciences, so it builds a theorisation based on the prediction, in control and in the intention to maintain a constant equilibrium, being incompatible with the complex nature of the social sciences (Demo, 1989).

Therefore, the concept of open systems presents a more complex analysis of social reality and points to a reorientation of the observer's vision for the diversity, interrelationships and adaptation mechanisms that occur in the system and between it and the environment (Morin, 2000).

For Morin (2006), "complexity is a fabric (complex, which is woven together) of heterogeneous constituents inseparably associated: it places the paradox of the one and the multiple", that is, the complexity paradigm brings together and at the same time, distinguishes the parts. and, in addition, clarifies that they are "... part of phenomena at the same time, complementary, competing and antagonistic, respects the diverse coherences that unite in dialogical and polylogical and, with this, faces the contradiction by several routes" (Morin, 2000, p.387). Bringing the reformulation of the concept of systems, which no longer has a linear cause-effect relationship, starting to consider the reciprocity relationships that are associated with self-organization and the dynamism of the system.

From then on, new concepts emerge that seek to demonstrate the complexity of systems, starting to address principles such as uncertainty, indeterminism, non-linearity, self-organization, emergence, interrelations, coupling, dynamic equilibrium, coevolution, recursion and path dependence (Morin, 2006). These new concepts have brought to the term a greater potentiality to represent the reality of complex phenomena. Non-linear behaviour demands interactions between agents and occurs when a small change is able to fundamentally change the behaviour of the system, and the whole diverges from the sum of its components, which results in self-organization (Anderson 1999). As for the issue of emergency, appear when dynamic interactions of multiple agents follow local rules as opposed to top-down commands (Escobar, 2003).

For Morin (2002, p. 133), in this process of self-organization, organization is "[...] the chain of relations between components or individuals that produces a complex unit or system, endowed with qualities unknown to the components or individuals. " As for the

complementary, competing and antagonistic form, the process of recursion is established "[...] by which an active organization produces the elements and effects that are necessary for its own generation or existence, a circular process by which the product or the ultimate effect becomes the first element and the first cause (Morin, 2002, p. 186). In other words, an organization must be capable of producing itself, of regenerating, in the end, of reorganizing itself permanently, proposing innovative organizational practices for a complex environment.

In this way, "interaction between the parties can lead to the self-organization of the system, without the need for central control. This implies that local interactions can generate behaviours that emerge from the bottom up" (Furtado, 2015, p.22), new behaviours, new organizational practices, new processes, that is, constant innovation. Thus, it is assumed as presupposition for the present study that the interaction between the parts of an organizational system causes collective behaviour to emerge through organizational practices, and this interacts simultaneously with its environment as a way of seeking its self-organization by means of changes in its structure. This collective behaviour is non-linear, that is, disproportionate to its causal factors, and its agents change and adapt in response to feedback in order to interact toward self-organization and the emergence of new behaviour.

2.2 Review of concepts related to innovation

In recent years, innovation has been the focus for many researchers, resulting in a number of research projects that deal with innovation per se, and others which tackle innovative organizations. Thus, the innovation phenomenon, as it is called, is subject to different interpretations within the literature which leads to a multiplicity of theoretical concepts and models.

One of the first relevant studies on innovation was conducted by Joseph Schumpeter, who made his contribution by a study of economic development through technological progress. Schumpeter (1978, translation 1997) links the concept of development to innovation, and shows that what keeps the capitalist engine in motion results from new consumer goods, new production methods, new markets, new sources of raw material, and new forms of organization; thus, it attributes to innovation the role of continuously revolutionizing the economic structure, annulling old habits of consumption by new ones, through a dynamic defined as 'creative destruction'. For Schumpeter, the terms invention and innovation are distinct and at the same time complementary; he states that the term invention relates to the simple fact of creating new technical or organizational artefacts, and innovation comprises the entire process encompassing the invention

and its effective incorporation into the economic system, which it then transforms.

In this context, Schumpeter (1997) argues that transformative innovations cannot be predicted ex-ante, but when they are set in motion in the system itself, they can produce changes, which are different from those occurring on a day-to-day basis, leading to a break in the equilibrium achieved in a circular flow. For the author, organizations may be influenced by the market, but they must anticipate change by altering the flow and persuading consumers to want new things, or things that differ in one aspect or another from those they were in the habit of using, thus breaking the balance of the circular flow.

The resources needed to make the new combinations feasible, according to Schumpeter (1997), are available in society, being employed in the activities that make up the circular flow. They depend on innovations, waiting for new forms of combination to be created that will dislodge them from the places where they were employed or to allocate them to new activities to be produced in the future; these interacting activities are what Schumpeter terms economic development. This process of innovation encompasses the following five possibilities: I - Introduction of a new product (something people are not familiar with) or a new quality of a good; II - Introduction of a new method of production, that is, something not experienced in the activity itself, which in no way needs to be based on a new scientific discovery, but results in a new way of commercially managing a commodity; III - Opening of a new market, that is, one that the product has not yet entered, whether or not that market already existed; IV- Obtaining a new source of resources, again whether or not this source already existed or had to be created; V) Establishment of a new organizational structure, such as a new position or fragmentation of a monopoly, a new method or a new process.

To this Schumpeterian scenario where competition is based on innovation, on the contest between price and performance, and on the creative destruction of skills possessed by companies, Teece, Pisano and Schuen (1997) bring the concept of dynamic capabilities as the capacity of the company to integrate, build and reconfigure internal and external competencies in a rapid response to changes in competitive environments through which the level of success and failure of companies can be explained. For Teece, Pisano and Schuen (1997), dynamic capabilities emphasize the development of managerial skills and combinations of organizational, functional and technological skills, difficult to imitate, integrated and grounded in research in areas such as Research & development (R & D) management, product and process development, technology transfer, intellectual property, production, human resources and organizational learning.

With this approach, innovation can be seen as a dynamic capacity of the organization.

Innovation processes, as evidenced by Nelson and Winter (1982), can be viewed as broader evolutionary processes whereby firms have improved and transformed their products, processes, and market approaches individually or in different combinations into a continuous learning process. The definition adopted by Lam (2005) for innovation is similarly a process of learning and creating knowledge, in which new problems are defined and, consequently, new knowledge is developed to solve them. In terms of organizational innovation, Lam (2005) clarifies that it responds to the idea of creative destruction, when social rules are routinely destroyed although their stability was a source of meaning, in order to create new ways of thinking, new modes that replace the familiar ones.

The Organization for Economic Cooperation and Development (OECD), seeking to standardize the concept of innovation, defines innovation as the implementation of a new product (a good or service) or a considerably improved product or process, or a new marketing method, or a new organizational method in business practices, workplace organization or external relations. In this definition it presents four main areas of innovation: in product, process, the organization and marketing, as follows: (a) Product Innovation is the insertion of a new or significantly improved good or service; (b) Process Innovation is the implementation of a new or significant better form of production or method of delivery; (c) Organizational Innovation is the implementation of a new organizational method in business practices, work environment or external relations; and (d) Marketing Innovation is a new market method involving significant changes in the design or packaging of products. As part of its definition, the OECD states that all innovations must contain some degree of novelty, something new to the company, new to the market or new to the world.

Finally, in Karlsson and Tavassoli (2016), innovations are presented as the result of new combinations of inputs in the form of innovation resources, ideas, information, knowledge and/or technologies, which are variables that are internally generated in resource saving and R&D insofar as they touch organizational innovation, elucidate authors who are concerned with the knowledge of land surveying, practical databases, lessons learned from experience and other tactical resources, the introduction of training programs for developers and employees or the initiation of supplier or customer development programs. Thus, for these authors, organizational innovations are related to all processes of organizational change, procedures, systems, etc., and promote teamwork,

information exchange, coordination, collaboration, learning and innovation.

2.3. Brief context about organizational practices

The term practice has been gaining ground in academic debates, especially in approaches to organizational strategy, which seek to reduce the impacts of constant changes by extending knowledge and to encourage organizational competitiveness in the globalized market. A study in Bedani and Veiga (2015) exposes the epistemological deficiencies observed in the national and international literature with regard to organizational practices, observing that this construct needs epistemic and methodological deepening.

Jarzabkowski, Balogun and Seidl (2007) clarify the difference between praxis and practice. According to these authors, praxis means the interconnection between the actions of individuals or groups and institutions, which may or may not be dispersed, that is, they involve different actors in a social, political or economically established context and have a significant impact on the direction and survival of the organization. As far as practice is concerned, the authors elucidate that it is intrinsically linked to doing, since it provides the behavioral, cognitive, procedural, discursive and physical resources through which multiple actors are able to interact in the social performance of collective activities, and the way in which they are used routinely determine the patterns that reveal how the activity is constructed.

Organizational practices, in Kostova's (1999) view, evolve over time, influenced by organizational history, people, interests, and actions that have been institutionalized by organizations. Thus, for Kostova, the organizational practices are related to the shared knowledge and competencies of the organization, and can be accepted and approved by its members, because they are perceived as the correct way to carry out certain tasks. With this in mind, Kostova (1999) considers that the practices are constituted by two distinct elements: (1) a set of written or tacit guidelines showing the way that the organizational functions should be coordinated; (2) cognitive elements (values and beliefs) that establish how to understand and interpret such guidelines.

From this perspective, Bedani and Veiga (2015) clarify that practices are moderately independent of organizational values, because they are more flexible and changeable, and different from organizational beliefs and values. Hence they can fit into the internal control systems and the pressures that arise from an organization's external environment. Thus, two organizations with similar cultures or values can produce completely divergent organizational practices. Within this approach, Bedani and Veiga (2015) explain that practices represent fundamentally a set of tacit items of knowledge, which makes it difficult to

communicate them explicitly to the members of the organization. Therefore, the learning of the practices depends on the efforts of the individuals to carry out the tasks and the participation of the group in solving the organizational problems.

For Le Clus (2011), the workplace and co-workers are crucial in supporting, valuing and producing learning opportunities and therefore learners have to be updated and have their own work practices, permanent work programs and good performance, to sustain the organization's competitive advantage. Le Clus reports that learning can be implanted as an integral part of social practice, in which the work environment gives the members of the organization the chance to acquire knowledge that connects to the genuine and efficient practice. Thus, according to the author, non-local learning can be divided into two forms: (1) formal learning that is planned and organized by the organization in an effort to increase income without work; and (2) informal learning that is unintentional or unplanned and results from other activities, including observation, repetition, social interaction, and problem solving.

In support of the above approach to learning practices, Teece, Pisano and Schuen (1997) clarify that learning is a process whereby repetition and experimentation allow tasks to be performed better and faster. In such conditions, they believe that learning involves not only organizational but also individual ability. Learning requires common communication codes and coordinated search procedures. These authors explain that the organizational knowledge generated by the learning activity consists of new activity patterns and practices, or a new organizational logic.

Thus, in a scenario of permanent change and high competitiveness, Bedani and Veiga (2015) believe that new organizational practices can emerge which emphasize speed, flexibility and innovation, such as employee alliances, the outsourcing of activities considered non-strategic, fragmentation of business units, reduction of organizational boundaries, flexible working groups and the temporary hiring of staff.

2.4. Concept of innovation with reference to organizational practices

Global market scenarios indicate that innovations determine the improvement of performance and, consequently, the increase of organizational competitiveness. For Teece, Pisano and Schuen (1997), the competitive advantage of companies lies in three aspects: (a) in managerial and organizational processes, that is, how the company does things, or what can be referred to as its routines, or patterns of current practice and learning; (b) shaped by the position of its specific assets, i.e., the specific technologies that the company possesses, its patent and intellectual property records, complementary

assets, customer base and external relations with suppliers and other complementary companies; and (c) the paths and options available to these assets, which are the strategic alternatives available to the company, such as the paths already taken by the company that allow it to direct its actions.

For the OECD (2005), an organizational firm can be seen as an example of one type of organization in business enterprises, with the power to innovate by organizing local work and its external relations. This type of innovation aims at improving the performance of organizations by reducing labor costs, providing workplace satisfaction and improving labor productivity, gaining access to non-tradable assets (since external knowledge is not coded), or the cost of supplies. Technological innovations in product and process (TPP) are defined by the OECD (2005) as a process of implementing products and processes requiring new technological knowledge and new technology. Because it is a process innovation TPP innovation when implemented in a market can be seen as a form of product innovation if it is used in a production process.

Finally, to understand the behavior of innovation in companies, Karlsson and Tavassoli (2016) record the need for practices such as the search for different sources of information and knowledge to create innovation and complementarities, together with exchanges between them. For these two writers the influence of previous information and knowledge resources of the companies should be recognized, with the external networks and the capacity to use information and knowledge about the various activities. They conclude that the ability to obtain external sources probably depends on internal R & D being carried out continuously and on the internal absorption capacity

being sufficiently high. They also emphasize that larger firms generally have a greater internal pool of innovation inputs, more links with external sources, greater financial resources, and greater opportunity to pool risks for a number of innovation projects. Thus, they infer that larger companies are more inclined to innovate than smaller companies' human uneasiness in the virtuous circle of transcendental existentialism in itself, situated on the agenda of discovering the concreteness of being and existence, which will bring about the incorporation of a new truth verified throughout the context.

III. METHODOLOGY

This essay is elaborated through the Content Analysis Method whereby, according to Bardin (2011), the analysis of content can be defined as a cluster of communication analysis techniques with the objective of revealing, through systematic and objective description procedures of the contents of messages, indicators that allow the inference of knowledge about the conditions of production and the reception of these messages. The method requires categories related to the search object.

The systematic diagram of the application of the content analysis method (Fig.1) was divided into three stages (pre-analysis, material exploration and the treatment of results and interpretation), so as to compare the meanings of innovation in the context of the organizational practices, based on the documents used to generate productive indications for the inference process and contributing to the interpretations to reflect the validated results, followed by a specification of the items used with a description of each the diagrammed elements.

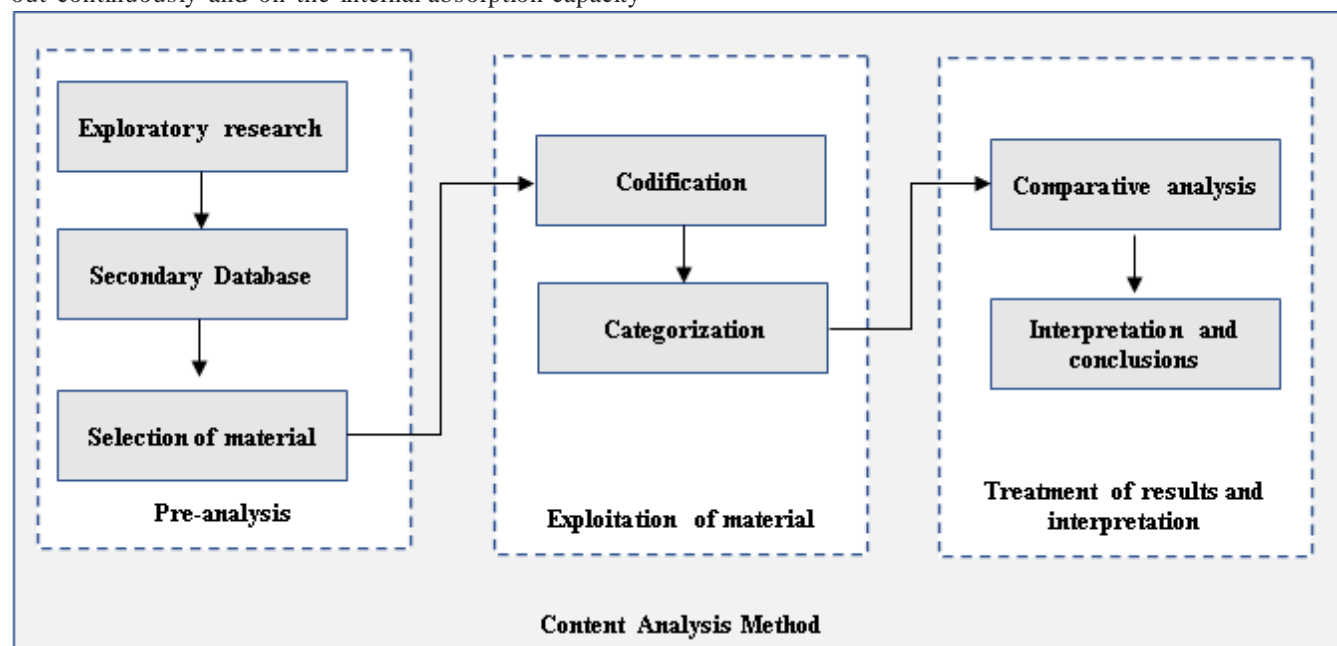


Fig.1: Diagram of the Content Analysis method considered in this research

Source: Prepared by the authors on the basis of Bardin (2011).

Table.1: Specifications for the Diagram of the method of analysis considered in this research.

Elements	Descriptive
Content analysis	Set of message content decomposition techniques for the reconstruction of meanings.
Pre-analysis	A reference to the organization of the material to be investigated. Such structuring allows the analyst to conduct the successive analysis operations.
Exploratory research	Preparatory study of the main objective of the research, in order to allow greater clarity and precision.
Secondary Database	Source of findings on the theoretical reference of the discourses related to innovation and organizational practices.
Selection of material	Step of choosing the documents that will be used for the elaboration and analysis of the content
Exploitation of material	Step for construction of cut-outs of the texts in units of registers; definition of classification and aggregation of information into categories.
Codification	Process for marking the analysis units, with signs or symbols that allow their subsequent grouping (in categories or subcategories).
Categorization	Process of systematizing raw data and allocating it to categories or subcategories, for further discussion of relevant characteristics.
Treatment of results and interpretation	Capturing the evident and potential content of all the collected material.
Comparative analysis	overlapping of the various categories in each analysis, highlighting the aspects considered similar and those understood as different
Interpretation and conclusions	Procedures that use the results for interpretation and inferences to elaborate the conclusion of the research

Source: Prepared by the authors.

For Bardin (2011), when using the method one must create categories related to the research object, complementing that the logical deductions or inferences obtained from the categories are responsible for identifying the relevant questions contained in the content of the messages. In the material exploration stage, two phases were performed: the first one refers to the coding process in which the most relevant aspects in the analyzed literature were selected; and the second phase, the categorization process, where the selected data were

divided into categories and subcategories in order to compare the meanings of innovation in the context of organizational practices, presented in Table 2.

As a result, the productive indications for the third stage (Treatment of results and interpretation) were generated, from the identification of the analytical categories, the inference procedure was carried out, in order to contribute to the interpretation process, for the subsequent description of each diagrammed element and confronted, reflecting the results.

Table.2: Specification of analysis categories and subcategories

Category (innovation)	Subcategories	Source
Breaking the balance	Transformation	Nelson e Winter (1982); Schumpeter (1997); Teece, Pisano and Schuen (1997);
	Different combinations	
Innovative Capacity	Continuous learning	Nelson and Winter (1982); Karlsson and Tavassoli (2016)
	Development of new ideas	
Category (Organizational practices)	Subcategories	Source
Guidelines	Determine patterns	Kostova's (1999); Jarzabkowski; Balogun; Seidl (2007); Le Clus (2011);
Behavioral resources	Cognitive elements	Kostova's (1999); Jarzabkowski, Balogun and Seidl (2007); Bedani e Veiga (2015)
Shared knowledge	Learning	Teece, Pisano and Schuen (1997); Bedani e Veiga (2015); Le Clus (2011)

Source: Prepared by the authors.

IV. RESULT OF THE STUDY OF INNOVATION IN THE CONTEXT OF ORGANIZATIONAL PRACTICES

This section presents the results of the study, after the analysis of content in accordance with the proposed objectives. The section deals with three topics: (1) a survey of the conceptual meanings of innovation that contribute to the competitiveness of the organization; (2) a list of characterization of organizational practices at an institutional locus; and (3) a confrontation between the meanings of innovation and a firm's practices under the

complexity theory approach in order to provide the required study.

4.1 Survey of the conceptual meanings of innovation that contribute to the competitiveness of the organization

Innovation becomes an indispensable condition for the survival of organizations in a highly competitive world. Table 3 and the fig.2 presents the categorization of the content and main contributions of innovation to organizational competitiveness, based on the concepts discussed in this essay.

Table.3- Innovation categories and subcategories.

Category	Subcategories	Contribution
1. Breaking the balance	1.1 Transformation 1.2 Different combinations	- New goods or services - New organizational methods - New markets - New features - New forms of organization
2. Innovative Capacity	2.1 Continuous learning 2.2 Development of new ideas.	- New organizational routines - New technologies - New skills

Source: Elaborated by the authors from the research data.

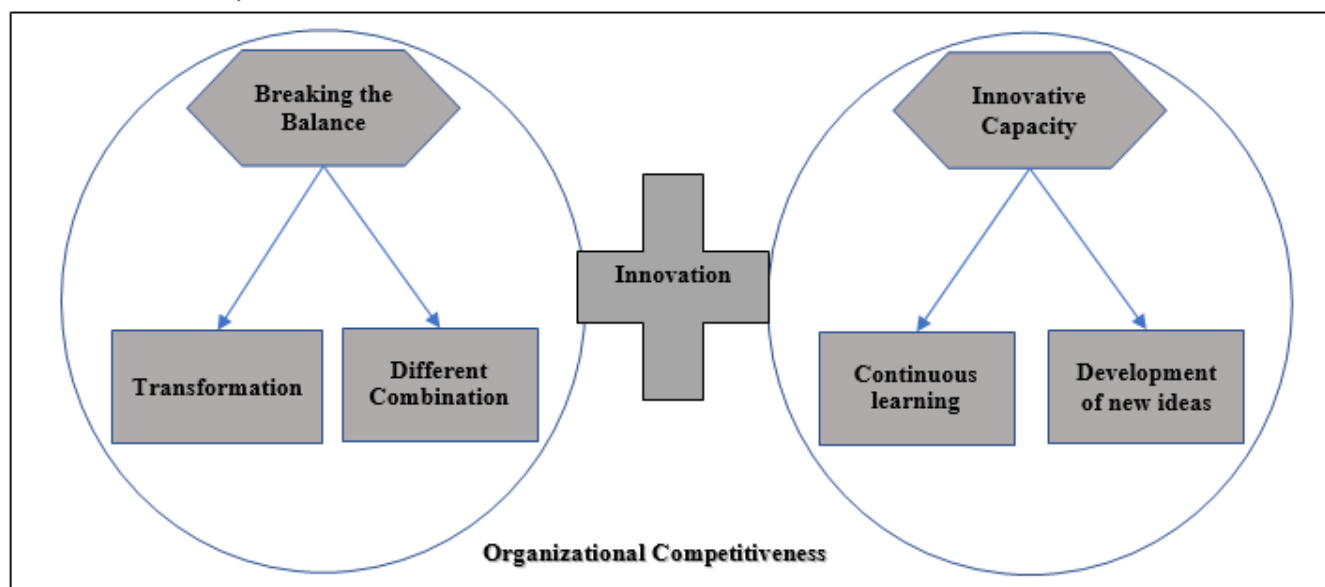


Fig.2: Diagram of the Categories of innovation that contribute to organizational competitiveness

Source: Prepared by the authors

The breakthrough categories of balance and innovative capacity are related to the decision-making process that precedes organizational change, which allows the competitiveness in the market to be included in the deliberations. The category of innovative capability is related to innovation as made up of a series of gradual improvements in existing methods, products, services, or processes in the organization which are intended to implement innovations focused on development efficiency, productivity and competitive differentiation. With regard to the breaking the balance category, they are actions that

modify the status quo and lead to innovation in the form of a new product, service, process or strategy with significant impact, completely replacing existing technologies and methods. Organizational competitiveness demands speed and flexibility, with an intention to reduce development time, seeking quality and the satisfaction of its consumer market – this is the great challenge of innovation for organizations. Thus, these categories through the transformation, combination and development of ideas, make possible the practice of continuous learning and the

generation of innovation in the organizational environment.

4.2 Characterization of organizational practices in an institutional locus

In an economy based on information and knowledge, where people are increasingly recognized as essential

elements in the organization, we need to look for practices that help these people learn, unlearn and learn continuously. Table 4 and the fig. 3 presents the categorization and main characteristics of organizational practices, based on the concepts discussed in this essay.

Table 4: Organizational practices categories

Category	Subcategories	Feature
Guidelines	<i>Determine patterns</i>	<i>Organizational competence that establishes the direction of actions</i>
Behavioral resources	<i>Cognitive elements</i>	<i>They suffer internal and external influence; are flexible and changeable; they comprise the tacit knowledge, mental activities, emotional states and motivations of a set of individuals</i>
Shared knowledge	<i>Learning</i>	<i>It allows interaction, is collectively active in activities such as observation, repetition, social interaction and problem solving.</i>

Source: Elaborated by the authors from the research data.

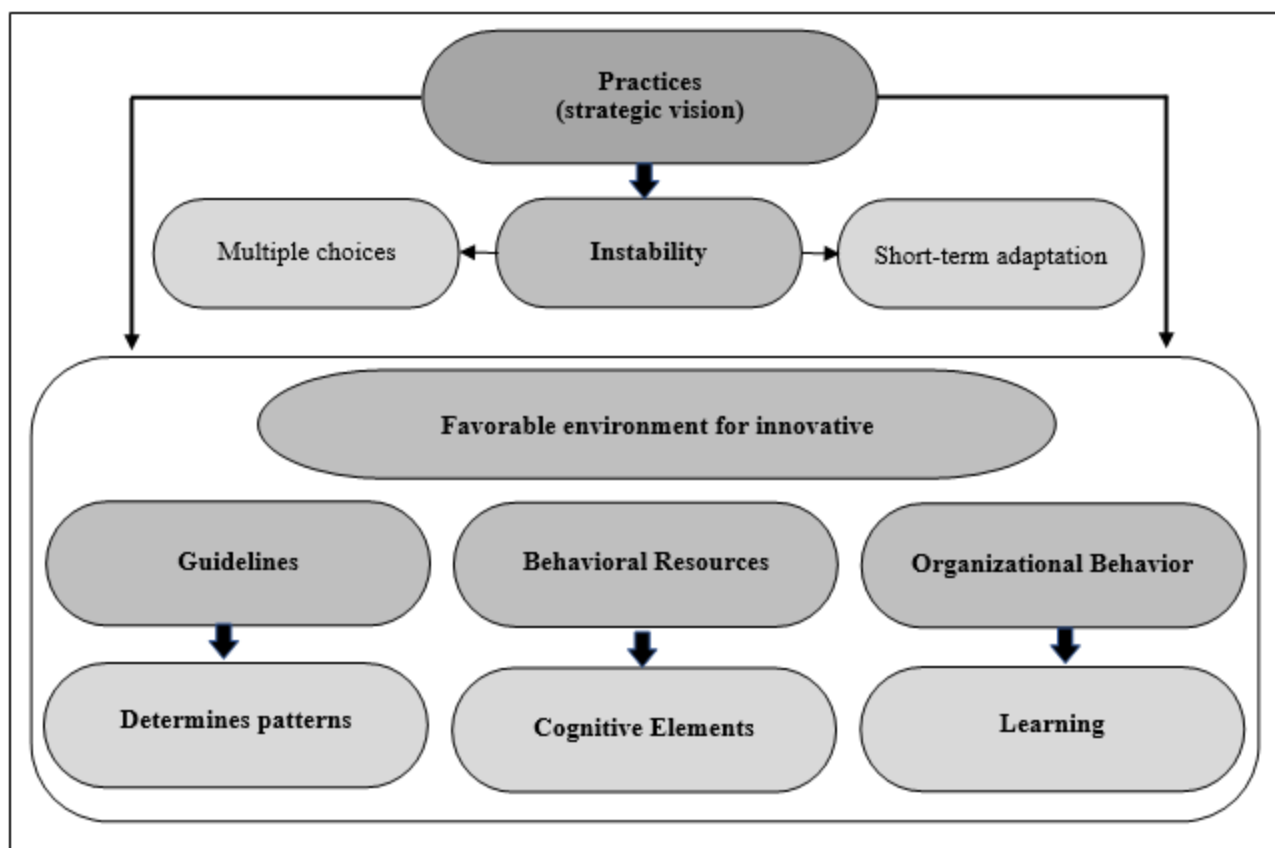


Fig. 3: Diagram of the Categories of innovation that contribute to organizational competitiveness

Source: Prepared by the authors

It is observed in this context that the practice is a matter of survival for the companies, because it allows the formation of an environment that favours the creation of new solutions to meet the needs of the organization and the market. Thus, it is not only a question of implementing practices, but also of connecting them to a strategic vision where knowledge and other behavioral resources are at the centre of decision-making.

As a way of contextualizing organizational practices, one can illustrate the ways of communicating, managing people and processes, controlling, monitoring, socializing, developing processes and strategies, that is, the manner of any activity developed by human beings that leads routines awaiting development in the organization. These organizational practices can reduce operational costs, improve productivity, and prevent quality problems.

In the case of more traditional businesses, the organizational culture must be transformed through the establishment of practices that encourage collaboration, safeguarding, sharing, internalization, retention and the creation of new knowledge in a strategic, engendered and measurable way.

4.3 Confrontation between the meanings of innovation and organizational practices under the focus of complexity theory

Organizational practices widely used in the recent past are no longer effective in complex systems, they become unpredictable and irregular. Organizations in this new environment need to be able to cope with turbulence, learning and relearning constantly, in order to allow their evolution, that is, to create an adaptive system capable of responding to or changing each new information that it receives from the environment. And the best way to adapt is through the behavioral resources inherent to their agents of transformation, that is, the individual adopts a behavior

that changes as it evolves and interacts with the environment. Organizations seek to adapt to changes in the external environment in search of stability, that is, return to balance. This process, represented by the interrelation and reciprocity between the parties, lead to the decisions and actions that lead to self-organization through the dynamism of the environment.

From the concepts presented above, it is possible to visualize the existing harmonization between the meaning of innovation and the organizational practices, represented in Fig. 4. This time, the concepts and characteristics that are presented allow us to relate and assess the relationship between innovation and organizational practices.

In this context, the Complexity Theory allows analyzing the organizational practices and the relation of their various functions, it allows to conceive how the processes of external pressure break the internal balance and direct to the processes of self-organization which allows the evolution and the organizational innovation.

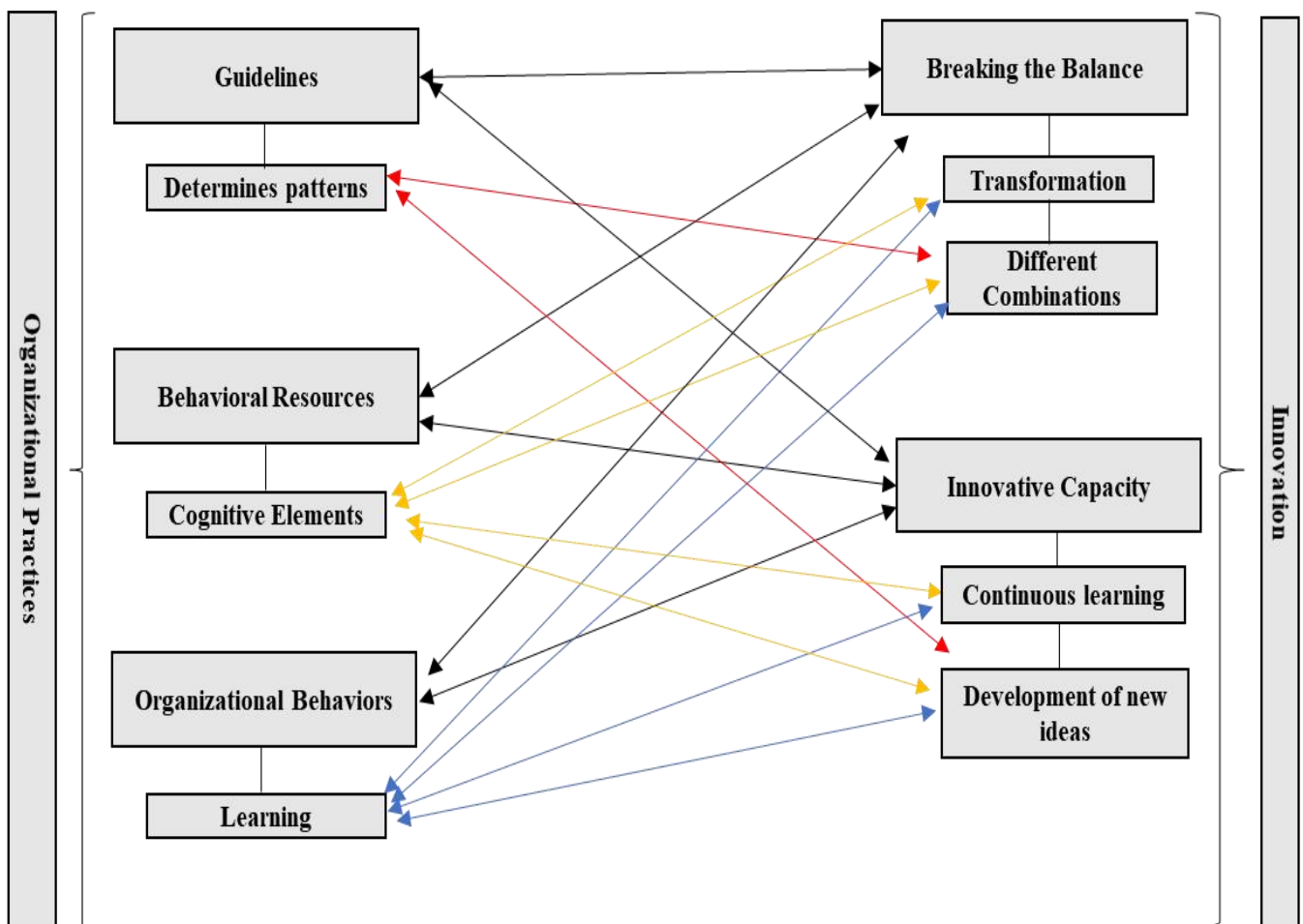




Fig. 4: Conceptual model of the Confrontation of innovation meanings with organizational practices

Source: Elaborated by the authors from research data.

Table 5 - Descriptive of the conceptual model of the confrontation of innovation meanings with organizational practices

Element	Descriptive
1 Organizational Practices	Behavioural, cognitive, procedural, discursive and physical resources that determine the patterns which allow us to understand how the activity is constructed.
1.1. Guidelines	Precepts which establish the direction of actions, process standards and procedures.
1.1.1 Determines patterns	It indicates the direction of actions, elaboration and improvement of organizational activities that are interrelated, allowing the generation of new ideas, continuous learning and new combinations in the organization.
1.2 Behavioral Resources	Formed by cognitive elements that undergo influence and in turn influence the processes of innovation, thus necessarily being flexible and changeable.
1.2.1 Cognitive Elements	Set of tacit items of knowledge (mental activities, emotional states and motivations) that make possible the exchange of information and the generation of knowledge.
1.3 Organizational Behaviors	Change the decision-making process as a way to establish self-organization, through communication and creativity.
1.3.1 Learning	Socialization of information in formal or informal communication processes among members of the organization, that is, process by which members acquire knowledge, connect theory to practice.
2. Innovation	Implementation of something new (product, service, process, methods).
2.1. Breaking the Balance	The effect of actions that change the status quo and lead to innovation in a product, service, process or strategy with significant impact, completely replacing existing technologies and methods.
2.1.1. Transformation	Ability to reduce environmental pressure through actions that address significant organizational changes.
2.1.2. Different Combinations	Combinations of organizational, functional and technological skills, integrated and based on research, product development, processes, technology, production, human resources and organizational learning.
2.2. Innovative Capacity	The ability to integrate, build and reconfigure internal and external competencies so as to respond rapidly to changes in the competitive environment.
2.2.1 Continuous learning	Something which results in a series of gradual improvements in existing products, services, processes or methods in the organization.
2.2.2. Development of new ideas	Patterns of internal and external interaction and organization, and the ability to mobilize and promote interactions between individuals and explicit tacit knowledge.
	Interconnection between categories of organizational practice (guidelines and behavioural resources) and categories of innovation (breaking the balance and innovative capacity).
	Interconnection of the subcategory of organizational practices determining patterns with their respective subcategories of innovation, different combinations; information sharing and knowledge creation.
	Interconnection between the subcategory of organizational practices /cognitive elements and all subcategories of innovation.
	Interconnection between the subcategory of organizational learning practices and all subcategories of innovation.

Source: Elaborated by the authors from research data.

The breakup of balance is the moment in which the organization realizes that the activities developed no longer produce positive effects, this is due to the set of interpretations and interactions of the actors involved in the process, allowing to generate new ideas through the establishment of new organizational guidelines, that is, to establish new strategies capable of directing the company to innovative actions, this process is a continuous learning that allows the self-organization. Organizational behavior

is based on learning, where routines and operational processes go through combinations, both in terms of organizational structure of the firm and structural characteristics of the market, creating a dynamic of transformation, through the exchange of information between the members of the firm and the market. In addition, it is inferred that there is a correspondence between the innovation process and organizational practices, since the organization is subjected to external

and internal pressures, leads to the improvement of its practices and, consequently, directs the company towards innovation. In this way, organizational practices that encompass the generation and / or adoption of new ideas, techniques, procedures and work structures, leading to a better management of the technical and social system, which increases the efficiency and effectiveness of the organizational process, creating a capacity innovative way to achieve organizational competitiveness.

V. CONCLUSION

In outlining the proposal of this essay, how organizational practices can influence the innovation process and allow a company to have competitive capacity, the objective is that the presented results can serve as reflection for a new perspective of analysis based on complexity theory, considering that the organizational practices can suffer various interferences and adapt to the continuous changes of the market, while the interactions can generate behaviors that emerge from the bottom up and allow the structuring of new directions that propitiate the development of organizational innovations, since the priority is to remain competitive in order to survive in the market.

Organizational practices can suffer various interferences and adapt to changes, both internal and external, which allows to generate a new system capable of changing the routines of the company and, consequently, create a new organizational culture that inspires the search for innovation. This process is stimulated by new guidelines for continuous learning and a constant search for new ideas, which changes the organizational behavioral pattern for practices aimed at improving organizational competitiveness. Thus, it is fundamental that the culture and the organizational climate are favorable to the search for innovation, and that the agents of the organizational practices are the differential for the competitiveness, therefore, the engine that drives the innovation machine and guarantees the competitive differential of the company.

Finally, it is believed that the answer to the question of research is achieved by confronting the meanings of innovation with organizational practices, inferring that, empirically, they are concepts influenced by interdependent actions taken between them, and are in continuous process of improvement. In this way, organizational guidelines are geared towards large-scale, effective and feasible solutions, and the tools and processes that enable the coordinated action of agents must be available in abundance, allowing innovation to be part of the organizational culture. This study may attract the interest of academia and other academics in the area

of organizational strategy and management through a new focus on organizational practices as a tool for innovation.

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Systematic Review of Current Medical Literature on the Impact of Oral Health on Quality of Life

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Abstract— Much has been studied about the impact of oral health on quality of life. The literature is vast on this subject and many are the results of the most varied studies. This study aims to systematically review the current medical literature on the impact of oral health on quality of life. A scan was carried out in the main portals of indexation and the articles with the greatest impact and relevance factor were selected for this study. Although there are a large number of articles regarding the impact of oral cavity on quality of life, there are still many divergent results, mainly in patients with edentulous users of total prosthesis.

Keywords— Oral Health, Quality of life, WHO.

I. INTRODUCTION

Quality of life (QoL) indicates the level of the basic and supplementary conditions of the human being. These conditions range from physical, mental, psychological and emotional well-being, social relationships such as family and friends, as well as health, education and other parameters that affect human life. It is not a new concept, but its importance has grown. The World Health Organization (WHO) in 1948 defined health not only as the absence of disease or infirmity but also the presence of physical, mental and social well-being. Recently, the use of quality of life as a necessary concept in the practice of health care and research has been reinforced (MINAYO; HARTZ, BUSS, 2000)

To directly measure the health of individuals, structured and simplified instruments have been developed and tested, capable of recognizing the states of "complete physical, mental and social well-being" of the subjects. Quality of life is an important measure of health impact and the interest in measuring it is relatively recent, both in health care practices and public policies, in the fields of disease prevention and health promotion (SEIDL and Zannon 2004)

Several instruments have been proposed, managed by interviewers or self-administered. The instruments of measurement of quality of life can be divided into two groups: generic and specific (CAMPOS; OLIVEIRA; RODRIGUES NETO, 2014).

The generic instruments are used in the evaluation of the QoL of the population in general. In the field of application, population-based questionnaires are used without specifying diseases, being more appropriate to epidemiological studies, planning and evaluation of the health system. The most commonly used in the world are Sickness Impact Profile (SIP), Nottingham Health Profile (NHP), McMaster Health Index Questionnaire (MHIQ), Rand Health Insurance Study (Rand HIS), The Medical Outcomes Study 36-Item Short Form Health Survey (SF-36), World Health Organization Quality of Life Assessment (WHOQOL-100), among others (PATRICK; DEYO, 1989).

The specific instruments are capable of evaluating, individually and specifically, certain aspects of QoL, providing greater capacity to detect improvement or worsen the aspect under study. Its main characteristic is the sensitivity of measuring the changes, due to the natural history or after a certain intervention. They may be specific to a particular population, disease, or to a particular situation. (KATZ et al., 1992)

OHIP is a specific instrument for measuring the impact of oral health on quality of life. This questionnaire has a summarized Brazilian version called OHIP 14Br, elaborated by Jacobovitz et al. (2003).

II. SYSTEMATIC REVIEW

The review on the masticatory function of edentulous patients rehabilitated with complete dentures with maxillomandibular mucosupores has been very much reported in the current medical literature. Poor masticatory function results in the swallowing of large

deviations in food or changes in diet, resulting in foods that are more difficult to chew. In addition, a difficulty in destroying psychosocial factors that negatively affect the quality of life (OLIVEIRA et al., 2007).

Waad et al (2003), in their article, carried out a randomized clinical trial to evaluate the quality of life and satisfaction of users of conventional total prosthesis and total prosthesis retained by two implants. Edentulous adults, aged 35-65 years, were randomly divided into two groups that received a conventional mandibular prosthesis ($n = 48$) or an overdenture supported by two osseointegrated implants with a connection bar ($n = 54$). All results in their general enjoyment and other characteristics, with their original units and their comfort, in visual analogue scale, for well being with prostheses. Health-related quality of life was also assessed before and after treatment. Late regression analysis (GP = general mean) was significant in the non-conventional group overdenture group ($P = 0.0001$). Age, sex, marital status and health status were scored as general assessment associates. In addition, the implant group presented significantly higher evaluations in the thirteen comfort lapses (comfort, stability and ease of chewing). The quality of life was not higher in the implant-retained implant user group.

A longitudinal clinical trial involving 103 individuals was conducted to evaluate the impact of oral implant therapy on the psychosocial well-being of individuals with dental prosthesis problems. There were four experimental groups: (1) a group whose individuals were edentulous in an arch and received implants to retain an oral prosthesis (GI); (2) individuals edentulous in an arch and received conventional prostheses (CDG1); (3) edentulous individuals requesting replacement of their prosthesis with conventional prostheses (CDG2); (4) toothed individuals requiring routine treatment and included for comparison. Data were collected in each pre and post-treatment group, using specific oral and oral health measures (OHIP) and generic (SF36). Individuals in the GI, CDG1 and CDG2 also completed an enthusiasm scale with the prosthesis. After treatment, subjects who received implant prostheses (GI) reported a significant improvement in well-being and health-related quality of life, as well as participants who requested and received conventional prostheses (CDG2). Individuals who requested implants but received conventional prostheses (CDG1) reported little improvement in prosthesis satisfaction and only a modest improvement in their quality of life. None of the individuals who used dental prostheses reported health-related quality of life as good as teeth dentin (ALLEN; MCMILLAN, 2003).

Zani et al (2009) compared the satisfaction of edentulous patients who had been rehabilitated with embedded prostheses on implants and fixed prostheses in the

mandible and evaluated the technical aspects of prostheses in relation to patient satisfaction. This is a cross-sectional study involving 30 patients, 15 of whom were rehabilitated with implants embedded on implants and 15 treated with fixed prostheses. Patients answered the OHIP-14Br questionnaire, validated for Brazilian Portuguese, to analyze satisfaction. In addition, the patients underwent clinical examination to estimate the condition of their prostheses. Statistical analysis, using the Mann-Whitney U test, did not reveal significant differences in pleasure between patients with embedded prostheses on implants and those with fixed prostheses. It was concluded that the two types of prostheses were perceived as equally satisfactory by edentulous patients and that the condition of the prostheses did not influence individual satisfaction in terms of rehabilitation.

Couto et al (2018) validated a Portuguese version of the Oral Health Impact Profile (OHIP-14) for people with mild intellectual disabilities (OHIP-14-MID-PT). The Portuguese version of the questionnaire was prepared based on the original English version, following the guidelines defined internationally. A total of 240 people (or attending) were interviewed at institutions in the central region of Portugal, affiliated with Humanitas, to measure quality of life related to oral health (OHRQoL). The OHIP-14-MID-PT presented high reliability (ICC = 0.999; Cronbach's $\alpha = 0.922$). The total OHIP-14-MID-PT scores were significantly associated with self-perception of better oral health status and less need for dental treatment, more natural teeth and better results in the oral health index. OHIP-14-MID-PT has proven to be a consistent, valid and reliable instrument with good psychometric properties to determine the impact of oral health on quality of life in adults with mild intellectual disabilities in Portugal.

Preciado et al (2013) studied the Quality of Life with Implant-Prosthesis (QoLIP-10) questionnaire to assess the impact of implant-supported rehabilitations on oral health-related quality of life (OHRQoL); 131 patients with fixed screw prostheses and removable prostheses were analyzed with QoLIP-10 and OHIP 14sp. The QoLIP-10 confirmed its psychometric capacity for users of screwed prostheses and had results very similar to those of OHIP 14sp when compared. The group with screwed fixed prosthesis had a better quality of life when compared to the group with removable prosthesis.

Kuo et al (2011) legitimized the Chinese version (Taiwan) of the Oral Health Impact Profile (OHIP-49T) and developed a summarized form of OHIP (OHIP-14T) for the elderly. They measured 1402 individuals, 65 years of age or older, who used or needed dental prostheses. The assessment of OHIP-49T, related to the criterion, was measured by associations between the OHIP-49 score with prosthetic need and prosthetic status. A subset

(OHIP-14T), obtained by a controlled regression procedure, was compared to the original Slade OHIP-14 (OHIP-14S). Cronbach's alpha and ICC values were 0.97 and 0.98 for OHIP-49T and 0.90 and 0.93 for OHIP-14T. Mean OHIP-49T scores were significantly associated with prosthetic status ($P = 0.0013$) and prosthetic requirement ($P = 0.0004$). The OHIP-14T score had a stronger discriminatory capacity than the OHIP-14S. The OHIP-49T showed satisfactory reliability and validity for this elderly population in Taiwan. OHIP-14T is more effective in measuring the quality of life of older people who use or need to use dental prostheses than OHIP-14S. HEYDECKE et al (2005) determined the impact of embedded overdentures on two conventional mandibular implants or total dentures in leisure and sexual activities. One hundred and two subjects, aged 35-65 years, received mandibular overdentures fitted by two implants (IOD; $n = 54$) or new conventional mandibular total dentures (CD; $n = 48$) in a randomized controlled clinical trial. A Social Impact Questionnaire was used to assess the impact on social and sexual activity, including avoiding conversations, refusing invitations, avoiding sports, and feeling uncomfortable in kissing and sexual relationships, and loosening of the prosthesis during such activities. Quality of life related to oral health was measured with the Oral Health Impact Profile (OHIP). The IOD group presented lower scores on the OHIP scale and, consequently, a better quality of life when compared to the CD group. Edentulism has a negative impact on social and sexual life. Mating mandibular overdentures provide greater improvement in discomfort in intimate activities than new conventional dental prostheses.

BERRETIN-FELIX et al (2008) verified the consequences of fixed oral rehabilitation implanted in quality of life (QoL) of the elderly. Fifteen patients were studied, of which 10 were female and five were male; all were aged > 60 years old, were completely edentulous, had removable prostheses in both arches, and were treated with implanted fixed prostheses. Three QOL questionnaires, two related to oral conditions (Oral Impact on Daily Performance - ODP - and Oral Health Impact Profile, short version - OHIP-14) and one dealing with global aspects (WHOQOL - Quality of Life of the World Health Health) BREF), before the 3, 6 and 18 months, after the surgical placement of the implants. The ODP and OHIP-14 questionnaire scores were better than after the dental treatment. The WHOQOL-BREF was less sensitive, confirming the greater reliability of specific (focal) questionnaires compared to general issues in such situations. Treatment with fixed implant-supported prostheses improved QoL in the elderly whose effects are better detected by specific instruments focused on the subject.

Allen and Mcmillan (1999) evaluated the impact of tooth loss on total denture wearers using the Oral Health Impact Profile (OHIP) and compared the validity of OHIP 49 against OHIP 14 in a population with total prosthesis. The study participants were divided into two groups: patients receiving implanted prosthesis ($n = 48$) and edentulous control group of the same age group and gender, requesting conventional total dentures ($n = 35$). The OHIP data were calculated using the weighted standardized and simple counting methods. Non-parametric statistical tests were used to compare the responses of the implant and control subjects. Both groups were dissatisfied with their conventional prostheses and had relatively similar levels of dissatisfaction. Individuals in the implant-retained prosthesis group had a worse quality of life assessment than the group with conventional prostheses. The results suggested that OHIP-49 and OHIP-14 had a similar ability to discriminate between groups. This indicates that OHIP-14 can be a helpful aid in a clinical setting.

Montero et al (2012) pointed the Oral Health Impact Profile to edentulous patients (OHIP-20sp) in the Spanish population and analyzed the factorial of prosthetic well-being. A total of twenty-one ($n = 21$) edentulous patients using mandibular implant prostheses (IO) and twenty ($n = 20$) with conventional total prostheses (CD) were retrospectively assessed in this study. The reliability coefficient (Cronbach's alpha = 0.91) showed high consistency. There was no significant difference in quality of life and satisfaction between the two groups, since 48% of the sample showed occasional or frequent dissatisfaction with at least one questionnaire item. The OHIP-20sp was found to have satisfactory efficiency to measure the quality of life and satisfaction of total edentulous users of total prosthesis.

Perea et al. (2013) investigated the differences in impact on oral health related quality of life among users of total dentures, depending on their sociodemographic characteristics, factors related to prosthesis and oral status. 51 patients aged between 50 and 90 years, between 2005 and 2010, with at least one complete denture in the Department of Bucco - holic Prostheses of the Universidad Complutense (Madrid), were included in this cross - sectional study. All participants answered the Oral Health Impact Profile (OHIP-14sp) questionnaire. The prevalence of impact was 23.5%, with an average score of 9.8 points. The location of the prosthesis significantly influenced the patient's overall satisfaction, with the prosthesis being less comfortable. Having a complete removable prosthesis as an antagonist significantly impaired patient satisfaction. Patients without prosthetic stomatitis and those requiring prosthesis repair or replacement reported significantly higher overall OHIP-14sp scores. The use of conventional total prosthesis has negative impacts on the HRQoL of elderly patients,

especially in the case of inferior prosthesis requiring repair or replacement, with a removable total prosthesis as an antagonist. Prosthetic stomatitis in this study was always associated with other serious diseases, which may have influenced the self-perception of discomfort with the prostheses.

Øzhayat and Gotfredsen (2012) evaluated the effects reported by 200 patients with fixed dental prostheses (DPF) and 107 patients with removable dental prostheses (DPH) on the change in the quality of life related to oral health (OHRQoL) with the type of prosthetic treatment. Participants completed Oral Health Impact Profile 49 (OHIP - 49) before and after treatment. All participants had a significant improvement in OHRQoL. The improvement was greater for the RDP group than for the FDP group. Removable dental prostheses that replaced masticatory teeth alone did not significantly improve OHRQoL. Older age, being female and having teeth replaced in the aesthetic zone were associated with deterioration of OHRQoL. Both RDP treatment and FDP treatment were associated with a reduction of the most frequently reported problems prior to treatment. Fixed dental prostheses and RDP treatments improved OHRQoL and reduced the number of problems. Participants in the RDP improved more than the participants in the FDP.

Raes et al. (2017) conducted a study on the quality of life related to oral health in unit implants. 96 patients received 102 dental implants. The implants were immediately provided, and the permanent crowns were cemented after 12 weeks. Oral Health Impact Profile Questionnaires (OHIP - 14) were completed before surgery, after installation of the implant and provisional crown, permanent corona installation, 12 months after the final crown was installed and 60 months after the final crown was installed. OHIP-14 showed that patients, when they were edentulous, showed high scores at school and a poor quality of life. In the period of the installation of the implants and provisional, there was a substantial improvement in the quality of life. The OHIP-14 score was very low with the installation of definitive crowns and up to 12 months after the procedure, indicating good quality of life. After 60 months using the crowns, there was a small increase in the OHIP-14 score but still maintained a good quality of life.

Furuyama et al. (2012) studied the quality of life related to oral health in users of fixed prosthesis on implants and removable prosthesis. 79 individuals screened at the University of Tokyo responded to the OHIP-46 Japanese version. All users of fixed prosthesis on implants presented better quality of life, when compared to the user of removable prosthesis.

Oh et al. (2016) compared oral health-related satisfaction and quality of life (HRQoL) between fully edentulous

patients treated with fixed implant prostheses (PF), removable implant prostheses (RP), or mucosupported (CD) dentures. Eighty-six patients - 29 FP, 27 RP and 30 CD patients participated in this study. The research was conducted through interviews with a questionnaire that included the patient satisfaction scale and the oral health impact profile (OHIP - 14). Patient satisfaction was measured after prosthetic treatments and HRQoL before and after treatments. After prosthetic treatments, HRQoL increased in all three groups ($P < 0.5$). The FP and RP groups did not present a significant difference in satisfaction and HRQoL, and both groups presented greater improvement compared to the CD group, which showed good satisfaction and good HRQoL, but at levels lower than FP and RP.

Assunção et al. (2007) compared the satisfaction and quality of life in an elderly population using conventional prostheses and implant-supported prostheses. 34 patients were submitted to a questionnaire based on the Oral Health Impact Profile and oral health quality of life to evaluate their levels of satisfaction and quality of life with their prostheses (OHIP 14). There were no significant differences between groups, regarding comfort, aesthetics, masticatory capacity, general satisfaction, pain, functional, phonetic, social and psychological limitations. Comparing the stability of total dentures, the implant-supported prosthesis group presented the best results.

Boerrigter et al. (1995) evaluated thirty-two men and 118 women to determine satisfaction with dental prostheses. Patients were randomly divided into two groups; one received conventional total prosthesis and the other received total implant-supported prosthesis. The group that received total implant-supported prostheses had better evaluation and greater satisfaction with their prosthesis in all aspects and in all stages of the study.

Oral rehabilitation with implants provided a way to minimize the problem of the stability and retention of total dentures, thus increasing their functionality, leading to improved patient satisfaction and higher quality of life (VAN DER BILT et al., 2006).

In relation to natural dentition, Prado (2004) compared the masticatory efficiency of the total and implant surgery of the total denture, in 21 individuals with total dentures (PT group), 10 individuals with implanted dentures (PIR group) and 15 with natural dentition. The masticatory performance index was obtained by calculating the mean geometric diameter of the chewed and sieved particles. After analysis, the PT group obtained a mean of 21% of the masticatory efficiency, when compared to the DN group; and the PIR group had a mean of 89% when compared to the same DN.

Slade and Spencer (1994) proposed and validated a questionnaire called Oral Health Impact Profile (OHIP), with the objective of measuring the social impact of an

oral disease. The questionnaire with 49 questions on oral problems was applied to 328 people. OHIP was considered a reliable and valid instrument for the detailed measurement of the social impact of oral disorders, offering potential benefits for clinical decision-making and research.

Slade (1997) perfected OHIP, summarizing the questionnaire in 14 questions: the new questionnaire was called Oral Health Impact Profile 14 (OHIP-14). The reduction was aimed at facilitating the use, making the instrument more comprehensive, yet without harming reliability. The OHIP-14 and OHIP-49 scores indicated the same standard test of variation among socio-demographic groups of older adults.

Att and Stappert (2003) compared the effect on oral health-related quality of life (OHIP) of two types of rehabilitation: total multisupported prosthesis (PTMS) and total implantable prosthesis (PTIR). The evaluations were done before the prostheses were delivered and two months later. The authors verified that rehabilitation with PTIR was significantly associated with improvement in quality of life. Treatments with PTIR provide a significant improvement, in a short time, more than treatments with PTMS, in oral health related quality of life. A visual analogue scale was used to evaluate the ability to chew certain foods and the comfort, stability, aesthetics, phonetics and ease of hygiene of the prostheses. All indices evaluated were significantly better in the patient rehabilitated with mucosuporated and implanted prostheses, demonstrating that the level of patient satisfaction was similar to the two prostheses.

Jacobovitz (2003) translated, adapted, validated, and determined the accuracy of OHIP-14 for Brazilian culture with the help of three English teachers, and one judge evaluated the translations. This version was applied to 280 patients with a mean age of 42 years. Socio-demographic data and self-perception of oral health and the need for treatment were also collected. The correlation analyzes indicated validity of the concept of the Brazilian version of OHIP-14. OHIP scores increased the self-rated measure of subjects from "very healthy" to "very sick". The individuals with greater need for dental treatment, likewise, had a higher score than those who had less need for treatment. The adapted version of OHIP-14, for Brazilian culture, has demonstrated high values of accuracy and validity and can be considered satisfactory for use in Brazil.

Heydecke et al. (2003) compared the satisfaction of patients using superior fixed and removable dentures on implants. We selected 16 individuals who had participated in other studies. The research was carried out in two stages. In the first, some patients received the fixed prostheses, whereas the others received removable prostheses. After two months of adaptation, the prostheses

were changed and two more months were waited. In both steps, patients responded to the EVA psychometric scale. The variables analyzed in the VAS were general satisfaction with prostheses when compared to natural teeth, comfort, phonetics, stability, aesthetics, ease of hygiene, occlusion and ability to chew seven foods (white bread, cheese, raw carrots, sausage, nuts and salad). After the analysis, the patients chose which prosthesis they would remain with. Of the thirteen patients who completed the study, four chose the fixed prosthesis as final and nine the removable prosthesis. Aspects such as phonetics, ease of hygiene, general satisfaction and esthetics were the factors that most influenced the choice of removable prosthesis. The factors that exerted influence in the choice of fixed were: comfort, general satisfaction, phonetics and stability.

Att and Stappert (2003) reported a clinical case, in which there was rehabilitation with implant-supported prosthesis, in a patient with poor oral health and low quality of life according to OHIP-14. Serial exodontia and eight implants were performed in the same session, 4 in the mandible and 4 in the maxilla. After the period of osseointegration, the implants were implanted. Aesthetic, phonetics and masticatory function of the patient were reestablished. The patient had a very low score on the OHIP-14 scale, which means that there was a significant improvement in quality of life.

Scott, Forgie, and Davis (2006) evaluated the impact of oral health on quality of life in edentulous individuals who needed new PTMS, and the prostheses were made by two different techniques. Sixty-five edentulous people participated in the study. Thirty-three had PTMS constructed using the copy technique or neutral zone (a technique that allows artificial teeth to be distributed, adequately biomechanically in relation to the alveolar ridge and the para-prosthetic muscles) and 32 by the conventional technique. The people answered the OHIP-14 questionnaire before and after the preparation and installation of PTMS. Overall, respondents expressed improved satisfaction with the new lower prosthesis. However, the group of people with neutral zone prostheses showed significant improvements, for all seven evaluations, compared to only five of the seven evaluations, for the people in the conventional group. According to the results of the study, although there was a need for PTMS replacement, this fact does not necessarily have significant impacts on oral health related quality of life.

Kelly et al. (2012) conducted a study to determine the quality of life, based on the masticatory efficiency of users of implanted and supported implants. Fifty patients were evaluated, 25 with implants supported and 25 with mucosuporated prostheses. The users of implant-supported

prosthesis presented masticatory efficiency and superior quality of life to users of mucosuated prosthesis.

Lang et al. (2016) conducted a study of the impact on the quality of life of patients submitted to dental implants with immediate loading and late loading. All were submitted to dental extractions in series, and the osseointegratable implants were immediately installed. In Group 1, a temporary bolted interim prosthesis was performed and, in Group 2, a provisional total prosthesis with mucus supported. The oral health related quality of life questionnaire (OHRQOL) was used for these patients by a visual analogue scale of 48 questions related to 6 domains: comfort, function, speech, aesthetics, self-image and oral health. The pooled data showed significant differences for all the questions between pre-treatment and post-treatment responses, indicating that users of mandibular overdenture retained with implant had a better quality of life.

Thomason, Lund, Chehade et al (2003) examined patient satisfaction with conventional total prostheses and fixed prostheses on mandibular implants 6 months after confection. Sixty edentulous individuals (aged 65-75 years) were randomly assigned to use a conventional mandibular prosthesis or a prosthesis supported by two implants with retentive ball-shaped anchors. Patients rated their overall satisfaction and other characteristics of their prostheses along with their ability to ingest certain foods at 100-mm analogue visual scales prior to the use of the tests and after 2 and 6 months. Both treatment groups reported greater satisfaction with their new prostheses at 6 months. Overall satisfaction scores were higher in the implant group than in the conventional prosthesis group by approximately 36%. The only question that the conventional protees surpassed the protests about implants was in the cleaning aspect of the prosthesis.

Harris et al. (2013), in a randomized, prospective and controlled study, showed that 122 edentulous patients (mean age 64; 39 men, 83 women) underwent initial assessment of satisfaction and quality of life with the Oral Health Impact Profile - 49 (OHIP - 49) and Denture Satisfaction. The patients were divided into two groups, and one group received mucosuporated prostheses and the other received new implanted prostheses using them for 6 months. The two groups obtained improvement in the satisfaction and quality of life, being the group with implant-supported prosthesis having better satisfaction and better quality of life.

Meijer, Raghoobar, van't Hof, (2003) conducted a prospective randomized clinical trial to evaluate 10 years of treatment of patients who received an implanted mandibular overdenture (IRO) or a conventional total prosthesis (CD) and to assess the satisfaction of these groups with their prostheses. The IRO group presented

substantially higher satisfaction with the CD group in all age groups of use of the prostheses.

Preoteasa et al (2012) evaluated the satisfaction of complete edentulous patients, users of conventional prostheses and fixed implants implants. The study sample consisted of 36 patients - 18 treated with a newly manufactured conventional prosthesis and 18 with fixed prosthesis on implants. All patients were satisfied with their prostheses, but the patients treated with implants presented greater satisfaction in all the requirements of the research.

Xin and Ling (2016) translated the original English version of the oral health impact profile (OHIP) -14 into the Chinese version and tested the psychometric properties of the Chinese version for use among Chinese adults. The formal psychometric properties were tested according to the standard procedure of the international quality of life assessment project (IQOLA). A total of 592 adults were surveyed. There were 550 valid questionnaires. The Cronbach's alpha of the translated scale was 0.93 and the corrected item-total correlation ranged from 0.53 to 0.71. The 14 items were divided into four domains. There was a certain logical relationship between items in the same domains. There was a highly significant association between perceived oral health status, perceived need for dental care, and OHIP-14 scores. The translated Chinese version of the OHIP-14 demonstrated good reliability and validity. Its good psychometric properties provide the theoretical evidence for later use in the Chinese population.

III. CONCLUSION

Based on the data collected by the current medical literature, we can say that oral aude has a direct impact on quality of life. Usuarios of total prosthesis mucosuportada and total prosthesis implants supported have a great number of studies on quality of life, being the users of implant implanted with better quality of life and satisfaction. There is a direct relationship between quality of life and satisfaction, those who are more satisfied with their oral condition tend to have a better quality of life.

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Inorganic Contaminants Evaluation in Tuberous and Leafy Vegetables Consumed in Paraíba Valley, Brazil

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Abstract— *The aim of the present study is to investigate the aluminum, cadmium and lead concentrations in vegetables such as lettuce, potatoes, carrots, beets and cassava often consumed in human diet. Calcination and acid digestion methods were used to prepare the samples. The Spike test has shown that the methods were viable for almost all samples. The recovered analyte percentage ranged from 88.0% to 108.7% in the acid digestion, and from 55.1% to 109.6% in the calcination method. Comparative analyses conducted in lettuce samples have shown lead concentrations $26.4 \pm 2.6 \text{ mg kg}^{-1}$ in electrothermal atomic absorption spectrometer (ETAAS) and $33.3 \pm 0.3 \text{ mg kg}^{-1}$ in inductively coupled plasma optical emission spectrometer (ICP-OES). The herein presented results allow saying that the concentrations of the elements analyzed in each sample were above the limit set by the Brazilian Ministry of Health and within the tolerance limit set by the Codex Alimentarius.*

Keywords— *Al, AAS, Cd, Pb, food.*

I. INTRODUCTION

Metal elements may affect the environment, as well as humans, in different ways, depending on their availability and essentiality; it happens due to their physical and

chemical features. Some elements such as B, Ca, Fe, Mg, Mo, among others, are essential at concentrations between micro- and milligrams per day [1;2;3]. On the other hand, elements such as Al, Cd and Pb do not present known biological function and are well-known for their toxicity when they are inhaled or ingested in excess [4-9].

Aluminum is seen as non-essential. In addition, there is evidence that the Al^{3+} ion may be linked to health issues such as Alzheimer's disease, and that it may exacerbate intoxications in people with impaired renal function [7;10]. The Al^{3+} may be incorporated to the tissue of vegetables cultivated in soils showing high bauxite content; thus, it is a contamination liability and, consequently, a Public Health concern [7;8;9]. It is known that cadmium (Cd) mobility and toxicity mainly depend on its oxidation state. Thus, Cd may become bioavailable and harm the environment, as well as humans [3;11]. Therefore, this element has been investigated to help better understanding its toxicity mechanisms and setting threshold concentrations that cannot cause any type of harm in case of exposure [12;13]. The particulate lead, which is transported in the form of oxides, may be aspirated due to its wide distribution in the atmosphere [6;11;14]. Whereas the gastrointestinal Al absorption is

influenced by several factors, mainly age and diet [7;9]. The lead toxicity results from its capacity to interact with the essential metals of the main metabolic pathways, mainly with Zn, Ca and Fe [2;9].

Paraíba Valley is a São Paulo State region located on the triple border between Minas Gerais, São Paulo and Rio de Janeiro states. This region has been the target of several technical-scientific investigations focused on assessing and warning about the impact of the regional development on the quality of life of humans and on the environment [4;15;16]. Okada et al. (1997) have assessed the Cd and Pb contamination degree in milk samples from Northern Paraíba Valley. They found that 19.7% of the samples showed lead levels above the maximum limit set by the legislation in force. Soares et al. (2010) have investigated the Cd, Cr and Pb concentrations in pasteurized milk purchased in marketplaces in different Paraíba Valley cities, whereas Bayod Filho et al. (2012) have investigated the Ca, Cr, Mg and Mn concentrations in umbilical cord blood and breast milk samples. These authors have proposed analytically-validated procedures and found contamination gradient increase over the years, fact that led them to report such risk to the health departments in the affected counties.

Similarly, different studies conducted throughout the 2000s have measured the contamination impact of different metal elements on vegetables and on the agricultural soils in some Paraíba Valley cities. Salazar et al. (2006) have investigated the concentration of oligo-elements (Cu, Fe and Zn) in samples comprising vegetables consumed in Lorena County (SP). However, the way the samples were prepared did not allow validating the analytical procedures, thus compromising data reliability. Nonetheless, they could see that the investigated samples showed indications that the concentrations of some elements were above the tolerance limit set by the legislation [17]. Salazar et al. (2011) have found passive Ni contamination in soil samples and in vegetables consumed in Lorena and Taubaté counties (SP), after they properly proposed and validated simplified analytical calcination and acid digestion procedures. According to the authors, the contamination results from the inappropriate use of fertilizers presenting trace element concentration as an attempt to remediate the presence of this micronutrient [16].

In light of the foregoing, the investigation and monitoring of different elements and contaminants are demanding and increase researchers' interest in better understanding their toxicity mechanisms, as well as their interest in environmental and sanitary sensing. Therefore, the aim of the current study was to investigate the Al, Cd and Pb concentrations in vegetables often consumed in Paraíba

Valley region, mainly in Taubaté and Lorena counties (SP).

II. MATERIALS AND METHODS

2.1 Sampling, reagents and solutions

The sampling consisted of lettuce (*Lactuca sativa*), beet (*Beta vulgaris*), potato (*Solanum tuberosum*), carrot (*Daucus carota*) and cassava (*Manihot utilissima*) samples purchased in street markets and supermarkets in Taubaté and Lorena counties; the tuberous samples comprised roots and skin, whereas the leafy samples comprised leaves and stems. All samples were fresh and showed no signs of putrefaction [16;18].

The solutions were prepared by employing analytical degree reagents, ultrapure water obtained from using Milli-Q (Millipore Corp, de Billerica, MA, EUA) water system at 18.2 MΩ cm resistivity, nitric and chloridric acid distilled in quartz sub-boiling (Milestone, Sorisole, Italy). To prevent contamination, the vials, glassware and polypropylene materials were washed and soaked in 10% v v⁻¹ HNO₃ and fully washed with deionized water. All the chemical reagents were of the P.A. degree. The mineral acids used were of the Dinâmica brand. The metallic patterns used, with 1-mg mL⁻¹ concentration, were of the SpecSol brand with NIST traceability, Reagent organic solvents and other chemical reagents of the Vetec brand [18].

2.2 Sample preparation

First, each vegetable sample was washed in distilled water to remove soil and other relevant debris. Subsequently, they were brushed with polypropylene bristles and washed in deionized water [16]. The lettuce shoot was carefully cut along with the stalks of each leaf, except for the main leafstalk, which was discarded along with the roots. The potato, beet, carrot and cassava root samples were grated in a polypropylene grater and placed in porcelain capsules. Then, the capsules holding the samples were taken to the oven at 120 ± 5°C, for 24 h, for dehydrated mass obtainment [18]. After the dehydration process was complete, the samples were placed in polypropylene beakers covered with PVC film and stored in a desiccator. Calculations were made for each dried sample analyzed in the current study in order to determine how much of these samples represented, in weight, the corresponding fresh samples (eq.1):

$$M_f = (100 \cdot M_s) / (100 - \%Moist) \quad (1)$$

Wherein M_f is the mass of the fresh sample (g), M_s is the weighted mass of the dry sample (g) and % Moist is the mean moisture content of the sample. The samples were prepared by using adaptations of the procedures

developed by Wieteska et al. (1996) for plant sample preparation via acid digestion and calcination; then, they were subjected to further determination through ETAAS or FAAS [19].

2.2.1 Calcination method

Firstly, the calcination of dehydrated samples was carried out by weighing approximately 0.5 g of each vegetable in porcelain crucibles and, then, covering them 19. The crucibles were transferred to a muffle, which was heated at 500°C for 2 h; the heating was done at 12°C min⁻¹, with 20-minutes threshold each, at 100, 200, 300 and 400°C. The calcination residues were digested in 2.0 mL of deionized H₂O, 0.5 mL of HCl and 1.0 mL of concentrated HNO₃. The crucibles were covered with watch glass and heated on a plate, for 30 min, in sand bath, in order to assure better heating and reflux control to prevent analyte loss [16]. After the digestion and cooling were complete, the entire digestion system was properly rinsed with deionized water, the crucible solutions were quantitatively transferred to 50.0 mL flasks and supplemented with deionized H₂O.

2.2.2 Acid Digestion method

A 0.5 g of each sample was weighed in 50 mL glass beakers. Next, 5.0 mL of an acidic mixture composed of HNO₃ and HClO₄ (4:1 v/v) and of 2.0 mL of deionized H₂O were pipetted into each beaker. Then, each beaker was covered with watch glass and transferred to sand bath in order to allow mild digestion, as recommended when one works with this type of acid mixture. The digestion time ranged from 1 to 2 hours; the system solution was kept in continuous reflux until the digestion product became as clear as possible [19]. After the digestion and cooling processes were complete, the crucible solutions were quantitatively transferred to 50.0 mL flasks and supplemented with deionized H₂O. The Al, Cd and Pb determination values and the M_f of the vegetable samples were used to calculate the metal mass per fresh sample mass, through Equation 2:

$$m = (C/M_f) \cdot f \quad (2)$$

Wherein the parameter “m” is the metal concentration per fresh sample mass (mg Kg⁻¹ or µg Kg⁻¹); “C” is the metal concentration in the solution (mg L⁻¹ or µg L⁻¹); “M_f” is the fresh sample mass (g); and “f” is the unit conversion factor.

Addition and analyte recovery tests were used to assess result accuracy by adding 2.0 µg L⁻¹ of Cd standard, 10 µg L⁻¹ of Pb standard and 30mg L⁻¹ of Al standard to 0.5 g of dehydrated samples. Interlaboratory analyses of lettuce samples digested through calcination and acid digestion were referred to inductively coupled plasma optical

emission spectrometry (ICP-OES) in order to give greater reliability to the spike and recovery tests performed in the current study [16;18;20;21].

2.3. Instrumentation

All atomic absorption measurements were performed in the Perkin Elmer; Model: AAnalyst 800, using a deuterium lamp (D₂) for background correction. The aluminum was determined through FAAS (flame atomic absorption spectrometry). The electrothermal atomic absorption spectrometry (ETAAS) system was used to determine Cd and Pb [21]. The herein used experimental conditions are described in Tables 1 and 2.

Table.1: Experimental conditions for lead determination through atomic absorption.

	Al	Cd	Pb
Wave-length (nm)	309.3	228.8	283.3
Slot opening (nm)	0.70	0.7	0.7
Lamp current (mA)	25	4	440
Sample aliquot (µL)	--	10	10
Chemical modifier aliquot (µL)	--	10	10
Determination module	FAAS	ETAAS	ETAAS
Gas flow (L min ⁻¹)	N ₂ O / C ₂ H ₂ (16.0 / 7.8)	--	--
Spectroscopic buffer (% v v ⁻¹)	KCl (0.1)	--	--

Table.2: Graphite Furnace Programming (ETAAS) to determine Cd and Pb.

Elements Stages	Cd				Pb			
	A	B	C	D	A	B	C	D
Drying	150	1	2	25	150	1	2	25
		0	0	0		0	0	0
Pyrolysis	800	3	2	25	900	3	1	25
		0	0	0		0	0	0
Atomization	140	0	5	0	150	0	5	0
		0				0		
Cleaning	50	5	5	25	250	5	3	25
				0				0
Cooling	245	5	3	25	20	5	5	25
				0				0

A - Temperature (°C); B: Heating Ramp (s); C: Platform Time (s); D: Argon Flow (L min⁻¹).

The experimental conditions of the inductively coupled plasma optical emission spectrometry (ICP-OES) used in the current study are shown in Table 3. The ICP-OES showed axial configuration (Vista AX, Varian, Mulgrave, Victoria, Australia); it was equipped with a charge-

coupled device (CCD) refrigerated at -35 °C to allow measurements from 167 to 785 nm, as well as with a Cross Flow nebulizer (flow rate 1.50 mL min⁻¹) coupled with a Scott Spray Chamber (20).

Replicates	4
Wave-length, (nm)	Al(396.153), Cd(228.802), Pb(220.356)
Monitoring element	Ar (430.010)

Table.3: ICP-OES operating conditions (Vista AX, Varian).

Plasma Parameters	Operating conditions
Power (W)	1450
Plasma gas flow (L min ⁻¹)	14.50
Auxiliary gas flow (L min ⁻¹)	0.2
Nebulizer flow (L min ⁻¹)	0.54
Radio Frequency Generator (MHz)	40.0
Torch position (mm)	
Horizontal	-1.0
Vertical	2.0
Depth	1.0
Reading time (s)	25.20

III. RESULTS AND DISCUSSION

3.1 Validating the sample preparation procedures

The methods adopted in the current study were feasible when the recovered analyte rates ranged from 95.9% to 108.8% in the acid digestion, and from 102.7% to 122.9% in the calcination, for Al. When applying the t-test and the F-test ($p < 0.05$) it was verified there are statistically significant differences in results obtained for Al in carrot and cassava or Cd in potato and beet, Pb in beet and carrot. However, it is possible to verify that the repeatability oscillated in methodological terms and by the analyzed element. Tables 4 and 5 show the recovery results of the calcination and acid digestion procedures, respectively.

Table.4: Results of Al, Cd and Pb concentrations in the addition and recovery tests, after calcination ($n = 4$).

Element	Assays	Samples				
		Lettuce	Potato	Beet	Carrot	Cassava
Al	Spiked (mg kg ⁻¹)	45.3	30.0	54.4	30.0	38.0
	Result (mg kg ⁻¹)	41.3±1.4	30.8±3.9	55.3±1.7	36.9±3.9	40.6±1.0
	Recovery (%)	91.2	102.7	101.6	122.9	106.8
Cd	Spiked (µg kg ⁻¹)	4.6	3.0	3.3	3.0	4.6
	Result (µg kg ⁻¹)	4.7±0.1	3.0±0.3	3.1±0.2	2.9±0.1	3.9±0.3
	Recovery (%)	102.2	101.0	93.9	97.1	85.2
Pb	Spiked (µg kg ⁻¹)	28.5	10.0	14.1	10.0	13.5
	Result (µg kg ⁻¹)	23.9±1.0	6.3±0.4	10.1±1.2	5.5±2.5	14.8±5.9
	Recovery (%)	83.9	62.8	71.6	55.1	109.6

Table.5: Results of Al, Cd and Pb concentrations in the addition and recovery tests, after acid digestion ($n=4$).

Element	Assays	Samples				
		Lettuce	Potato	Beet	Carrot	Cassava
Al	Spiked (mg kg ⁻¹)	45.3	30.0	57.6	30.0	38.0
	Result (mg kg ⁻¹)	48.8 ± 0.9	32.6 ± 0.8	58.9 ± 2.0	28.8 ± 0.9	34.6 ± 1.2
	Recovery (%)	107.7	108.8	102.2	95.9	91.1
Cd	Spiked (µg kg ⁻¹)	4.6	2.2	3.4	2.7	4.6
	Result (µg kg ⁻¹)	4.4 ± 0.3	1.4 ± 0.1	2.3 ± 0.3	2.7 ± 0.3	3.5 ± 0.7
	Recovery (%)	95.5	72.3	67.6	100.9	76.1
Pb	Spiked (µg kg ⁻¹)	28.5	10.0	12.6	17.5	13.5
	Result (µg kg ⁻¹)	26.4 ± 2.6	8.8 ± 1.2	2.4 ± 0.7	16.9 ± 2.6	12.8
	Recovery (%)	92.6	88.0	108.7	96.4	94.8

According to the data in Tables 4 and 5, the two methodologies achieved high recovery in the Al analysis through FAAS, except for the Al in the carrot samples subjected to the calcination method. This result can be attributed to the KCl buffer, which was not sufficient to minimize the calcination interference and temperature.

The recovery test did not show satisfactory analytical Cd recovery (> 85%) in the digests obtained through the acid digestion applied to potato, beet and cassava samples; the recovery values were 72.3%, 67.6% and 76.1%, respectively. On the other hand, the recovery test showed satisfactory analytical results in the other digests (values above 85%) subjected to the two methodologies, fact that enables applying the acid digestion and calcination methodologies to analytically determine the Cd in the samples of interest.

The results in the current study have also shown that both methodologies achieved high Pb recovery in the ETAAS analysis, except for potato, carrot and cassava samples subjected to calcination. These results show possible losses caused by Pb entrainment during this stage. The herein found values can be considered analytically satisfactory for all samples subjected to acid digestion pretreatment, except for the aforementioned samples and methodologies. It allows applying the acid digestion methodology to analytically determine Pb in the samples of interest.

The low lead recovery in the calcination method may be attributed to a possible Pb entrainment during the heating ramp, whereas the low cadmium recovery in the acid digestion method may be due to a possible reaction of the HClO₄-derived chlorine, which generated volatile chlorides [14].

The interlaboratory analyses conducted in the lettuce sample showed Al concentration $19.3 \pm 0.3 \text{ mg kg}^{-1}$ when it was determined through FAAS, and $18.2 \pm 0.2 \text{ mg kg}^{-1}$ when it was determined through ICP-OES. The addition and recovery tests, as well as the interlaboratory analysis, showed similar results, fact that made it possible using the sample preparation procedures to determine Al. The interlaboratory analyses conducted in the lettuce digests showed Pb concentration $26.4 \pm 0.3 \text{ } \mu\text{g kg}^{-1}$ when it was determined through ETAAS, and $18.2 \pm 0.2 \text{ } \mu\text{g kg}^{-1}$, when it was determined through ICP-OES. The results of the interlaboratory analysis made it possible using the acid digestion methodology and reinforced the results found in the analyte addition and recovery test used to determine Pb. With respect to Cd, it was not possible comparing the techniques, since the analyte was below their detection limit ($\text{LOD} < 0.001 \text{ mg L}^{-1}$). The fact that

Cd was not detected through ICP-OES may be explained according to the techniques. The ETAAS techniques show higher sensitivity and, consequently, better detection and quantification limits than the ICP-OES ones [8;12].

3.2 Determination of Al, Cd and Pb

Table 6 shows the Al, Cd and Pb determination values found in the vegetable samples from Lorena and Taubaté counties.

The Pb levels found in the samples from Taubaté County were higher than those found in the samples from Lorena County. After all samples were analyzed, it was possible finding alarming Pb concentrations in cassava samples from both counties, as well as in the lettuce sample from Lorena County. According to the Brazilian Ministry of Health for Al content in lettuce, potato, carrot and cassava are set up 4.1, 1.7 and $7.5 \text{ } \mu\text{g kg}^{-1}$, respectively. In relation to Cd content is recommended up to 1.7, 5.3, 4.0 and $3.7 \text{ } \mu\text{g kg}^{-1}$ for lettuce, potato, carrot and cassava, respectively. Finally, for Pb content is accepted around 7.5, 0.23, 31 and $0.8 \text{ } \mu\text{g kg}^{-1}$, respectively [1].

By comparing the Al results to the tolerance limits set by the legislation, it was possible seeing that all samples showed Al levels above the allowed limits, mainly the lettuce samples, wherein the Al concentrations in Taubaté and Lorena counties were 13 and 60 times higher than the tolerance limits, respectively. It shows absorption kinetics [8;9;22] more favorable to leafy than to root vegetables. This absorption kinetics may result from air and water-related contaminations due to the geological features of the region [7;9]. Anthropogenic factors are among those mostly influencing result oscillations, since the Al concentration was higher in Taubaté County, where the industrial activity is more intense than in Lorena County. However, Lorena County is closer to the region showing the highest mining activity (bauxite extraction), fact that may have caused the lettuce samples to be exposed to Al contamination. Results shown in Table 5 allowed concluding that the Cd levels were above the tolerance limit estimated by the Brazilian Ministry of Health; however, these levels were within the tolerance limits set by the *Codex Alimentarius*. According to CODEX STAN 248 (2005), those values for Cd is above 0.2 and 0.1 mg kg^{-1} for leafy and tuberous vegetables, respectively. On the other hand, for Pb content in leafy and tuberous vegetables, the CODEX STAN 210 (2001) set up values around 0.3 and 0.1 mg kg^{-1} , respectively [23;24].

Table.6: Al (mg kg⁻¹), Cd (µg kg⁻¹) and Pb (µg kg⁻¹) determinations in vegetables consumed in Lorena and Taubaté counties (fresh mass base).

	Lorena			Taubaté		
	Al	Cd	Pb	Al	Cd	Pb
Lettuce	252.6±5.7	9.9±0.9	63.9±9.0	52.4±11.4	4.1±0.5	161.3±15.8
Potato	7.7±3.4	5.8±3.5	25.93±5.11	45.6±8.9	3.9±0.8	54.4 ±8.1
Beet	26.4±3.5	15.2±1.4	31.4±1.6	59.3±12.0	8.0±2.1	63.0±1.2
Carrot	70.0±3.8	9.0±1.9	97.8±9.8	92.8±9.3	13.3±0.4	33.1±8.3
Cassava	28.9±1.3	30.4±4.3	233.6±48.1	186.9±18.6	17.8±1.9	349.6±26.2

This scenario and the concern about controlling the contamination and setting safe exposure levels can be seen in other countries, as shown in Table 7.

Table.7: Mean daily Cadmium intake and absorption by Americans [25].

Exposure Sources	Exposure	Intake	Absorption (%)	Absorption (µg / day)
Air (environment)	0.03 µg/m ³	0.6	25	0.15
Cigarette (pack)	3.0 µg/pack	3.0	25	0.75
Food	--	30.0	5	1.50
Water	1.3 µg/L	2.6	5	0.13

The contamination level in the samples resulted from features found in the soil, water and in the region where the vegetables were collected. Accordingly, it was possible seeing that, in addition to the herein investigated elements, other elements may have entered the food chain and contaminated the milk consumed in the region, as Okada et al. (1997) and Soares et al. (2010) have observed for Cd and Pb. In parallel, Bayod Filho et al. (2012) and Izário Filho et al. (2014) have found that both the elements analyzed in the current study and other inorganic contaminants and nutrients can be already found in the bloodstream of unborn children and pregnant women, as well as in breast milk samples; it shows a contamination gradient that starts in the moment the fetus is formed and goes on throughout pregnancy due to the intake of doubtfully-safe food [5;25]. However, it is necessary conducting an in-depth study about the Al, Cd and Pb interaction with other elements in the human body in order to assess the deleterious effects the population circumscribed in these counties are subject to over time, as well as to help better understanding the biosorption of the herein studied and other elements by the human body [2;6;9;11;12;13;14].

The Environmental Sanitation Technology Company (Cetesb) has implemented an environmental program in

the region, in 1993, in order to help monitoring lead and cadmium concentrations in sediment, water and grass samples, as a way to minimize the impact caused by anthropogenic activities on the quality of life of its inhabitants [4;15].

IV. CONCLUSION

All vegetable samples investigated in the present study showed Al, Cd and Pb levels above those allowed by the legislation. The most worrisome results refer to the Cd levels in the lettuce and cassava plants from Lorena County, whose contents were more than five and eight times higher than those allowed by the legislation, respectively. All samples showed Pb concentrations higher than those specified by the Ministry of Health. However, the Cd and Pb levels were within the tolerable daily intake limit set by the *Codex Alimentarius*. Yet, these results may work as an indication of environmental contamination in these counties, since the Al levels in the vegetables were above the values allowed by the Brazilian Ministry of Health and by international bodies. The values found in the current study represent the total concentration of the herein investigated elements. Chemical speciation studies should be conducted in order to assess the impact caused by the daily intake of these elements, as well as to determine their bioactivity and interaction mechanisms in the human body.

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Some unresolved quality concerns in Cameroonian higher education resulting from the negligence of adopting the Bologna Process Quality Assurance (QA) agenda

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Abstract— In 1999, the European Bologna Process reinforced quality assurance (QA) in higher education (HE). While Cameroon is a signatory non-member state of the Bologna Process, many unresolved quality concerns in its HE system still exist because the Bologna Process has been adopted on an a-la-carte basis whereby some action lines have been adopted while others have not – for instance QA. In Cameroonian HE, QA is a neglected pillar of the Bologna Process. This article examines some undisclosed quality concerns regarding Cameroonian HE in the advent of the Bologna Process. The study employs a qualitative research design using interviews and focus group discussions. Findings present quality concerns regarding: the lack of adequate educational resources; periodic monitoring, follow up/mentoring; student admission; and university ranking. The paper suggests a reconsideration of the Bologna Process in Cameroonian HE as a process and not an event with more action lines adopted such as QA; and the use of Total Quality Management (TQM) principles as workable strategies used in solving quality concerns in HE.

Keywords— Bologna Process, harmonisation, higher education, quality assurance, Total Quality Management (TQM).

I. INTRODUCTION

The cross-border movement of the Bologna Process QA agenda through the lens of harmonisation

This introduction unveils the cross-border movement of the Bologna Process reform through the lens of harmonisation across Europe, Africa (particularly the Central African Economic and Monetary Community/CEMAC region), and Cameroon. It highlights action lines that have been adopted to illustrate the gap in QA which underpin the negligence of

adopting the Bologna Process QA agenda in Cameroonian HE. It also presents the aim of the article.

According to Woldegioris, Jonck, and Goujon (2015), harmonisation is a process that benchmarks programmes, certificates and qualifications, quality control, qualification recognition, accreditation, QA mechanisms, and credit systems. The main aim of harmonisation is to enhance compatibility and comparability of qualifications geared at promoting employability across regions (Woldegioris et al. 2015) and establish a common language for regulators (Azatyan and Kopp 2012). Woldegioris et al. (2015 p.242) added that harmonisation also deals with 'policy integration in higher education' and makes use of 'voluntary intergovernmental integration', which creates commonalities. According to Bofinger, Habermas, and Nida-Rümelin (2012) and Majone (2014 p.15), with European Union (EU) harmonisation, Europeans were meant to learn that the preservation of their 'welfare-state model of society', as well as diversity across cultures of their nation-states, could only be possible by joining forces, combining their resources to exert global influence on the political agenda and provide solutions to global problems, which implies 'to abandon European unification now would be to quit the world stage for good'. Cippitani and Gatt (2009 p.388) added that based on the reality of problems plaguing the EU, a decision to integrate Europe by restructuring the European HE system was made by European Higher Education ministers resulting in the 1998 Sorbonne Declaration. The Sorbonne Declaration (Sorbonne Communiqué 1998) is known to set the foundation for the Bologna Process, and was a joint agreement between Britain, Italy, Germany, and France to harmonise the architecture of the European HE system. In 1999, 29 countries voluntarily signed the Bologna Process

and agreed on a shared set of action lines to create the European Higher Education Area (EHEA) by 2010 (Bologna Declaration 1999), and foster a competitive and attractive EHEA (Fearn 2008; and Torotcoi 2017). The objectives/action lines/agenda of the Bologna Declaration (1999) were to:

- ❖ Enhance the readability and comparability of grades/degrees and diploma supplements to enhance graduate employability and European HE international competitiveness;
- ❖ Adopt a HE system comprising of two main degree cycles: undergraduate and graduate; or three cycles including Bachelor's-Master's-PhD;
- ❖ Adopt a credit system known as the European Credit Transfer System (ECTS) to enhance student mobility and lifelong learning;
- ❖ Enhance free mobility among students, teachers, administrative staff, and researchers;
- ❖ Promote quality assurance (QA) through European cooperation to develop comparable methodologies and criteria;
- ❖ Promote basic 'European dimensions in higher education' in integrated study programmes, research and teaching, mobility programmes, inter-institutional co-operation, and curricular development.

The biennial follow-up meetings of the Bologna Process also led to further action lines (Eta 2018 p.16). In Prague, the following action lines were added (Prague Communiqué 2001):

- ❖ Attention to lifelong learning;
- ❖ Inclusivity of students and HE institutions; and
- ❖ Boosting the attractiveness of EHEA.

In Berlin, this action line was added (Berlin Communiqué 2003):

- ❖ Doctoral studies and cooperation in the European Research and European Higher Education Areas.

Despite the addition of more action lines, existing action lines like QA among others have also featured in later Communiqués to provide room for monitoring and follow up. The Prague Communiqué (2001) for instance highlights that ministers aimed at promoting tighter cooperation between recognition and QA networks through mutual trust and acceptance of national QA systems¹.

¹For more information on the Bologna Process QA agenda relative to the Prague Communiqué (2001) and other Communiqués, see <http://www.ehea.info/pid34363/ministerial-declarations-and-communications.html>

Osterwalder (2009) remarks that across world region efforts have been made to harmonise educational systems. Although competition is paramount, a high level of regional cooperation is aimed at harmonising regional practices to promote competitiveness (Eta 2018, p.1; 2015). To ensure the success of the Bologna Process, Croché and Charlier (2012 p.467) note that the declarations between 2008 and 2010 led to a joint project organised by the European University Association (EUA) and the Association of African Universities (AAU), financed by the European Commission (EC) titled '*Access to success: fostering trust and exchange between Europe and Africa*'. In Africa, the African Union Commission (AUC) implementing the 'African Union (AU) Plan of Action for the Second Decade of Education in Africa (2006–2015)' embarked on establishing a strategy for harmonising African HE aimed at: promoting cooperation in information exchanges, devising a possibility of standardising the curricula, attaining comparability of qualifications, and harmonising procedures/policies to promote professional and academic mobility (Mohamedbhai 2013 p.9), reinforcing quality within HE and easing processes that trigger HE systems to effectively inter-operate (Woldetensae 2009 p.3). Woldegiorgis et al. (2015 p.246) remark that the 'African harmonisation strategy' and the European Bologna Process have similar objectives as they both address: credit transferability, QA mechanisms, promotion of staff and student mobility, mutual recognition of academic qualifications, and creation of regional HE. According to the Association for the Development of Education in Africa (ADEA 2015 p.2) although the African Arusha Convention has aided the implementation of harmonisation at three levels, including: (1) national levels through the creation of national regulatory bodies; (2) sub-regional levels through the creation of the African and Malagasy Council for Higher Education (CAMES) and the South African Development Community (SADC); and (3) regional levels by a 20-member committee representing 19 ratifying African nations, whose secretariat is accountable to the UNESCO regional office for education in Africa (BREDA); there still exist many criticisms². Due to those raised against the Arusha Convention, some 'promising initiatives' have been implemented, such as the creation of CAMES, which in collaboration with ADEA and the Association of African Universities (AAU) have been

²For more on the criticisms of the Arusha Convention, see ADEA (2015) on http://www.adeanet.org/en/system/files/policy_brief_harmonization_en.pdf.

authorised to adopt the 'Licence-Master-Doctorat approach' (LMD). This will speed the promotion of mobility and mutual recognition of qualifications among member states which are predominantly Francophone.

In the CEMAC African region, the LMD was a political decision adopted by CEMAC heads of state (Eta 2015). According to the CEMAC Council of Ministers (CEMAC 2006), within the CEMAC region the LMD action lines are:

- Professionalisation of educational programmes;
- Introduction of the credit system;
- Implementation of two-programme system (undergraduate and postgraduate); and three degrees: Bachelor's, Master's, and Doctorate;
- Adoption of nationally, sub-regionally, and internationally comparable readable certificates;
- The 'semestrialisation' of training periods (Eta and Vuban 2017 p.347).

QA has not featured among any of the action lines in this context. However, Nyborg (2004 p.4) notes that the Bologna Process has had consequences for national legislation; Cameroon, a signatory state to the CEMAC convention, has been compelled to implement the LMD in its HE system (Eta 2015). Eta and Vuban (2017 p.348) remarked that the LMD objectives were adapted by the Cameroon Ministry of Higher Education to harmonise the dual-degree structure (Doh 2008). Due to the bilingual nature of the Cameroonian HE system, the Anglo-Saxon HE system called it BMP (Bachelor's-Master's-PhD; Vuban 2018) or BMD (Bachelor's-Masters'-Doctorate; Mngo 2011) in accordance with titles of degree structures (Eta and Vuban 2016). According to the Ministry of Higher Education (2007 p.2-3), the LMD/BMP/BMD has three broad and nine specific objectives. The LMD/BMP/BMD in Cameroonian HE is meant to:

- Enhance social, cultural, and human development through senior staff training with a strong sense of citizenship; respond to the challenges of the Millennium from both Central African sub-regional and national levels;
- Ensure national economic development and graduate employability;
- Promote research to aid outreach in partnership with the private sector.

The specific LMD objectives in Cameroon (Ministry of Higher Education 2007) include: (1) ensuring training is internationally flexible and comparable; (2) fostering student mobility; (3) ensuring certificate equivalences; (4) fostering understanding of training grades and levels of professional integration; (5) fostering the possibility of

professional integration among students by establishing efficient applied and academic disciplines; (6) promoting transversal skills including mastery of ICT and modern languages; (7) developing new methods of teaching while integrating distance learning, alternating training, electronic (e-learning) and ICT; (8) instituting reforms in teaching programmes to ensure diversification of training courses in potentially lucrative fields; and (9) forming a new generation of productive graduates who can adapt in a fast dynamic global context. This shows that QA was not adopted as part of LMD/BMD/BMP in Cameroonian HE. Most participants in the study raised that although QA is part of the European Bologna Process, they do not understand why QA is not part of the Bologna Process/LMD/BMD/BMP in Cameroon. This indicates the Bologna Process QA agenda is a solution-based mechanism, appropriate for solving quality concerns in HE, but a neglected option in Cameroonian HE.

According to Vuban (forthcoming), the non-adoption of the Bologna Process QA agenda stems from three arguments/causes. First, a systemic relationship in the adoption/adaptation of the Bologna Process/LMD reform exists between CEMAC and Cameroon, which explains the non-adoption of the Bologna Process/LMDQA agenda in these contexts. QA was never adopted at the CEMAC regional level as part of the LMD reform, impacting strongly on Cameroon from a national level leading to the non-adoption of QA as part of LMD/BMD/BMP reform in the latter.

Second, there are two ways in which the Bologna Process has impacted on reforms outside Europe as while some nations seem to pilot the Bologna tools and action lines like QA procedures and diploma Supplement on an *a-la carte* basis (or piece-meal basis); other nations adopt action lines wholesale to permit them restructure their HE systems following the three-cycle Bologna model (World Education News + Reviews [WENR] 2007). Author (submitted manuscript) argues that the non-adoption of QA as part of the LMD action lines in CEMAC and LMD/BMD/BMP in Cameroonian HE originate from the fact that the Bologna Process in these contexts have been adopted on an *a-la carte* or 'piece-meal' basis.

Third, while the Bologna Process has been an ongoing activity in Europe along with more ministerial meetings, more action lines adopted, and existing actions monitored like QA; however, in Cameroonian HE, the LMD/BMD/BMP has been an event but not a process, otherwise, the ongoing activities of the European Bologna Process would have been an integral feature in Cameroon.

In addition to Vuban's three arguments, the fourth argument is that although the Bologna Process has led to global, regional, sub-regional and national harmonisation of HE systems which may make one to easily conclude that there is complete/total convergence or harmonisation of HE systems, however, using individual Bologna Process action lines to examine the process of harmonisation across contexts presents a different perspective. To this effect, I would say there exist two distinctive categories of harmonisation which I describe as 'surface harmonisation' and 'deep harmonisation'. With 'surface harmonisation' it is easy to tell (or clear) that HE systems are moving closer towards each other and are doing seemingly the same things even if they are not implementing all agreed upon action lines. In other words, 'surface harmonisation' superficially considers what goes on across HE systems - such as the Bologna Process reform. 'Deep harmonisation' considers details of what goes on across HE systems as prescribed by agreed upon action lines adopted by signatory states. With 'deep harmonisation' the extent to which action lines are implemented across HE systems are considered bringing about divergence and convergence. 'Deep harmonisation' occurs because individual institutions, nations, regions and sub-regions tend to implement policies, programmes, processes, action lines (and every other indicator used for ensuring harmonisation) based on their contextual realities. It is easier to identify areas of divergence/differences than convergence/commonalities in 'deep' than 'surface' harmonisation. This explains why from a 'deep harmonisation' perspective, I have been able to spot that although some form of harmonisation of HE systems exists in the advent of the Bologna Process from international, regional and national perspectives, the Bologna Process QA agenda has not been adopted in some regions (such as CEMAC) and nations (such as Cameroon) although 'surface harmonisation' of HE systems exists across contexts using the Bologna Process. In other words, I argue that the Bologna Process in Cameroon was adopted from a 'surface harmonisation' perspective.

These four arguments confirm that QA is a neglected pillar of the Bologna Process/LMD reform in Cameroonian HE and the reason why there still exist some unresolved quality concerns in this context needing attention. There has been no extant research regarding the Bologna Process QA agenda in Cameroonian HE, which justifies the worthiness of this article. The lone paper that analyses some concerns of the Bologna Process/LMD/BMD QA agenda in this context (Vuban, forthcoming) is not yet published, and this addresses quality concerns related to: the educational

content; personnel; professionalisation; 'private education syndrome'; and biculturalism. This paper importantly provides room to discuss more quality concerns caused by the negligence of adopting the Bologna Process QA agenda in Cameroonian HE. Therefore, the aim of this article is:

- To further examine some unresolved quality concerns encountered as a result of the negligence of adopting the Bologna Process QA agenda in Cameroonian HE.

This article also presents literature on existing advantages and concerns related to QA in HE, a quality theoretical framework known as Total Quality Management (TQM), methodology of the study, findings, conclusion, and references.

Existing advantages and concerns related to QA in HE

The institutional agenda for QA and national educational policy-making/reform has been connected to the Bologna Process (Esyutina, Fearon and Leatherbarrow 2013; Palfreyman 2008; Jakobi and Rusconi 2009). Quality is defined as satisfying the expectations of customers (students/parents/businesses/society), conforming to specifications or value, loss avoidance, conforming to requirements and fitness for use (Stensaker 2007).

According to Van der Bank and Popoola (2014 p.404–405), advantages of QA in HE include providing every student with an equal opportunity to learn and involvement of students in self-assessment in the learning process. QA provides essential information/processes regarding continuous improvement in training and education and the ability to benchmark programmes with other institutions, even internationally. It establishes an intellectual context in which academics become responsible for the evolution of their own academic/professional lives. Graduate employment is possible when quality education is provided. Quality in HE promotes responsibility and greater autonomy through an emphasis on self-assessment processes.

However, according to Task Force (2000 p.23–25), university lecturers and students in developing nations (such as Cameroon) suffer from peculiar issues that affect the quality of HE. While lecturers suffer from poor salaries and low incentives, outdated rote-teaching methods, staff recruitment concerns due to issues surrounding independent scholarships and academic freedom, concerns regarding the politicising of HE and lecturer absenteeism (p.23–24), students have their own crises. Task Force (2000 p.24–25) note that students suffer from difficult study environments including overcrowded classrooms and limited facilities, poor living conditions and services, poor transition from secondary to HE, concerns with selection criteria, lack of

remedial programmes, financial constraints, infrastructural maintenance, and managing research. Central problem areas governing QA within the Bologna Process in Europe from a student standpoint (Klemenčič 2009) revolve around inadequate funding of HE, curricula modernisation, skill development, and learner-centred teaching. Using principles of Total Quality Management (TQM) is perceived to be a workable strategy used in addressing quality concerns within organisations (HE inclusive).

The Total Quality Management (TQM) theoretical framework as a tool for ensuring quality in higher education

According to Sudha (2013), the advent of industrialisation and the adoption of a new scientific approach to management meant that quality was of central concern. TQM, originated from the United States, was transferred to Japan and was diffused and extended to North America and Europe (Grant, Shani, and Kristan 1994) – hence a cross border quality theoretical framework.

Sallis (2002) presents a chronology of the quality movement: the pre-1900s were characterised by quality as an integral aspect of craftsmanship. Between 1900 and 1920, emphasis was laid on quality control by foreman. The 1920s and 1940s were characterised by quality-control inspections. From 1940 to 1960, focus was on statistical process control. Between 1960 and 1980, efforts were made to ensure quality assurance and Total Quality Control. Between 1980 and 1990, Total Quality Management (TQM) was stressed. From 1990 to present, the focus has been on TQM, the culture of continuous improvement and organisation-wide quality management. According to Ali and Shastri (2010), The World Bank and UNESCO reports illustrate that social and private returns of HE are less (1%) than those of primary (25%) and secondary education. This has triggered thoughts about reducing subsidies for HE. Consequently, there have been attempts to raise the quality of, and boost multinational financial support for HE (Mbua 2003).

Although many theories of TQM exist, this paper focuses on Crosby's TQM theory. According to Crosby's four absolutes of quality management (Crosby 1992):

- Individuals define quality based on conformance to requirements;
- The best way to ensure quality is through prevention;
- Zero Defects are the performance standards for quality; and
- Quality is measured by the price of nonconformity and not indexes.

Relating Crosby's theory of TQM and his four absolutes to education, educational stakeholders define quality education based on educational norms and expectations. Richardson (1999) notes that norms and ground rules encourage behaviours that help individuals attain educational goals and objectives and discourages negative behaviours in HE. According to Farooq, Akhtar, Ullah, and Memon (2007), the aim of zero defect is to ensure that all HE stakeholders do things correctly by matching educational programmes with the organisation's (HEIs') personality. Alghamdi (2016) defines zero defects as '...commitment to success and the removal of failure; errors can be removed based on the willingness of institutions; and seeking to achieve zero defects tends to enhance profits through saving costs'. HEIs must guard themselves against citizens' large-scale criticisms in the wake of financial constraints (Levin 1998) by providing quality education – hence addressing the price of nonconformity. According to Alghamdi (2016) Crosby's fourteen steps to improve quality management include:

- Management commitment; setting a clear quality policy statement;
- Quality improvement team; everyone must be involved in improvement efforts;
- Quality measurement; showing nonconformance issues that enable the aim;
- Costs/price of quality; determining costs and values of quality;
- Quality awareness; increasing awareness among the organisation;
- Corrective action; working with employees to eliminate poor quality;
- Zero defects planning; every member of the HEI work to achieve zero defects;
- Supervisor training; educational leaders should identify their roles in the development process through training;
- Celebration of Zero Defects day; to create the approach of zero defects, informing staff there will be change;
- Goal setting; ensuring specific and measurable goals;
- Error-cause removal; communication between staff and leadership regarding difficulties in application;
- Appreciation/Recognition; staff recognition, such as prizes or certificates;
- Quality councils; involving professionals' investigation into how issues can be addressed;

- Repetitions of actions; quality of improvement never ends.

There are five barriers to TQM (Sebastianelli and Tamimi 2003) including: lack of customer(student) focus, inadequate resources for TQM, lack of leadership for quality, lack of planning for quality, and inadequate human resource development/management. Owlia and Aspinwall (1996) present a conceptual framework with six criteria, representing quality dimensions in HE including:

- Tangibles: sufficient equipment/facilities, ease of access, visually appealing environment, support services;
- Competence: sufficient staff, theoretical/practical knowledge, qualifications, teaching experience, communication;
- Attitude: understanding students' needs, willingness to help, availability for guidance/advice, personal attention;
- Content: relevance of curriculum to future opportunities, communication/teamwork, flexibility of knowledge, cross-disciplinary, primary knowledge/skills.
- Delivery: effective presentation/sequencing/timeliness, consistency, examination fairness, feedback from students; and
- Reliability: trustworthiness, valid awards, handling complaints, solving problems.

II. METHODOLOGY

This article aims to further examine unresolved quality concerns due to the non-adoption of the Bologna Process QA agenda in Cameroonian HE. Ball (1990) argues that inattention has been paid to research methodology particularly educational policy literature as it tends to be more dominated by critique/commentary than empirical research. Participants were asked about the types of HE reforms/policies they were aware of in Cameroon today, to conceptualise/explain these policies and problems. They were aware of the Bologna Process (LMD/BMD/BMP), professionalisation, QA, harmonisation, governance, and internationalisation and so on. Participants conceptualised these reforms/policies and explained their problems. Most participants said although QA is part of the European Bologna Process, they do not understand why QA is not part of the Bologna Process/LMD/BMD/BMP reform in Cameroon. Based on participants' perceptions and the four claims raised above, I argue examining some problems plaguing QA in Cameroonian HE is a timely venture in

policy studies/the Bologna Process community Cameroonian HE.

Data was collected in Cameroon in Yaounde, Bamenda, and Buea in the following institutions: Cameroon Christian University (CCU), University of Buea (UB), Cameroon's Ministry of HE (MINESUP) and many more. The study employed a qualitative research design (Poovey 1995) using interviews and focus group discussions. Based on Patton's perspective regarding selecting sample sizes in qualitative inquiries and purposeful and snowball sampling techniques, the sample size of this study was obtained comprising of 56 interviewees (including heads of departments, faculty officers, vice deans, and many more). Two focus group discussions were conducted on four students and four lecturers (totalling eight); meaning a grand total of 64 participants were used. Ethical considerations included avoidance of harm, anonymity, utilisation, and protection of data, right to withdraw, informed consent, reciprocity, and confidentiality. Participants had pseudonyms based on their status, followed by a letter, abbreviation/name of their institution, and year to ensure anonymity (e.g. University Official-A;UB:2015).

Credibility and trustworthiness of the research methods and data were ensured through crosschecking by my supervisor, Thesis Advisory Panel (TAP) members and research participants. Thematic analysis was used in analysing data with themes generated using NVivo software. Themes were based on common patterns or similar ideas of participants' responses. Various types of HE systems in Cameroon have been used including public/state universities (French-speaking/Francophone; and English-speaking/Anglophone/Anglo-Saxon universities), private universities and African/global universities, with comparisons where necessary to illustrate HE system quality concerns across these contexts. Although data is very rich, some literature has been used to boost criticality and duly referenced; as well as self-reflexivity (Brinkmann and Kvale 2015).

Due to the fact that QA is also a neglected pillar of the LMD in the CEMAC region, findings in this study can be transferred to the CEMAC region; (and perhaps other nations across the globe which have adopted the Bologna Process/LMD reforms but have not adopted the Bologna Process QA agenda) to inform policy and practice.

III. FINDINGS

This section focuses on the untold story of quality concerns in Cameroonian HE, which would have been solved by the Bologna Process QA agenda. Here, quality concerns related

to: student admission; university ranking; periodic monitoring, follow up and mentoring; and lack of resources are addressed. The term ‘university’ is also synonymously referred to as ‘higher education institution’ (HEI) or simply higher education (HE).

Concerns related to the nature of student admission

According to some interviewees, quality in Cameroonian HE is of concern in relation to student admission. An interviewee discussed what goes on at the Francophone and Anglo-Saxon universities in Cameroon:

If you take the University of Buea [Anglo-Saxon university], we have entry requirements in terms of points. In the Department of Journalism and Mass Communication for example, if you have anything less than eight points you can't be admitted into the department....None of these Francophone universities in Cameroon have entry requirements be it the University of Dschang or the University of Yaounde which pose quality concerns. After obtaining GCE“A” Levels, students who try to secure admissions into the University of Bamenda or University of Buea [public Anglo-Saxon universities] but are unable to do so either because they don't have five “O” Levels as it is the case with this university [University of Bamenda]or have passed in four subjects including English Language and excluding Religious Studies while satisfying other requirements as it is the case with the University of Buea, seek admission in Francophone universities.(University Lecturer A;UBa&UB:2015).

This quotation indicates a clear difference between public/state Francophone (French-speaking)universities and Anglophone (English-speaking/Anglo-Saxon)universities in Cameroon regarding student admissions. While Francophone universities practice an open-door policy (entry requirements and points not considered), Anglophone universities practice the selection criteria policy (entry requirements and points considered). In the aftermath of admitting Anglophone students who could not secure admissions in Anglophone universities in Francophone universities, such students face difficulties in understanding instruction delivered in French; lecturers also face high student-teacher ratios and administrators face problems controlling, governing, and managing large number of students, thus hindering quality. Despite the open-door admission policy in Cameroonian French-speaking universities, a participant narrated that Anglophone

universities also suffer from large intake and student admission problems, as every student wants to study in Anglophone universities because of the quality provided, career prospects and possibility of securing admissions abroad which is more realisable when studying in Anglophone universities:

If you ask Francophones there right now, everybody would want to come to Anglophone universities rather. This is because the quality is there, in terms of quality of: staff; teaching methods, the approach and commitment;and influence from the language [English] because English is a universal sort of language and you have a greater opportunity of having jobs than if you study only in French which narrows your scope and prospects of going to do postgraduate studies out of here. (University Lecturer A;UBa and UB:2015).

The crave for student admission into Anglophone universities is a problem from a quantitative perspective. Another interviewee recounted that ‘...This year we admitted into the University of Buea closed to 6,500 students and there are so many who were not admitted. So, each time we receive about 12,000 to 13,000 applications for admissions...’ (University Official/Lecturer-D;UB:2015). There is risk to quality due to high demand for student admission in Anglophone universities resulting in exploding student population and consequently high student-teacher ratios, lack of infrastructure, and facilities to cater for students' needs. Some participants remarked that admission into some private HEIs in Cameroon is poor as students who failed Advance Levels and could not seek admissions into state universities are admitted. This is known as ‘private education syndrome’ (Vuban, forthcoming). This evidence confirms that QA concerns in Cameroonian HE, such as that related to the nature of student admission, would be tackled if the Bologna Process QA agenda was part of the LMD reform.

Concerns related to ranking of universities

According to Voegtler, Knill, and Dobbins (2011) the Bologna Process has mounted pressure on national governments to ensure their legitimacy. Procedures of evaluation and reporting through Stocktaking reports have produced rankings to compare HE systems among signatory states (Voegtler et al. 2011). According to some participants, the global ranking of universities has served as a disincentive for Cameroonian HE. Findings indicate that the

lack of well-developed universities in Cameroon affects university ranking. Thus:

...when we talk of a university as far as I am concerned, a complete university should have [about] 17 faculties. I don't know of one in Cameroon that has this! Cameroon has not taken time to really develop one single university. Recently, there was a publication on grading universities in Africa. Cameroon's University of Dschang came number 800 in Africa! This just tells you what I am trying to talk about. Universities in Nigeria, South Africa really dominated! It means that we still have a lot to do [in terms of creating quality faculties among others]...If we find the University of Dschang being number 800 in Africa how much more in the world? We cannot even compare with the rest of the world! (University Assistant Lecturer-D;CCU:2015).

This denotes the lack of quality educational resources and capacity (faculties) among Cameroonian universities. The Times Higher Education World University Ranking illustrates that African universities have low standards compared to others globally. Between 2011 and 2015 two South African universities were placed between the 100th and 340th position on the league table (Uzochuku 2017). The education sector of Africa cannot be compared to Europe, North/South America, or Asia because of its numerous problems making it a low world-class standard³. However, the global benchmarking of HE systems to promote comparability (Voegtli et al. 2011) has failed to consider diversity and contextual realities across HE systems, particularly in developing nations such as Cameroon, which poses concerns for quality global rankings. Despite low positions on league tables, Cameroonian universities may be trying their best to provide 'quality' education, which has either aided students' admissions or fostered graduate employability abroad. Other participants said:

Look at what is happening in Africa concerning the ranking of universities. The ranking is done

according to western standards! (University Official-G;BUST:2015).

Today, we are measuring our yardstick by the ranking of universities. Cameroon doesn't have any ranking institution to rank us. We depend on ranking institutions in Spain, France, Germany, US, China and so on to rank us...When you say a university is ranked as per the number of Nobel knowledge be they Peace or Science or whatever, then you are knocking out African universities including South Africa [and Cameroon]. It's only four [universities] in South Africa and two [universities] in Egypt that have been ranked [globally]. So, if you use that criteria of a Nobel Prize winner then you will have less than 10 universities [globally] ranked from Africa [and Cameroonian universities will be absent]. (University Official-B;UYI:2015).

These quotations indicate that ranking of universities has been a westernised or globalised practice. Africa, and Cameroon in particular, lack ranking or accreditation institutions based on their existing educational contextual realities. This affects the definition of quality education and the scope of quality indicators from a global standpoint, disincentivising African and Cameroonian HE. Mohamed bhai (2013) remark that the lack of national QA accreditation mechanisms in many African states has been a major handicap. The second quotation further stresses that in addition to educational facilities (such as quality/quantity of faculties used for quality comparisons across HE systems), another ranking criterion and quality determinant is that of Nobel Prize awards, which tend to be a disservice to Cameroonian universities because Cameroon has not been awarded a Nobel Prize and therefore comparisons on quality with global HE systems cannot be made this way.

This confirms that QA concerns in Cameroonian HE would have been tackled if the Bologna Process QA agenda was adopted as part of the LMD reform. Task Force (2000) suggest that institutional accountability should be the responsibility of those concerned with governance who are responsible to periodically test and verify the standards of quality.

Concerns related to periodic monitoring, follow up, and mentoring

According to participants, concerns related to periodic monitoring, follow up, and mentoring is a major challenge for quality control in Cameroonian HE:

Sometimes in state universities, they

³ See problems plaguing African HE systems which pose concerns for quality under existing advantages and concerns related to QA in HE above.

[Cameroonian government] give what is known as research allowances and it is expected that they [university teaching/research staff] do research. But I have my own way I look at this...., the government does not even care if these people do research. You [Cameroonian government] give somebody money to do something, you don't care if he [or she] [university lecturer(s) in public universities] uses it to do the thing. Why, because even those who end up doing research, the government does not use the data for policy. They just sit in their political meetings and take decisions. They don't care what the researchers are up to. What questions they want to answer and what researchers have as answers for them. So, you do research, your data remains in your drawers for the rest of your lives. It is never used! (University Official/Lecturer-C;BUST:2015).

This illustrates that poor follow up in Cameroonian HE serves as a major indicator for quality concerns, which can be viewed as: (1) the Cameroonian government restricts research allowances to state universities, while private universities are financially unsupported, posing research crises and quality concerns in the latter; (2) there is lack of follow up of research by the Cameroonian state (funder) as funding research is merely a state function than state investment in HE; (3) 'politics in education' partly explain why research in Cameroonian HE is useless as data is never used to inform policies/practices. Some interviews also stressed that quality concerns in Cameroonian HE stem from the privatisation of HE and poor mentorship:

Private universities in Cameroon are supposed to be mentored by public higher institutions but they [public universities and MINESUP] have gotten the concept of mentoring up-side-down. Wrong! With mentoring they [public universities and MINESUP] only look for results. If we [public universities and MINESUP] should mentor, we [public universities and MINESUP] should consider mentoring everything that is inputs, processes, outcomes, and feedback. We [public universities and MINESUP] do not have to mentor only results! If you are mentoring people doing certain things, you are looking at programmes, structures, processes, examinations, quality of teaching, course outline, curriculum relevance, and all that. That is mentoring! We [public universities and MINESUP] are supposed to be mentoring, in theory! You know we have more than 200 higher

education institutions which are private in this country! What are they [MINESUP and private HE providers] opening them for? Are they [MINESUP and private HE providers] happy to be stealing money from poor people? People just get crazy!!! (University Official-A;UB:2015).

This illustrates that although private HEIs in Cameroon are mentored by public HEIs, such mentorship is theoretical not practical. It seems private HEIs in Cameroon are just being assigned to state universities for mentorship for the sake of it but where actual mentorship is needed, this is absent from either a policy, programme, practice and process perspective. That is the mentorship of private universities by state universities in terms of structures, examinations, quality of teaching, course outlines, curriculum relevance among others are absent – thus posing quality concerns. Participants also noted that, the lack of follow up in public universities causes poor lecturer assiduity as they just do anything they want; go for lectures anytime they want; provide students with just manuals without trying to direct them on what to do; and some of them even show up just towards the end of the semester and run down (teach) the whole course(s) of the semester within just say two weeks – thus leading to quality concerns. This confirms that QA concerns in Cameroonian HE would have been tackled if the Bologna Process QA agenda was adopted as part of the LMD reform.

Concerns related to the lack of educational resources

Concerns about the lack of educational resources addresses a broad range of resources: human, material, financial, and time resources. Task Force (2000) affirms that problems faced by HE can relate to poor resourcing. Time is a typical resource constraint in Cameroonian HE:

....most teachers do not have the luxury of time to think how knowledge acquired in class can be applied out of the classroom. This is the major challenge they have because they have to think the application themselves but they do not have the luxury of time because as I said the teachers do not have a good pay package. So, they spend most of their time teaching extra classes [in other universities] in order to make earnings meet. So, this becomes a difficult problem for the provision of quality education. (University Official-A;UCAC:2015).

The lack of teaching time makes teaching difficult as well as the application of knowledge outside the classroom, essential for professionalisation/graduate employability (Eta

2017), and to extend knowledge in the economy (Klemenčič 2009). Poor salaries are one major barrier to time management for lecturers as they divert time meant for instructional delivery to seek employment in other universities to increase their income. This poses problems for assiduity in class, leading to quality concerns. Furthermore, participants also mentioned the lack of material resources/facilities including electricity, internet, equipment and infrastructure which pose concerns for quality. To illustrate financial constraints, an interviewee referenced the University of Bamenda:

One major problem is finance. Currently, the University of Bamenda [for instance] is just coping with what it has in terms of money. So, we still need the financial support to build new classrooms, equip libraries and get things worth running the universities. (University Official-K;UBa:2015).

This illustrates that problems Cameroonian HEIs face stem from inadequate finance needed to build and equip infrastructure and to hire staff needed to ensure effective quality education. Task Force (2000) affirmed that financial constraints pose worse conditions for teaching and learning. Cameroonian HE suffers from lack of qualified personnel caused by brain drain. An interviewee said:

Sometimes, some policies will not work because the brains that should look into those policies to make some sense are not involved; or they have been drained out of the system and this is a major aspect of quality assurance problems and quality control problems. (University Official/Lecturer-C;BUST:2015).

This indicates that as university staff suffer from brain drain, this poses concerns for QA and quality control in relation to policy making and policy implementation. Teachers also suffer from work overload, low pay, and lack of expertise. These quality concerns would have been solved if the Bologna Process QA agenda was adopted as part of the LMD reform.

IV. CONCLUSION

This article examined undisclosed/unresolved quality concerns due to the non-adoption of the Bologna Process QA agenda in Cameroonian HE, caused by (1) the Bologna Process/LMD in Cameroonian HE has been adopted on an *a-la-carte* basis (World Education News + Reviews [WENR] 2007), whereby some action lines have been adopted, while others have not been adopted - for instance QA; (2) the Bologna Process/LMD in Cameroonian HE is an event not a process; (3) the systemic relationship between CEMAC and

Cameroon in the adoption/adaptation of the LMD explain that not applying QA at the CEMAC regional level influences the same in Cameroon; and (4) the Bologna Process in Cameroonian HE has been adopted from a surface harmonisation perspective. The article examined QA concerns such as that related to: student admission; university ranking; periodic monitoring, follow up and mentoring; and lack of resources. Central problem areas governing QA within the Bologna Process in Europe from a student standpoint (Klemenčič 2009) revolve around inadequate funding of HE, curricula modernisation, skill development, and learner-centred teaching. QA concerns related to the Bologna Process therefore remain a central focus. The Total Quality Management (TQM) theory (Alghamdi 2016) could be used to solve quality concerns in HE (Sudha 2013). Alghamdi (2016) notes that Crosby's 14 TQM steps to improve quality management include: (1) reinforcing management commitment; (2) ensuring quality improvement team; (3) promoting quality measurement; (4) examining costs/price of quality; (5) ensuring quality awareness; (6) considering corrective action; (7) Zero Defects planning; (8) promoting supervisor training; (9) celebrating Zero Defects day; (10) establishing criteria for goal setting; (11) ensuring error-cause removal; (12) encouraging appreciation/recognition; (13) using quality councils; and (14) repeating actions. To better understand quality in HE, a holistic perspective of quality in terms of its conceptualisations, concerns, contributions of HE stakeholders in the provision of QA and quality control, the role of QA and accreditation agencies, QA strategies, and QA theories is needed. I recommend researching into these areas to boost the quality of the Bologna Process/LMD across European, African, CEMAC and Cameroonian HE systems.

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DECLARATION OF INTEREST STATEMENT

Not applicable!

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BIOGRAPHICAL NOTES ON CONTRIBUTOR

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Mapping of Scientific Production on Intellectual Property: A Bibliometric Analysis

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Abstract—The purpose of this article was to analyze the profile of bibliometric production published on intellectual property in the interval of 20 years, in the period from 1998 to 2018. The research was conducted in the scientific databases of the Google Scholar platform and Scopus. The searches carried out in the databases took place through the insertion of the keywords "propriedade intelectual" (term in Portuguese) and "intellectual property" in the field referring to the "title" of the cited databases. During the searches 37,099 publications related to the topic intellectual property were identified. Among the areas of knowledge identified in the research, the one that had the most prominence in the number of publications was Social Sciences, with 1,237 articles published. With regard to the authors, the highlight in the amount of publications was to the American professor Keith Eugene Maskus, with 11 articles published. According to the survey, the journal with the highest number of publications was the Journal of Intellectual Property Rights, published by the Indian National Institute of Communication and Scientific Information Resources, with 73 articles. It is worth noting that most of these articles were written in English, in total 2,399 articles were published in that language. The country with the largest number of publications on intellectual property was the United States, with 767 articles published, 27 of which were published by the University of California, Berkeley.

Keywords—Bibliometrics, Scientific Production, Intellectual Property.

I. INTRODUCTION

Over the years, bibliometric research has played a key role in academic studies, guiding scientific production and technological development in several areas of knowledge.

A bibliometric research aims to show the development of academic studies in a specific technological area, identifying its main researchers, the institutions that present the largest volume of publications, as well as the regions and countries that excel in these academic productions.

In addition, a bibliometric research is presented as an indispensable tool in the analysis of academic scientific productions, because the data in these studies show the evolution and the advances occurred in a certain area of knowledge [16].

The bibliometric research carried out in this work is about intellectual property. Intellectual property is a protection granted to human intellectual creations, granting its inventors the right to obtain financial rewards for the use of them, for a determined period of time [2].

The protection of intellectual property enables the socioeconomic and technological development of a country by encouraging innovation, creativity, technical and scientific development and the expansion of various productive sectors of the economy [1].

For Oliveira and Boente [10] technological innovation is the primary condition for the evolution of bibliometrics studies, becoming an extremely indispensable tool to assist the researcher in the search for data that can provide support to the field of scientific production and dissemination of knowledge.

Therefore, this research aimed to analyze the academic scientific production related to the area of intellectual property in the last 20 years (from 1998 to 2018), providing researchers and academy with an overview of scientific-technological studies and advances in this area during this period.

This article is divided into five sections. The first section presents an introduction on the topics covered in this research. The second section presents a brief review of the literature related to the topics: bibliometrics and intellectual property. The third section shows the methodology used in the development of this research. The fourth section presents the analysis of the data obtained in the research. The fifth section brings the final considerations on the research.

II. REVIEW OF LITERATURE

Intellectual Property

The first manifestations on the use of the intellectual property occurred in the years of 1330, with the concession of the monopoly for the manufacture of glasses by the King of France Philippe de Valois and of 1406, with the hiring of craftsmen of Lombardy by the government of Florence, Italy, for the manufacture of products intended for the textile industry for a period of three years. During these three years, the artisans of Lombardy had exclusivity on the products developed, as well as the exemption of taxes on the production and commercialization of the same, but in contrast, they had the obligation to transfer the knowledge acquired in the manufacture of these products to the local artisans [11].

During the Middle Ages, the privileges were granted by the Monarchs, and were based exclusively on subjective criteria such as good will and sympathy. In addition, the terms of validity of the concessions varied according to the characteristics of the privileges that were granted to its inventors [9].

Other historical facts that marked the scene of international intellectual protection were: The United States Constitution of 1787 and the French Law of 1790. Both established in their articles that the protections of inventions were attributed by means of patents to their inventors [11].

The need for international protection of intellectual property was strengthened in 1873 in the city of Vienna from a manifest by exhibitors refusing to participate in an international invention show, arguing that it would not be possible to guarantee the protection of their inventions, under the risk of being improperly copied by other inventors and subsequently commercially exploited [8].

In view of this scenario, the first instruments of international protection related to intellectual property appeared: The Paris Convention (CUP), in 1883, which dealt with the protection of industrial property, and the

Berne Convention (CUB) in 1886, to copyright protection.

The Paris Convention of 1883 originally involved 14 countries and was based on three principles: 1) the independence of the granting of patents between the signatory countries, which determined the validity of patent concessions only at the national level; 2) that of equal treatment for nationals and foreigners, which assured all signatory countries the same advantages as those provided for in their legislation; 3) and the right of priority, which guarantees the applicant for a patent of invention or a model of utility, the right to deposit it in other signatory countries, within a maximum period of 12 months, counted from the date of your first deposit [6].

In the international arena, another important instrument for the protection of intellectual property was the Patent Cooperation Treaty (PCT), signed in Washington, USA, on June 19, 1970, to develop the patent system and technology transfer among member countries. Through the PCT it is possible to simultaneously claim the protection of a patent of invention in several countries by submitting a single international patent application.

Intellectual property is a driving force for the technological, economic, scientific and social development of a country. Through its protection mechanisms, it is possible to ensure and guarantee the rights of ownership of various human inventions.

Bibliometrics

According to Silva et al. [14] *"The term bibliometric is derived from the fusion of the suffix 'metric' with bibliography, information, science and library respectively, are analogous or very close in nature, objectives and applications"*.

According to Vanti [18] *"bibliometric studies are also used to evaluate the productivity and quality of the scientists' research, by measuring them based on the numbers of publications and quotations of the various researchers"*.

Bibliometrics as a method has the advantage of *"softening the elements of judgment and producing quantitative results that tend to be the sum of many small judgments and judgments made by various people"* [13].

A bibliometric research allows the identification and description of a series of patterns in the production of scientific knowledge. In addition, it serves to estimate with quality and quantity, the production of published scientific articles on a particular theme, highlighting the main authors (researchers and institutions) involved in this process, who collaborate for the enhancement of science [4].

In Table 1 shows some of the main bibliometric indicators [17]:

Table. 1: Adapted from Splitter, Rosa and Borba (2012).

INDICATORS	CONCEPTS
Lotka's Law	Investigates the frequency distributions of the author of articles of a certain theme/area.
Bradford's Law	It investigates the frequency distributions of the number of articles published by periodicals of a certain theme/area.
Zipf's Law	It investigates the frequency distributions of the vocabulary of texts of a certain theme/area.
Number of publications by author, journal, institution or subject	Investigates the volume of publications of authors, periodicals, institutions or subjects of a certain area.
Number of co-authors/collaborators	It investigates the dynamics of the volume of research carried out in a collaborative way, either between individual or group research, or national and international.
Co-publications: publication with authors of different countries, institutions	It investigates the cooperation between representatives of entities and countries, in joint research, with the purpose of creating a matrix that shows the main partners and provides the description of the scientific network.
Number of citations	It investigates the impact of articles, journals and researchers on the basis of the number of citations.
Affinity Index	It investigates the relative rate of scientific exchange (between countries, institutions) by means of quotations.
Scientific links	Investigates and measures the influence of networks between different scientific communities.
Co-citations	It investigates the number of times that two or more articles are quoted simultaneously in one article.

For Vanti [18], The Bradford Law or Dispersion Law allows, "by measuring magazine productivity, to establish the nucleus and areas of dispersion on a given subject in the same set of journals".

The most popular indicators in bibliometric articles are based on counting the number of articles, journals, authors, authorships, institutions or quotes. Affinity indices, scientific links, and co-citations are rarely used,

as well as the frequency distributions used in the Lotka, Bradford, and Zipf Laws [17].

Traditionally, bibliometric studies are developed from information obtained from large databases, such as the Web of Science, Scopus, among others.

At the beginning of the 21st century, two phenomena occurred that modified the way researchers are using bibliometric indicators. One of them was the development of the open Google Scholar search engine, from 2004, by Google and the creation of Microsoft Academic Search, created in 2006 and relaunched as Microsoft Academic, in 2016. In addition to the two search engines mentioned, there is also the free software Harzing's Publish or Perish, created by the Australian researcher Anne-Will Harzing, and developed based on the Google Scholar platform. All these search mechanisms have been helping researchers in the development of bibliometric researches, allowing the use of several types of bibliometric indicators related to a particular theme. The second phenomenon responsible for this change, in the form of the use of bibliometric indicators by researchers, was the indexing of journals in large international databases, which has been occurring over the years individually or collectively [15].

In Brazil, the lack of indexation of Brazilian journals (areas of administration, accounting sciences, tourism, among others) in the collection of large databases has discouraged the creation of a culture of more sophisticated bibliometric indicators by the Brazilian scientific community until the beginning of the 21st century [15].

III. METHODOLOGY

"The method materializes as the set of several steps or steps that must be followed to carry out the research and which configure the techniques" [5].

The methodology used in this research had a quantitative and descriptive character, which initially had a bibliographical survey on the subjects bibliometrics and intellectual property, carried out through researches in scientific articles, dissertations, theses, seminars and periodicals of the area.

Then, bibliometric researches were carried out in the scientific production databases of the Google Scholar and Scopus platforms, from articles published in periodicals and annals of indexed congresses related to the subject of intellectual property. The time cut used in this research comprised the period from 1998 to 2018.

Bibliometric research is widely used to quantify the processes of written communication related to a particular topic [12].

The quantitative technique seeks the theoretical basis in bibliometric laws and principles, detailing and outlining the paths that must be taken to map the scientific production [19]. Filho, Junior and Siqueira [7] affirm that

the principle of bibliometrics is to analyze the scientific activity by the quantitative study of the publications.

Bibliometric studies also allow the measurement of the content of theses, articles published in annals and periodicals, among others, by means of analyzes referring to authors, citations and methodology [3].

The bibliometric research developed in this work had the following process steps: definition of the research theme; choice of databases; elaboration of search criteria; data collection and analysis of the results obtained.

As for the search criteria used in the academic production databases, keywords were inserted in the "title" field of the cited databases, obeying the time interval established by the research (between 1998 and 2018). The keywords used in the research were: "propriedade intelectual" (term in Portuguese) and "intellectual property".

After the data collection, the data were transported to a spreadsheet, where they were processed, organized and tabulated, generating statistical graphs related to the bibliometric indicators related to the topic addressed in this research.

IV. DATA ANALYSIS

Figure 1 shows the volume of articles related to the theme "propriedade intelectual" (term in Portuguese) published in the Google Scholar platform database from 1998 to 2018.

According to the data collected, 1,908 publications were identified over the analyzed period (20 years). This is equivalent to an average of 95.04 articles published per year. These figures show that studies in this area in Portuguese-speaking countries, especially in Brazil, have grown over the years, arousing the interest of researchers and institutions for the subject.

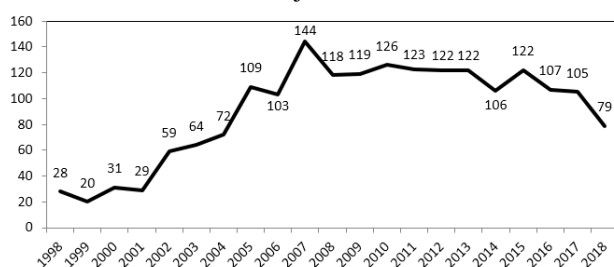


Fig.1: Number of publications with the title "propriedade intelectual" (term in Portuguese) in the Google Scholar database. Prepared by the authors (2019).

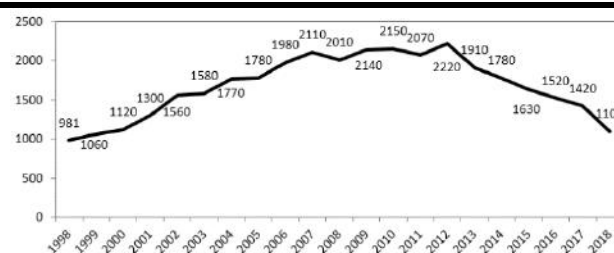


Fig.2: Number of publications with the title "intellectual property" in the Google Scholar database. Prepared by the authors (2019).

Figure 2 shows the volume of articles related to the theme "intellectual property" published in the Google Scholar platform database from 1998 to 2018.

Based on the data collected, a total of 35,191 publications were identified during the period covered by the term intellectual property written in the English language. This corresponds to an average of 1,759.55 publications per year. These figures show the interest of researchers and institutions in this area worldwide, showing the relevance of this theme to the scientific community.

Table 2 shows the authors with the highest indexes of publications related to intellectual property in the Scopus database within the analyzed period.

Table. 2: Authors with the highest indexes of publications on intellectual property in the Scopus database. Prepared by the authors (2019).

AUTHORS WHO PUBLISH THE MOST	AMOUNT
Maskus, K.E.	11
Naghavi, A.	9
Andersen, B.	8
May, C.	8
Saggi, K.	8
Cook, T.	6
Fromer, J.C.	6
Potkonjak, M.	6
Yang, C.H.	6
Bader, M.A.	5
Boldrin, M.	5
Chu, A.C.	5
Drahos, P.	5
Forman, L.	5
Granstrand, O.	5
Lemley, M.A.	5
Ostergard, R.L.	5
Rossi, F.	5
Samuelson, P.	5
Yang, D.	5

The highlight with regard to the number of articles published is for the American author Keith Eugene Maskus, professor of economics at the University of Colorado in Boulder, USA, with 11 articles published. The author has several articles published in the area of intellectual property and currently his research focuses on the international economic aspects of the protection of intellectual property rights.

Other authors that deserve attention in relation to the number of articles published in the area of intellectual property in the base of Scopus were: Alireza Naghavi, with 9 articles; Edward B. Anderson, Christopher May and Kamal Saggi, with 8 articles published each.

Table 3 shows the broader areas of published articles on intellectual property in the Scopus platform database. The highlight in relation to the number of publications was for the areas of Social Sciences, Business; Management and Accounting; Economics, Econometrics and Finance; Engineering; and Engineering.

Table. 3: Areas with the largest number of publications on the subject of intellectual property in the Scopus database. Prepared by the authors (2019).

AREAS THAT PUBLISH MORE ABOUT "INTELLECTUAL PROPERTY"	AMOUNT
Social Sciences	1237
Business, Management and Accounting	607
Economics, Econometrics and Finance	509
Engineering	440
Computer Science	313
Medicine	192
Arts and Humanities	182
Biochemistry, Genetics and Molecular Biology	113
Environmental Science	105
Agricultural and Biological Sciences	97
Engineering	82
Decision Sciences	72
Chemical Engineering	64
Materials Science	58
Pharmacology, Toxicology and Pharmaceutics	44
Earth and Planetary Sciences	42
Energy	40
Immunology and Microbiology	38
Multidisciplinary	37
Mathematics	31
Psychology	

Table 4 shows the journals that had the largest number of articles published on the subject of intellectual property in the Scopus database. The highlights with regard to the number of articles published were for the periodicals: Journal of Intellectual Property Rights, with 73 publications; and IntelktualNayaSobstvennost, with 61 articles published.

The Journal of Intellectual Property Rights is a legal journal covering intellectual property law and is published by the Indian National Institute of Communication and Scientific Information Resources. This journal was created in 1996 and publishes articles on case studies, patent reviews, technical notes on current issues of intellectual property law, literature reviews, world literature on intellectual property rights, national and international news, book reviews and conference reports covering topics on trademarks, patents, copyrights, trade secrets, and Internet laws.

IntelktualNayaSobstvennost is a Russian newspaper, which publishes articles related to engineering and technological media. The articles identified in this research have a correlation between the subject intellectual property and the areas cited.

Table. 4: Periodicals with the largest number of publications on the subject of intellectual property in the Scopus database. Prepared by the authors (2019).

PERIODICS MOST INTERESTED IN INTELLECTUAL PROPERTY	AMOUNT
Journal Of Intellectual Property Rights	73
IntelktualNayaSobstvennost	61
International Journal Of Intellectual Property Management	32
IIC International Review Of Intellectual Property And Competition Law	29
Research Policy	28
World Patent Information	28
Queen Mary Journal Of Intellectual Property	25
International Journal Of Technology Management	22
Prometheus United Kingdom	18
Journal Of World Intellectual Property	15
Technovation	15
Actual Problems Of Economics	13
Research In Developmental Disabilities	12
Espacios	12
International Journal Of Cultural Property	12

Journal Of Development Economics	12
Computer Law And Security Review	10
Journal Of International Economics	10
Ntut Journal Of Intellectual Property Law And Management	10
California Management Review	09

Table 5 shows the most prominent educational institutions in relation to the volume of articles published in the area of intellectual property. In the relation of these institutions it is possible to identify institutions of great renown in the academic environment, such as: The University of Oxford, Stanford University and Michigan State University.

The highlight of the number of publications was one of the most important and prestigious public universities in the world, the University of California, Berkeley, United States.

Table. 5: Educational institutions with the largest number of publications on the subject of intellectual property in the Scopus database. Prepared by the authors (2019).

UNIVERSITIES THAT MOST PUBLISH ABOUT THE THEME	AMOUNT
University of California, Berkeley	27
George Washington University	20
University of Washington, Seattle	18
University of Toronto	17
University of London	17
Australian National University	16
University of Oxford	16
University of Colorado at Boulder	15
Stanford University	15
Yale University	14
Duke University	14
Zhejiang University	13
City University of Hong Kong	13
Alma Mater Studiorum Università di Bologna	13
Maastricht University	13
Michigan State University	12
London School of Economics and Political Science	11
National Taiwan University	11
Cornell University	11
Max Planck Institute for Innovation and Competition	11

Table 6 shows the countries that had the largest number of publications on intellectual property on the Scopus platform. The ranking of the five countries with the

highest number of publications is led by the United States, followed by the United Kingdom, China, India and Australia. It is worth mentioning that Brazil occupies one of the last positions in this ranking, with only 42 publications.

Table. 6: Countries with the largest number of publications on the subject of intellectual property in the Scopus database. Prepared by the authors (2019).

COUNTRY THAT ARE MORE INTERESTED IN INTELLECTUAL PROPERTY	AMOUNT
United States	767
United Kingdom	256
China	152
India	144
Australia	122
Germany	100
Canada	98
Italy	65
Taiwan	65
Japan	62
France	58
Netherlands	50
Russian Federation	50
Spain	45
Switzerland	45
South Korea	43
Brazil	42
Hong Kong	37
Sweden	32
South Africa	31

Regarding the language of the publications, it is observed in Table 7 that the highlight is for the English language, in view of the universality of this language. In addition to publications in the English language, there are also publications in several languages, which shows that the subject of intellectual property has a worldwide scope and arouses the interest of researchers worldwide.

Table. 7: Languages with the largest number of publications on the subject of intellectual property in the Scopus database. Prepared by the authors (2019).

COUNTRY LANGUAGES THAT MOST PUBLISH ON INTELLECTUAL PROPERTY	AMOUNT
English	2399
Chinese	39
Spanish	38
French	31

Russian	18
German	16
Portuguese	16
Ukrainian	10
Japanese	10
Italian	06
Polish	04
Korean	02
Slovenian	02
Hebrew	01
Hungarian	01
Lithuanian	01
Persian	01

V. CONCLUSION

Scientific knowledge is an important mechanism for the technological evolution of a country and a society. The measurement of this knowledge through bibliometrics allows to evaluate the performance of researchers, institutions and periodicals, taking into account quantitative and qualitative metrics.

This bibliometric research aimed to map scientific articles and other academic productions related to the subject intellectual property, published in the bases and data of Google Scholar and Scopus, in the temporal cut of 20 years, more precisely between the years of 1998 to 2018.

The theme of ownership was chosen for this research as one of the main propulsive springs for the technological, economic and social development of a country, increasing its competitiveness in the national and international market, assuring to the companies the protection of its investments and combating piracy.

In this bibliometric research 37,099 publications were identified related to the subject intellectual property. The largest volume of publications occurred in 2012, with 2,342 published articles, 122 on the Google Scholar platform and 2,220 on the Scopus platform. These articles were selected and analyzed for authors, areas of knowledge, journals where they were published, institutions represented in the articles, countries that published the articles and languages in which they were written.

As for the authors, the highlight in the number of publications was to the American professor Keith Eugene Maskus, with 11 articles published.

Regarding the areas of knowledge identified in the research, it is observed that the Social Sciences area obtained the largest number of publications, with 1,237 articles published.

Among the journals identified in the research, it was verified that the Journal of Intellectual Property Rights, published by the Indian National Institute of Communication and Scientific Information Resources, presented the largest number of publications, with 73 articles published.

The institution with the largest volume of publications in the area of intellectual property identified in this research was the University of California, Berkeley, United States, with 27 articles published. It is worth mentioning that the United States was the country with the largest number of publications, with 767 articles published. In addition, most of the articles published in the two databases, related to intellectual property, were written in English, in total 2,399 articles were published in that language.

The results of this research point to a significant increase in the number of publications related to intellectual property, highlighting the importance of the topic to the scientific community and contributing to the world's technological and economic development.

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The Importance of Management Accounting in the Vision of Micro and Small Retail Entrepreneurs of the City of Salgueiro-Pe

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Abstract— Managerial accounting plays a very important role for all companies. Through it it is possible to make decisions that involve the future of the entity while taking into account its present. Therefore, good management accounting helps the company to become more prosperous. However, not being mandatory, companies do not always use it. At the same time, attention to small businesses is growing every day in Brazil. According to the Brazilian Micro and Small Business Support Service - SEBRAE, these small entities are considered the "backbone" of the national economy. In Salgueiro, back country of Pernambuco, Brazil, the predominant activity in the region is the retail trade, mainly made up of micro and small companies. For this reason, the objective of this study was to analyze the perception of microentrepreneurs about the importance of managerial accounting for their companies. The sample was selected from these microenterprises associated with the city's Chamber of Shopkeepers. For that, a closed questionnaire was applied, whose responses were qualitatively analyzed. The results showed that the microentrepreneurs of Salgueiro recognize the importance of managerial accounting and that the continuous use of their tools contributes to the good management of their businesses.

Keywords— Micro and small businesses. Management accounting. Management tools. Business management.

I. INTRODUCTION

Accounting, according to [1], is defined as the science that studies the evolution of a person's assets, their effects and reflexes, their growth, their administration and their future. It is through this science that information will be generated for the partners, employees, shareholders, etc. According to [2]: "a company without accounting is an entity without memory, without identity and without the minimum conditions to survive or to plan its growth." With this, management accounting emerges as an

indispensable tool for any type of business. Management accounting, as part of accounting science, deals with the analysis of information obtained and decision making [3]. The total relevance of managerial accounting in business management in any area of activity or size of the organization is perceived, since it represents a fundamental source of information in economic and financial level that assists managers in the decision-making process.

At the same time, attention to small businesses is growing day by day. Most countries are directing investments in this sector because they recognize the importance of the role played by Micro and Small Enterprises (SMEs) in the generation of jobs and businesses, income distribution and value creation.

In Brazil, surveys carried out by the Micro and Small Business Support Service [4] show that small businesses are considered the "backbone" of our economy. It is estimated that more than 98% of existing companies in the country are classified as such.

These small businesses, also called micro and small enterprises, have played a significant role in the national economy as they are great generators of jobs and wealth, contributing to the country's gross domestic product (GDP) increase significantly.

However, it is a fact that in micro and small companies some managers do not always give importance to managerial accounting, since, being a small business, they only care about meeting the fiscal requirements and obtaining profit without analyzing possible reductions of costs or to analyze other investments that could bring greater returns.

Often, micro and small businesses do not have an effective management system and because of lack of administrative and financial information, they close their doors in the first years of life.

[5] point out that many micro and small enterprises do not reach six years of life, causing social impacts such as

unemployment, damage to the government in the three spheres and to investors.

In the city of Salgueiro, in the hinterland of Pernambuco, the predominant economic activity is the retail trade and it, in the great majority, is composed of micro and small companies. Given that managerial accounting is a determining factor in order to efficiently manage these companies, this work will contribute to the success of micro-entrepreneurs in Salgueiro and the region, if they use this branch of accounting.

As a consequence of this, the incentive question arises of the execution of this research: What is the perception of microentrepreneurs in the city of Salgueiro about the importance of managerial accounting for their companies?

Therefore, this article aims to encourage especially the managers of Salgueiro-PE to develop and adopt information that aid in decision making, demonstrating the importance of managerial accounting and that it can and should be used by small companies as it is essential for its continuity and progress.

The present work is structured as follows: first, this introduction. Next, the theoretical reference followed by the research methodology used to collect the data for study. The penultimate part brings the analysis of the data collected and finally the final considerations.

II. THEORETICAL FOUNDATION

2.1 Microenterprises And Small Business Companies

There is no single criterion for defining micro or small enterprises. According to [6], "there are many parameters to define small enterprises, often within the same country as in Brazil".

The classification can be made taking into account the personnel employed as well as their billing [7].

For [4], microenterprise is one that has up to 19 employees (in industry) and up to 9 employees (in trade / services). At the same time, it is considered a small company, which has 20 to 99 employees (in industry) and 10 to 49 employees (in commerce / services).

In accordance with Supplementary Law 123/2006 and amendments in accordance with Complementary Law 155/2016, Micro-enterprises (ME), for the purpose of the National Simplification, are considered to be the entrepreneur, the legal entity or equivalent entity, which will in each calendar year, gross revenue equal to or less than R \$ 360,000.00. Small Business Enterprises (EPPs) are entrepreneurs, legal entities, or equivalent to them, who receive in each calendar year a gross revenue of more than R \$ 360,000.00 and equal to or less than R \$ 4,800,000.00 [8].

2.2 Management Accounting

In general, according to [9], "accounting is a science that allows, through its techniques, to maintain permanent control of the company's equity."

Managerial accounting, in turn, arose from the need for complementary information to assist managers of the entities.

According to [10], "managerial accounting has a deeper meaning and is directed solely and exclusively to the management of the company, seeking to supply information that fits in a valid and effective way in the decision-making model of the manager."

Das [11] add that the main objective of managerial accounting is to provide information that helps in decision making without having to strictly follow accounting principles. The information is shaped according to the interests of the administrators.

Managerial accounting plays a very important role for companies. It analyzes data that help managers and all those involved with the activity in decision making, thus facilitating the achievement of efficient and agile results, fundamental to the business management process. Misinformation can cause serious damage to an enterprise, from losing its profitability to its extinction in the market.

Management accounting is not mandatory, and companies do not always use it. However, its gradual implementation, with reports appropriate to the reality of the company, is fundamental for achieving the objectives of the entity, and can save it from bankruptcy.

Finally, [12] points out that have accounting and accounting information and not use it in the administrative process, in the management process, then there is no accounting management or management accounting.

2.3 Application of Management Accounting in Micro and Small Enterprises

According to CFC Resolution No. 1418/2012, microenterprises and small businesses must prepare the Balance Sheet, Statement of Income for the Year and the Explanatory Notes at the end of each fiscal year.

Although these statements are prepared in a simplified way because of the small financial movement of these entities, they can provide information that will be of great importance in decision making [13].

According to [2], the Balance Sheet is the demonstration of the company's financial and equity situation on a certain date, and its publication generally refers to the last day of the calendar year.

It consists of two columns: the Asset column on the left shows the application of resources by the company, consisting of assets and rights receivable, and the Liabilities and Equity column (PL) to the right of the

Balance Sheet, represent the sources of resources, being formed by Third Party Capital and Own Capital [2].

Regarding the Statement of Income for the Year, [14] shows that this statement is nothing more than a summary of expenses and income in a given period. In it, the expenses are deducted from the revenues so that the final result, which may be profit or loss, is indicated.

2.3.1 Analysis of Financial Statements:

As previously seen, the companies under study of this work are required by legislation to present only the Balance Sheet and the Statement of Income for the Year. For this reason, the analyzes presented below are directly related to these statements.

The main financial analysis techniques presented by [14] are Horizontal and Vertical Analysis and Financial and Economic Indicators.

[15] state that "the horizontal analysis of the financial statements shows the variation in each period, in percentage terms, of a certain statement line for a given year."

To perform the horizontal analysis, [16] explains that it is necessary to establish a standard demonstration, which will be the basis for comparisons, and for which the percentage of 100% will be assigned to each account and each group.

The vertical analysis, according to [15], "shows in percentage terms each item of a given statement in relation to a totalizer". [17] "is also a comparative process, expressed as a percentage, that applies when relating an account or group of accounts".

Important positioning made by [18] emphasizes that in order to obtain conclusions closer to the reality of the company, it is necessary to use Horizontal Analysis in conjunction with Vertical Analysis.

In turn, financial indicators are useful for managerial analyzes because they allow "comparing and investigating the relationships between the different parts of the financial information" [18].

In this sense, the Liquidity Ratios are used to evaluate the company's ability to pay, that is, to demonstrate the company's capacity to pay off its commitments, being evaluated in a long, short or immediate term [14].

On the other hand, the Indebtedness Indices allow to evaluate the level of indebtedness of the company, obtaining the information about the resources that the companies most use [19].

Activity Indexes, on the other hand, show the number of days that the company takes on average to receive its sales, pay its purchases and renew its stock [14].

Finally, the Profitability Indices show the economic situation of the company, being able to evaluate its degree of economic success obtained in relation to the invested capital [19].

In view of the above, the importance of managerial accounting in the life of companies is well known, since it provides clear and objective information according to the needs of each user, thus enabling them to understand the business development and financial situation [5].

III. RESEARCH METHODOLOGY

The methodology is the way the researcher used to develop a research. Method can be characterized as a set of systematic and rational activities that with greater security and economy allows the researcher to reach the goal. In this sense, through the method one arrives at valid and true knowledge, tracing the way to be followed, detecting errors and assisting the scientist's decisions [20]. The type of research is defined as to the objectives to be achieved. Thus, the method adopted for the elaboration of the present work is the one of descriptive research.

According to [21], a significant characteristic of this type of research is the use of standard techniques of data collection and its main objective is to describe the characteristics of a given population, phenomenon or establish relationships between variables.

In a descriptive research it is necessary to use some research instrument. In this case, it was elaborated through the application of a questionnaire to the microentrepreneurs of the city of Salgueiro-PE, opting for the National Simple, and whose main economic activity is the retail trade of the most diverse branches.

The research in question had as a characteristic to gather information about a local reality, involving, therefore, several researched ones, characterizing thus a research focused on the method of survey.

[22] point out that the surveys are widely used for descriptive research, since there is not a deep analysis of the results.

Regarding the problem approach, the research is considered qualitative. The use of this method is very common in accounting since it is a social science, therefore not always being exact, despite dealing with numbers [21].

Before starting the analysis itself, it is important to highlight that the population analyzed is a sample of the microentrepreneurs affiliated to the local Chamber of Shopkeepers (CDL), excluding all companies that provide services, as well as snack bars, restaurants and the like. The sample was selected by sampling by typicity. In this way, a non-probabilistic sample is created for convenience.

The questionnaire was structured with the first four questions directly related to the profile of the entrepreneur (age, gender, schooling and company performance in the local market). The next two questions, closed, agreeing or not with the proposition. Finally, ten questions also

closed, whose options of answers consisted of a scale of graduation (Likert type) with four categories: very important, important, not important and nothing important.

IV. DATA ANALYSIS AND INTERPRETATION

The questionnaires were applied between September 10 and 12, 2018 through visits to commercial establishments. One of the requirements for the application of the questionnaires is that they be answered by the legal representative of each entity. A total of 60 companies have been visited by Simples Nacional and their main economic activity is the retail trade (of medicines, fabrics, sports materials, agricultural products, footwear, clothing, jewelry, construction materials, general goods with a predominance of food products, among others). Of these 60 companies, 50 answered the questionnaire, thus determining the size of the sample.

Firstly, we sought to identify the age range of the respondents. In percentage terms, the results were as follows: 2% of the respondents stated they were under 25 years old, 16% were between 25 and 35 years old, 32% were between 36 and 45 years old, and 50% said they were over 45 years old. In this way, it was possible to identify that, among the companies surveyed, most of the micro or small entrepreneurs are over 45 years old.

Then the respondents were asked about the gender. 58% of them said they are men while 42% are women. This information demonstrates that, even today, most of the micro and small entrepreneurs in the Salgueiro retail trade (affiliated with CDL) are men. However, women have a significant presence in local commerce.

The third information surveyed was related to the level of education of the respondents. Only 6% of respondents have only the fundamental level. In relation to the average level, this percentage is much more expressive, reaching 36%. Respondents with top level are the vast majority, 50% of micro and small business owners analyzed said to have complete graduation. On the other hand, only 8% of these entrepreneurs have some kind of postgraduate degree.

When questioned how long ago their companies operate in the local market, none of the respondents stated less than 1 year. 8% of them said that their companies are in the market for 1 to 5 years. Those that operate in the market of 6 to 10 years already total 14%. But most respondents (78%) have been in the market for over 10 years.

The next question in the questionnaire applied questions the entrepreneurs if they have had any contact with any accounting statement, especially the Balance Sheet and Statement of Income for the Year. 68% of them said yes, while 32% said no.

Following this line of reasoning, it was asked whether they understand that it is possible to obtain information relevant to the management of the company through the analysis of the financial statements. The vast majority said yes (94%) while only 6% said they did not.

Continuing the analysis of the collected data, from that moment and as previously mentioned, the answers available to the respondents were divided into: very important, important, not important and nothing important.

It inquired about the financial situation of the company. That is, what is the perception of the respondents about this situation. None of the respondents considered anything or less important to know the financial situation of the company. 8% of them considered only important while 92% considered it very important.

About the company's economic situation, 4% of the respondents found it unimportant to know it. 28% found it important and 68% considered it very important to be aware of this situation.

Asked about the importance of sending tax documents, bank statements, and others to their companies' accounts on a monthly basis, 84% of respondents considered it very important, while 16% considered this practice important. The little important and unimportant options were not considered by the entrepreneurs.

He was also asked about consulting the accounting professional before making any decisions related to the management of the company. Respondents were divided about responses. 50% considered it very important, while 42% considered it important. The remaining 8% said they considered this query to be unimportant.

Regarding the preparation of the financial statements for the management of the company, again the respondents were divided. 50% considered it very important, while 48% considered it important. The remaining 2% said they considered minor.

Another issue raised for the respondents was the level of interest in receiving accounting reports periodically (although this represented disbursement to the company). In this question, all available answers were used. 38% considered it very important, while 42% considered it important. 16% unimportant and 4% unimportant.

Knowing the relationship between revenues and expenses of the company was to 78% of respondents very important. For the remaining 22%, knowing this relationship was considered only important.

On knowing the level of indebtedness of the company at a given moment, the great majority of the respondents, that is, 80% of them considered very important. 18% considered it important while 2% considered it to be minor.

The respondents were also asked about the importance of knowing the profit obtained by the company in a given period. 84% of respondents considered it very important and 16% important.

Finally, the questionnaire sought to know the respondents' level of importance about knowing the evolution of company equity over the years. 82% of microentrepreneurs in Salgueiro considered this information very important, while 18% considered it important.

The unimportant and unimportant response options were not always taken into account by respondents throughout the questionnaire. This in itself means that microentrepreneurs in the Salgueiro-PE retail business affiliated with the CDL consider managerial accounting to be very important or very important for the management of their companies.

However, during the analysis of the data, some contradictions on the part of the respondents became evident. An example of this is that 94% of microentrepreneurs in Salgueiro have agreed that it is possible to obtain information relevant to the management of the company through the analysis of the financial statements. In contrast, only 38% of them considered it very important to receive periodic accounting reports. That is, they recognized the importance of analyzing financial statements for the management of their companies, but they were not very interested in receiving such reports.

It is also important to point out that, despite the fact that most of Salgueiro's businessmen have been active in the market for more than 10 years (78% of the respondents), some of them have never had contact with any accounting statements. Analyzing these entrepreneurs alone, 36% never had access to the BP and DRE of their companies. A relatively high number for those who have been in the market for so long. However, 64% of them at least once, have maintained this contact.

In a timely manner, with respect to businessmen in Salgueiro for more than 10 years, 92% of them said that it is possible to obtain information relevant to the management of the company from the analysis of the financial statements, while 8% said no.

It is valid to consider, therefore, the relationship between the "older" microentrepreneurs of Salgueiro and their perception about the importance of managerial accounting for the entities. Although some had never had access to the financial statements, as noted in the questionnaire, they recognized their importance for the company's "survival".

The table below briefly outlines the issues raised for the microentrepreneurs of Salgueiro and the degree of importance they attribute to them. The percentages of

very important and important response options were added in order to provide a better understanding of respondents' perceptions.

Table 1 - The degree of importance attributed by the microentrepreneurs of Salgueiro-PE to the research questions

Questão	Grau de importância (%)
Knowledge about the financial situation of the company	100
Knowledge about the economic situation of the company.	96
Monthly submission of documents for accounting.	100
Regular consultation with the accounting professional.	92
Importance of preparing the financial statements for the management of the company.	98
Level of interest on receipt of periodic accounting reports (BP and DRE).	80
Knowledge of the relation between revenues and expenses of the company, in a given period.	100
Knowledge of the company's level of indebtedness	98
Knowledge about profit obtained by the company in a given period.	100
Knowledge of the evolution of the equity of the company, over the years.	100

V. FINAL CONSIDERATIONS

The present work, in a first moment, defined what is micro and small companies from SEBRAE and the National Simple Law. He then explained about managerial accounting, the tools most used by micro and small companies, as well as their importance for these companies to become more and more prosperous. Next, it sought to analyze the importance attributed by the microentrepreneurs of Salgueiro-PE (affiliated to the CDL) about the managerial accounting. To obtain this response, a questionnaire was applied so that, of the 60 applied, 50 were answered spontaneously, thus determining the size of the sample.

After analyzing the data, it is possible to affirm that the objective of this research was reached. In general, microentrepreneurs realize that it is important or very important to know the financial statements, especially the BP and the DRE, the economic and financial situation of the company, as well as its level of indebtedness, as well as the profit obtained during the year and the evolution of equity over the years.

Proof of this is that the percentages found in the issues raised were generally equal to or greater than 50% in the options discussed above. When it comes to the options of an unimportant response and nothing important they were not always taken into account. This, to a certain extent, corroborates the idea of the importance of managerial accounting for microentrepreneurs analyzed, discussed in the previous paragraph.

On the other hand, the research was not able to reveal whether the managers of micro and small companies of the retail trade of Salgueiro-PE, affiliated to CDL, use the accounting information as a support tool in the management of their businesses.

Considering this, and recognizing the limitations of the research carried out, we suggest a new and more detailed study about the applicability of the tools of managerial accounting in the micro and small enterprises of Salgueiro and the real benefits achieved due to their use.

Finally, taking into account the importance of SEBRAE for the development of micro and small enterprises as a whole, and in particular, the role played by the Chamber of Store Managers in Salgueiro, it is also suggested to apply courses and training on the importance of managerial accounting and its consequent applicability to the success of micro and small enterprises in the region.

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Dry-Type Power Transformers Thermal Analysis with Finite Element Method

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Abstract— *The transformer temperature is one of the main variables of interest in its manufacture and operation, since it interferes in the useful life of the transformer. In this sense, the present work proposes a thermal simulation for the temperature estimate of a dry-type transformer. Initially a thermal analysis was performed from experimental measurements of temperatures of a dry-type power transformer of 500kVA for different conditions of load. Posteriorly, a thermal simulation was proposed using finite element theory. Thus, the heat diffusion equation was used, with the following boundary conditions: convection and radiation equations; characteristics of the materials used; the measurement data and the dimensions of the transformer. FEMM 2D software was used for the proposed simulation. Finally, in order to validate the proposed analyzes, experimental measurements were compared with the values obtained in the thermal simulation. The results of the thermal simulation showed agreement with the experimentally measured values.*

Keywords— *Dry-type transformers, Experimental measurement, Finite elements, Thermal simulation.*

I. INTRODUCTION

Dry-type transformers are widely used in electric power distribution systems and are recommended for smaller indoor installations that require safety and reliability, require less maintenance and less damage to the environment [1].

The design and overload capacity of transformers are strongly influenced by thermal performance and behavior. The thermal influence on the power transformers is very relevant, and one of the main interest factors in the operation of transformers is the temperature, since it interferes with the aging of the insulation of the winding and, consequently, its useful life. Therefore, the temperature monitoring is essential to evaluate, in general, the wear of the transformer [2].

Studies have shown that the temperature is one of the major causes of deterioration of insulation material of power transformers and thermal stress. This thermal stress, caused by heat, is a condition where the insulation

material is affected by the temperature of the environment in which it is located, when this temperature is at extreme levels, and which has resulted in electrical faults in the distribution systems. A temperature distribution and overload or overheating is a particular interest of manufacturers and customers with the purpose of prolonging the life expectancy of transformers [3], [4].

Also, in the design stage, in order to estimate the temperature, there are several numerical methods of thermal simulation, capable of dealing with complex geometries and that become important tools for the transformer designer. In this sense the finite element method (FEM) comes being widely applied after the evolution of the computational systems [5].

Considering FEM this work presents an analysis through the simulation of the results of theoretical and experimental investigations of the thermal behavior of a dry-type power transformer, when this is subject to different load conditions.

These investigations, both theoretical and experimental, take into account several elements such as: transformer specification, thermal characteristics of the materials involved, transformer construction aspects; as well as the data collected in the experimental measurement, including the temperature at several points of the transformer, applied power and ambient temperature.

So, it is possible to perform of dry-type power transformer simulations to estimate its temperatures at various points and obtain thermal images of the variation and distribution of temperature that occurs internally and externally to the equipment. In this way, the data collected in the experimental measurement can be compared with the results obtained in simulations.

II. BACKGROUND

Some analytical and experimental studies of the temperature distribution in some types of dry-type transformers have been presented in the literature.

To this end a thermal mathematical model that calculates of the hottest spot temperature and its location in dry-type transformer windings was performed by [6].

This approach was based on three mechanisms of heat transfer: conduction, convection and radiation. However, the finite difference method was applied, and circular or oval forms of transformer geometry suggested finite element analysis to improve numerical accuracy. The heat conduction equation was also solved by the finite difference method by [7] in order to obtain the temperature distribution for the dry-type transformer at steady state.

The two-dimensional (2D) temperature distribution was calculated in [8] using finite element analysis, addressed by CFD (Computational Fluid Dynamics) analysis and using commercial ANSYS software. This work did not consider heat dissipation by thermal radiation.

Thermal analysis and temperature distribution of the transformers were also performed by [9] using a mathematical model using the finite difference method and cylindrical coordinates. To validate the model, the results were compared with the experimental data measured from an 800kVA transformer.

Another 2D thermal study of the cast-resin dry-type transformer was solved in [10] using cylindrical coordinates and the FEM to obtain temperatures in any location of the transformer. Basic modes of heat transfer, such as conduction, convection, and radiation were also used to obtain the steady-state temperature distribution of the transformer.

More recently, a coupled thermal-electromagnetic model for disc-type and foil-type winding to propose temperature distributions using FEM was performed by [11].

The proposed model was based on mechanisms of heat transfer, i.e. conduction heat, convection and radiation, in addition to some electromagnetic mechanisms. All the cooling surfaces were identified and heat transfer coefficients for each surface were presented. The model was applied to a 2,000kVA dry-type power transformer under different load conditions. Experimental temperatures were measured with thermocouples and infrared thermometers and used to compare the results of finite element simulations. In addition, in this model, commercial COMSOL software was used for 2D thermal modeling [11]. The results of [6]-[11] showed reasonable agreement between the calculated data and the experimental data.

In this sense, the present paper presents a thermal simulation of 500kVA dry-type transformer at steady state, with an approach based on the three mechanisms of heat transfer: conduction, convection and radiation; in cartesian coordinates, using the MEF as numerical method and the FEMM (Finite Element Method

Magnetics) 2D software to perform the thermal simulation.

III. THERMAL STUDY IN DRY-TYPE TRANSFORMERS

The general equation of heat diffusion in cartesian coordinates 2D and steady state is represented in (1), in which it provides a basic tool for the analysis of heat conduction. From the solution of this equation it is possible obtain the temperature distribution $T(x, y)$ of a steady-state material [12].

$$\frac{\partial}{\partial x} \left(k_x \frac{\partial T}{\partial x} \right) + \frac{\partial}{\partial y} \left(k_y \frac{\partial T}{\partial y} \right) + \dot{q} = 0 \quad (1)$$

Where k_x and k_y are the thermal conductivity [W/(m.K)] in the directions of x and y , \dot{q} is the heat generation by volume [W/m³] and T is the temperature [K].

According to [13], the term heat generation (\dot{q}) is defined in (2) as the amount of thermal energy that is generated per unit volume, which in turn is determined by the amount of power loss in a unit volume.

$$\dot{q} = \frac{\dot{E}_{ger}}{V} = \frac{I^2 R}{V} \quad (2)$$

Where \dot{E}_{ger} is the total rate of heat generation [W], I is the electric current [A], R is the electric resistance [Ω], and V is the conductor volume [m³].

The total rate of heat generation is a function of the amount of current flow in a conductor and the resistance of said conductor.

The conductor resistance is calculated according to (3).

$$R = \frac{\rho_e \cdot l}{A_c} \quad (3)$$

Where ρ_e is the electrical resistivity [$\Omega \cdot m$], l is the mean conductor length [m] and A_c is the conductor area [m²].

3.1 Boundary Conditions

When no boundary conditions are explicitly defined, each boundary imposes an isolated condition. However, a non-derived boundary condition must be defined somewhere (or the potential must be defined at a reference point in the domain) so that the problem has a unique solution [14]. The convection (4) and radiation (5) equations were used as boundary conditions of (1).

$$k \frac{\partial T}{\partial n} + h(T - T_0) = 0 \quad (4)$$

$$k \frac{\partial T}{\partial n} + \varepsilon \sigma (T^4 - T_0^4) = 0 \quad (5)$$

Where h is the convective heat transfer coefficient [W/(m².K)], T_0 is the ambient temperature [K], ε is the emissivity of the surface, σ is the Stefan-Boltzmann constant [W/(m².K⁴)] and n represents the direction normal to the boundary.

IV. EXPERIMENTAL MEASURES

The transformer used for the experimental measurements was 500kVA from the company Comtrafo, which has a transformation ratio of 13.8kV to 220/127V, and it is in full use on the Sao Bernardo do Campo campus of the Federal University of ABC, as illustrated in Fig. 1.



Fig. 1. Dry-type transformer used for the experimental measurements. Source: Authors.

The equipment used for temperature measurements was a thermal imager, also known as a thermal imaging camera and a temperature sensor of type PT100 installed in the low voltage winding of the transformer.

A three-phase power analyzer was used to measure electrical quantities, such as: voltage, current and power. The quantities were collected at the same time that the temperature data was measured.

Fig. 2 illustrates some of the equipment used in the experimental measurements.

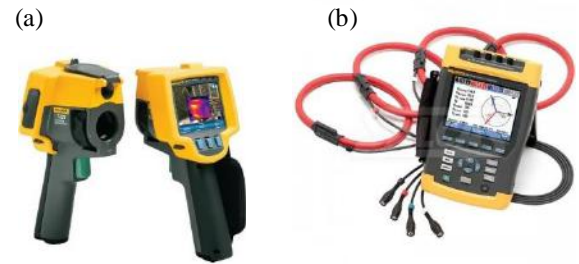


Fig. 2. Equipment used for the reading of temperature (a) and electrical quantities (b). Source: Fluke [15].

For the interpretation and treatment of the collected data, the specific software analyzer was used.

Since the thermal behavior is analogous in the three phases (coils) of the transformer, both the measurements and the simulations were performed in only one of the phases.

Fig. 3a [16] illustrates the details of one of the transformer phases used for collecting measurements and Fig. 3b shows the thermal variation found on the external surface using the thermal imager.

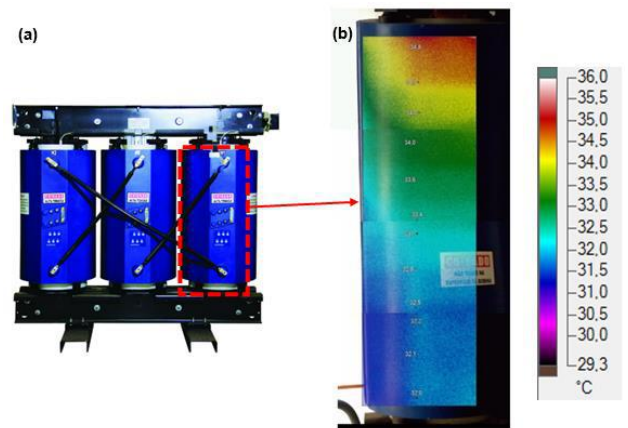


Fig. 3. Detail of one of the phases of the transformer used for measurement (a) and its thermal variation for a given power measured in °C (b). Source: (a) Comtrafo [16], (b) Authors.

Since the thermal imager has a limited visible screen and there were space constraints at the location where the transformer was located, the union of four image segments of the thermal imager was used, all being of the same scale, thus forming a single image of thermal variation on the surface transformer, as shown in Fig. 3b.

TABLE 1 shows the data collected from the electrical energy analyzer, for four different charging situations (powers).

Table.1: Data collected from the energy analyzer for different loading potences.

Reading	Voltage [V]	Current [A]	Power [W]
1	128.8	63.66	8,200
2	128.4	74.83	9,608
3	128.7	97.44	12,540
4	128.5	130.82	16,810

Source: Authors.

TABLE 2 shows the temperature results collected from the thermal imager and the thermal sensor considering the four different loading powers of TABLE 1.

Table.2: Data collected from temperature meters for different loading potences.

Reading	Ambient Temp. [°C]	Thermal Imager [°C]		Thermal Sensor [°C]
		Lower	Upper	
1	23	31.3	33.8	50.3
2	27	31.7	34.5	50.6
3	31	32.0	34.8	50.7
4	28	31.8	34.9	50.8

Source: Authors.

V. COMPUTATIONAL SIMULATION

As a pre-processing stage and for the realization of the 2D design of the transformer in the FEMM software, the constructive characteristics provided by the manufacturer and the constant dimensions proposed in [9] were used.

The creation of core geometry and low and high voltage windings (LV and HV) were performed only in one of the phases of the transformer.

Considering the symmetry of the sides of the coil and to reduce the speed of the system solution process, the simulation was performed in only one side of the coil, as illustrated in Fig. 4.

The data of the thermal characteristics of the materials used in the core, low/high voltage windings and in the insulation material, such as: M4 silicon steel, aluminum alloy 1,350 and epoxy resin, respectively, and their variations of thermal conductivity in relation to the increase in temperature were also provided by the manufacturer. These thermal characteristics of the materials used and the ambient air were considered in the simulations.

As boundary conditions, the variables used in solving the Equation (4) were: convective coefficients and ambient temperature. For the resolution of (5) the

variables involved were: emissivity and ambient temperature.

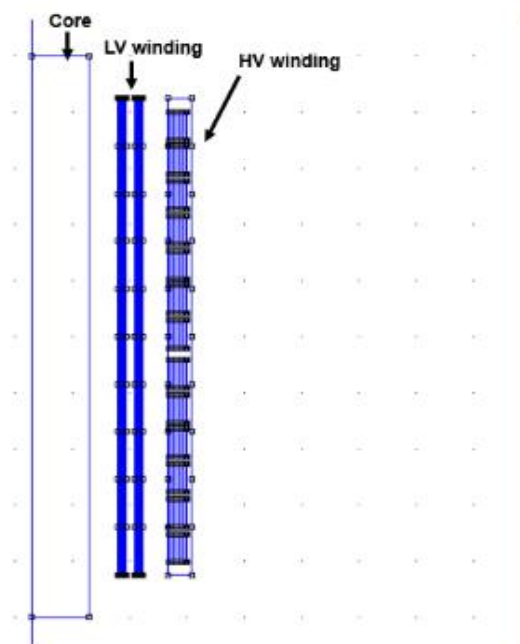


Fig. 4. 2D drawing of one side of the transformer coil in the FEMM software. Source: Authors.

In order to meet the required variables in (4), the surface where convective heat transfer occurs was identified and divided into sections along the height, these partitions being uniform throughout the low and high voltage winding. The values of the upper and bottom convective coefficients of [11] were used as reference for the simulation. The convective coefficients of the interval between the upper and bottom limits were calculated based on the temperature difference and the number of sections considered.

In (5), for the emissivity values, the data of [13] was used as reference and approximation of the values. The emissivity values are based on the temperature of 300K. The values of the ambient temperatures for both (4) and (5) were presented in TABLE 2.

The calculated values of the total rate of heat generation [W] were also considered in the FEMM software. These values are calculated according to (2), in which they vary with current and electrical resistance. The electric current (I) was collected directly in the transformer through the electric energy analyzer, as verified in TABLE 1. The equation (3) was used to calculate the resistance of the conductor.

To finalize the pre-processing, the computational domain was adapted and the mesh refinement was carried out, which boils down to increasing the minimum allowed angle for small triangles to be created. Thus, the meshes were created, and the domains of the problem were

divided into finite elements using Lagrange triangular elements, which is the FEMM standard element type.

Fig. 5 shows the meshes of all domains, including core and low and high voltage windings.

The processing step consists in solving the problem, based on the parameters and variables defined in the pre-processing. The software performs internally the matrix representation of each element, formation of the global coefficient matrix, application of the boundary conditions and, finally, the solution of the system.

After this, at the final step, post-processing, the graphical and numerical results are presented.

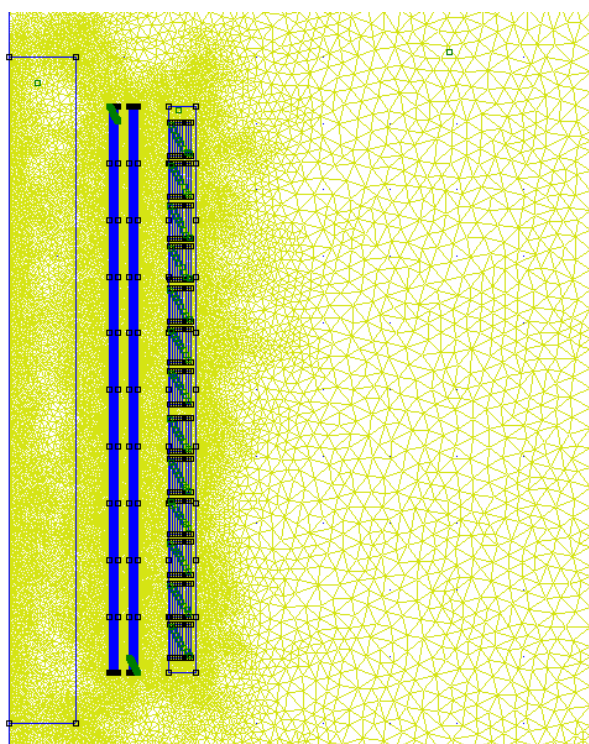


Fig. 5. Finite element domains divided into triangular elements. Source: Authors.

VI. RESULTS AND DISCUSSIONS

The thermal simulation results obtained in the post-processing step are visualized in Fig. 6.

In the highlighted approach of Fig. 6 it is seen that the temperatures in the upper part are higher than in the bottom part, this is because different convective coefficients were applied in the sections of the windings surfaces, being in agreement with the variations of the values collected in the experimental measurement for high voltage windings.

The temperature data obtained in Fig. 6 are in Kelvin and the TABLE 3 presents the values of the points in °C.

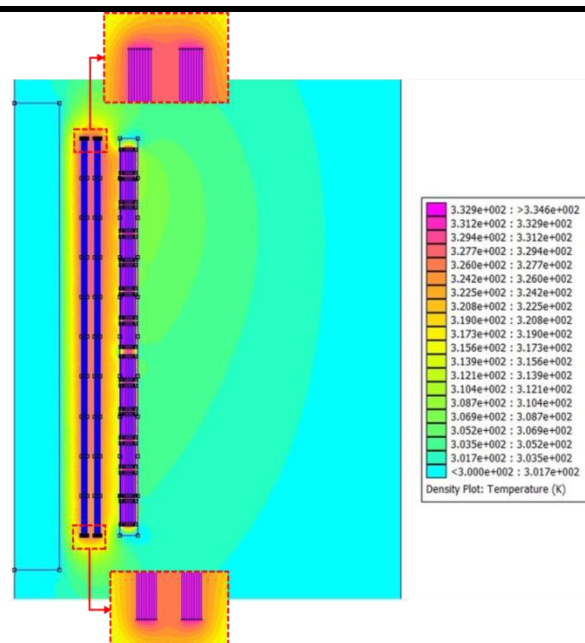


Fig. 6. Visualization of thermal simulation results. Source: Authors.

The TABLE 3 also presents the comparison between the temperatures measured experimentally with the values obtained in the thermal simulation, as well as the absolute and relative error. From TABLE 3 it is possible to observe low absolute and relative errors and that there was a direct relationship of the transformer operating temperature increase when compared to the transformer power increase and the ambient temperature.

Table 3. Comparative of temperature measures and simulated and their respective errors.

Power [W]	Site	Temperature			
		Measured [°C]	Simulated [°C]	Absolute Error [°C]	Relative Error
8,2	Surface				
	HV	31.30	33.75	2.45	8%
	Bottom				
	Surface				
	HV	33.80	36.85	3.05	9%
	Upper				
9,60	LV Winding	50.30	54.90	4.60	9%
	Surface				
	HV	31.70	34.70	3.00	9%
	Bottom				
	Surface				
	HV	34.50	37.65	3.15	9%
	Upper				

12,5 4 16,8 1	LV Winding	50.60	54.70	4.10	8%
	Surface				
	HV	32.00	34.80	2.80	9%
	Bottom				
	Surface				
	HV	34.80	37.85	3.05	9%
	Upper				
	LV Winding	50.70	55.50	4.80	9%
	Surface				
	HV	31.80	34.50	2.70	8%
	Bottom				
	Surface				
	HV	34.90	37.85	2.95	8%
	Upper				
	LV Winding	50.80	55.60	4.80	9%

Source: Authors.

The Fig. 7 illustrates the data presented in TABLE 3, which shows the measured and simulated temperature variations for the power of 8,200W.

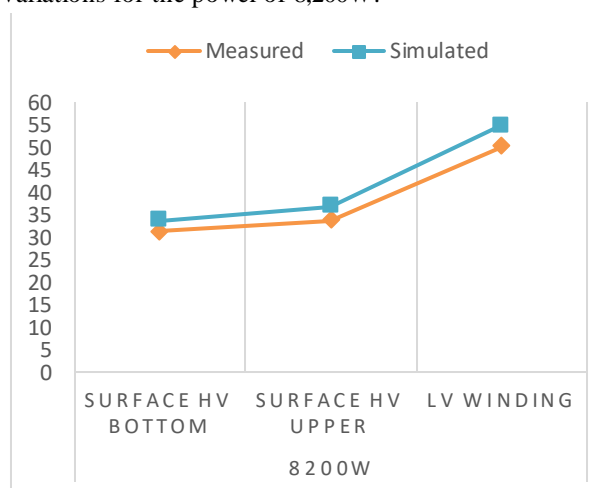


Fig. 7. Measured and simulated temperatures with load power of 8,200W. Source: Authors.

Comparing Fig. 3b, image obtained experimentally, with Fig. 6, simulated image, it is verified that both have a vertical temperature gradient. This characteristic occurs because the convective heat transfer is larger in the bottom part and smaller in the upper part, obtaining higher temperatures on the upper surface and lower on the bottom surface. Further, it becomes apparent that the air temperature is heated with increasing axial length, whereby the natural convection cooling effect is therefore greater in the bottom windings.

It can also be seen in Fig. 7 that the values measured experimentally compared to the simulated values for the

same power also showed agreement on the temperature variation on the surface and on the transformer windings.

6.1 Error Analysis

The errors found and described in TABLE 3 may be related to the conditions considered in the thermal simulation or even by inaccuracies in the experimental measurements.

Thus, effects of some factors on the temperature distribution of the measurements collected experimentally and the simulations carried out in FEMM software may have influenced the results, such as: inaccuracies and uncertainties involving the temperature readings by the thermal imager and the sensor, in the experimental part; and errors caused by numerical calculations due to some computational operations, such as rounding and estimation, in the theoretical part. Other prominent factors were:

I. Some measurements of the size / dimensions for the formation of the transformer geometry were approximated, also contributing to the divergence of measured and simulated values;

II. The simulation was performed in the 2D domain and in cartesian coordinates, and the 3D computational domain and cylindrical coordinates could present more accurate values, since they are closer to the actual configurations and geometries of the transformer;

III. Only the thermal study of the transformer was considered, not taking into account the electromagnetic interferences in the winding and the core of the transformer;

IV. The values of the boundary conditions for the convective coefficients and emissivities were also approximated for the geometry and applied materials, respectively;

V. The conductor resistivity variation was not taken into account with increasing winding temperature and ambient temperature, considering that the resistivity, and consequently the resistance, vary with the increase in temperature over time.

VII. CONCLUSION

In this work it was possible to demonstrate that the finite element analysis provides an efficient tool for determining the temperatures along a dry-type transformer under load. Furthermore, the heat transfer analysis allows to predict the temperature in several locations of the transformer and the temperature distribution considering different operating conditions.

Thus, considering that the transformer was simulated in two-dimensional geometry, with some characteristics and measures of approximate size/dimensions, it has been that the thermal simulation showed agreement with the

temperature variations of the transformer measured experimentally.

Finally, the results of this study may provide manufacturers with a better understanding of the nature of heat transfer in transformers, and may help to deal with thermal stresses more effectively.

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Payment for Environmental Services - An Example of Sustainable Management

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Abstract— *The payment for environmental services presents itself as a potential instrument that promotes the sustainable development, which contributes to the preservation of nature in order to keep the maintenance of environmental services performed by nature, which is fundamental to human beings. This work aims to review the PES in order to give an overview of the difference of this management system in relation to control systems and an introduction to the main systems currently implemented. It is clear by the described programs in this revision that most of them still rely on resources from the public administration, especially those cases implanted in Brazil. They are still relevant, necessary in several regions; however, they still face problems as to financial resources and still need to be dependent on the public resources to raise money. Thus, programs that do not need help from public resources could carry out an implantation of PES. Through the data presented, it is clear that the programs for the environment can be applicable in any regions. The maintainer can be public, private or a consortium between both and the goals desired by the property owners must be clear and objective.*

Keywords— *Ecosystem services, Preservation, Sustainable development.*

I. INTRODUCTION

The constant degradation of the environment over the years imposes on society and specially on the state that represents nowadays the command and control, and the private initiative once they represent the exploratory sector, the creation of new mechanisms that promote the exploitation of natural resource of sustainable form.

Practical experience has shown that hardly ever only the imposition of civil or criminal sanctions on the line of the polluter pays are not effective to maintain the environment. Thus it is more effective to encourage preservation than to apply penalties for non-compliance with environmental standards (ARAUJO JUNIOR et al., 2012).

According to Jardim and Bursztyn (2015), although there is an effort in the application of regulatory instruments,

such as command and control, environmental degradation continues to advance throughout the country. This fact can be seen when analyzing the few areas of permanent preservation (APP) and legal reserve (RL) that are effectively preserved in rural properties.

In this context, new instruments of an economic nature began to be devised that they could go beyond the traditional mechanisms of control that already exist aiming at internalizing the external costs generated by environmental degradation and to encourage traditional owners and inhabitants to preserve ecosystems with the payment of remuneration. Thus, the idea of payments for environmental services – PES arises (ARAUJO JUNIOR et al., 2012).

This work aims to review the PES in order to give an overview of the difference of this management system in concerning to control systems and an introduction to the main systems currently implemented.

II. MATERIAL AND METHODS

A non-systematic review of the literature was carried out from the consultation of articles, prioritizing those published less than ten years ago in the electronic databases of the CAPES (Coordination of Improvement of Higher Level Personnel) journal portal as well as specific journals of the study area. It was also searched by the Google search engine to collect IN the internet publications on websites, newspapers or magazines related to the topic, which were intentionally selected according to criteria of relevance to the study, since it is a recent topic and with few studies in the area. All the information collected was analyzed and when pertinent incorporated into the study for the analysis and discussion.

III. REVIEW AND DISCUSSION

The PES is a recent and innovative policy that has been introduced in both developed and developing countries (JARDIM; BURSZTYN, 2015). This differs from the traditional mechanisms of command and control, constituted by regulatory measures, which determine the technical parameters for economic activities to achieve

the expected objectives of the policy, requiring, as a rule, that all economic agents REACH the objectives set by regulation, Regardless of their costs (SEROA DA MOTTA, 2006).

Thus, PES is defined as an economic instrument based on the concept of internalization of externalities. These authors argue that economic agents must incorporate in their decisions the costs or, in the case of environmental services, the benefits of their activities with environmental effects (YOUNG, 2005).

In Brazil, coercive instruments, such as fines that are based on the "polluter pays" principle and are protected under Brazilian environmental legislation (Forest Code - Law No. 4,771 / 65 and Law on Environmental Crimes - Law No. 9605/98) have been used as a mechanism to guarantee the environmental services provided by forests and preserved natural environments. However, some authors have shown that pollution control is more effective when using incentive policies, such as those based on the "provider-recipient" principle (CLAASSEN et al., 2001).

The National Water Agency - ANA (2012), also explains that the supplier-recipient model (incentive-based) is recognized to be more efficient and effective in controlling erosion and diffuse pollution than the traditional user / payer model.

It is in this context that the payment instrument for environmental services (PES) emerges, which is defined as a flexible compensation mechanism based on the "provider-recipient" principle, in which environmental service providers are paid by the beneficiaries of these services (BERNARDES, 2010).

Therefore, the purpose of this payment is to compensate those owners or squatters, who voluntarily help to preserve or produce any environmental services through resources monetary or otherwise.

The implementation of a management tool generally implies trade-offs, that is, the most efficient instrument to achieve an environmental objective may not be so efficient for a social objective, thus there is no optimal management option. It is important to consider the different characteristics of the environmental services in question to define the instrument (BÖRNER et al., 2009). The definition of the instrument goes through the understanding of the term "environmental services", so it is necessary to understand the concepts of natural ecosystem and managed ecosystem.

The natural ecosystem is a functional system, where complementary relations between living organisms and their environment occur. Thus, this system consists of biotic components (plants, animals, microorganisms) interacting in the environment, and of abiotic components (water, soil, light, humidity, temperature, etc.). The relationships between both form the structure of the

system, and the dynamic processes in which they participate constitute the function of the system.

The managed ecosystem can already be defined the ecosystem altered by human actions.

The complex interactions between the biotic and abiotic components in ecosystems ensure the survival of species on the planet.

It is identifying these relationships that the environmental services are defined and provided. More specifically, identifying ecosystem functions that provide goods and services that meet human needs directly or indirectly (Ecosystem services) (DE GROOT et al., 2002).

In this context, both the services provided to human being by natural ecosystems (ecosystem Services) as those provided by ecosystems actively managed by humans are considered for the definition of environmental services are considered.

Thus, according to Wunder et al. (2008), man-made activities that contribute to the maintenance of environmental provision are also understood as "environmental services".

Hercowitz and Whately (2008), differentiate "ecosystem service" from "ecosystem services", defining the former as one of many services provided by ecosystems (food supply, wood etc) and "ecosystem services" as the set of services not separable in Parties.

According to Millenium Ecosystem Assessment - MA (2003), environmental services can be divided into three groups:

A) Procurement services: These would be services that result in goods or environmental products of economic value, obtained directly by the use and sustainable management of ecosystems, such as water, wood and food;

B) Support and regulation services: these would be the services that maintain the ecosystem processes and the conditions of the natural environmental resources, in order to guarantee the integrity of its attributes for present and future generations, such as regulation of floods and drought, regulation of Microclimate, among others;

C) Cultural services: these would be services associated with the values and manifestations of human culture derived from the preservation or conservation of natural resources, such as leisure, religious, and other non-material resources.

Therefore, payment for environmental services can be understood as a commercial relationship based on the sale of one or more of these services to a buyer, as cited by Wunder (2005), who states that this is "a voluntary transaction in which a well defined service, or a land use that can secure this service, is acquired by at least one buyer of at least one provider, on condition that it guarantees the provision of the service (conditionality)."

There are two critical points in this definition of Wunder, the first concerns the formation of the market for the transaction to take place, and the second is in the valuation of the service.

The formation of the market is related to the level of impact of the service, which may be local, regional or global and in the demand for this service (GUEDES; SEEHUSEN, 2011).

The valuation of these services often becomes subjective, being dependent on the satisfaction of the individuals involved in the purchase process. Thus, a function of preferences, which depend on education, propaganda, cultural presuppositions, abundance or scarcity etc., ie, the value systems considered by each person (FARBER et al., 2002).

Guedes and Seehusen (2011), state that for the definition of the value of a given service, the analysis can be performed through the following groups: intrinsic values, use values and non-use values.

According to the authors, the intrinsic values correspond to the contribution of ecosystems and biodiversity in maintaining the health and integrity of these or a species, independent of human satisfaction. Being based on systems of theological or ethical value that can not be captured in monetary terms, making it excluded from the composition of the total economic value.

According to the same authors, the use values can be of direct use, when the agents benefit directly from these (such as wood and non-wood products, or scenic beauty services for tourist or recreational activities), indirect, related to the functions of ecosystems that indirectly benefit people (such as climate regulation, carbon storage, and maintenance of hydrological cycles) and option values related to leaving an option open for later use, such as maintaining biodiversity in the expectation of which components of it may be used for medical purposes in the future.

In order to define the economic contribution of environmental services, in terms of indirect use and option values, methods were developed to value them economically, since for these the values are not defined by the market (TEEB, 2010).

As stated previously by Wunder (2005), in a PES there must be at least one buyer of at least one provider. Most of these providers are rural landowners who, although they may have an environmental conscience, often have a small willingness to invest in these practices, often coupled with the low income of these individuals and the lack of public policies that somehow compensate these interventions, which generate positive externalities (GUEDES; SEEHUSEN, 2011).

Thus, the option of directing ownership to receive environmental benefits or adopting management and exploitation practices that would not provide such

services is due to the choice of alternatives whose relation between perceived benefits less the costs involved are greater (FARBER et al. 2002).

The definition of the product to be marketed is still one of the most challenging aspects in the area of environmental services (LANDELL-MILLS; PORRAS, 2002).

In addition to defining who is the buyer and who is the provider of the environmental service, according to Oliveira (2010, apud ARAUJO JUNIOR et al., 2012), such services can be understood in three ways:

- 1) as a way of integrating the traditional inhabitants of preservation areas and encouraging them to preserve it, through a contractually stipulated remuneration;
- 2) as a way to compensate for the loss of competitiveness in the market, due to the compliance with the rules of management and exploitation of resources;
- 3) as a way of gratifying the residents and landowners who voluntarily adhere to the rules of preservation.

Thus, according to this author, the relationship in a PES goes beyond the purchase and sale relationship, which may include compensation and compensation as well as compensation for the environmental service. As also stated by Kosoy and Corbera (2010).

The form of payments of these services can occur through (ARAUJO JUNIOR et al., 2012):

- 1) Tax subsidies (in Brazil, for example, ICMS-ecological);
- 2) Creation of specific funds for preservation (national or international);
- 3) Also by direct negotiations and private agreements;
- (4 Or through the capital market (eg trade in carbon credits).

Therefore, inductors, which act in the formation of demand and induce PES systems, can be divided into three voluntary interests as government-mediated payments and environmental regulations (BECCA et al., 2010)

Thus, the great difficulty in defining the limits of the market relationship can be minimized insofar as the government assumes the role of the buyer and stipulates the subsidies that would be offered, which is responsible for defining the goals to be met.

In the case of water, the environmental market acquires a local character and, consequently, is more easily reached, since the basic unit of conservation is the river basin itself being the task of defining the goals to verify the provision of the environmental service (JARDIM; BURSZTYN, 2015).

Although the unit is the hydrographic basin, the actions to be implemented are carried out at the property level. Thus the property that is inserted in the basin (or the part of it) should implement them to benefit from the payments.

Thus, according to Araujo Junior et al. (2012), the PES functions as an economic instrument based on the assumption that agents tend to change attitudes according

to the receipt of incentives and economic penalties, in order to increase their profits or their usefulness.

Thus, payments for environmental services have become a growing market instrument capable of translating positive externalities, that is, non-market environmental services, are financial incentives for owners to preserve the ecosystems that provide these services (WÜNSCHER et al., 2008).

According to Garden and Bursztyn (2015), in many cases, the level to be retained is much higher for the society than for the farmer, since the positive externalities resulting from good agricultural practices are not offset, the benefit is collective, but the costs of conservation are exclusive to the farmers.

Since the measures adopted on the properties have a positive impact radius, which in most cases exceed their limits, the benefits are not restricted to the mere receipt of payments by the producers, but somehow all the persons that are benefited directly or indirectly, as stated By Araujo Junior et al. (2012).

Still According to these authors, in this respect, it must also take into account the globally impacting aspect of the various polluting activities in the elaboration of global environmental strategies to reach the effectiveness of the protective measures, mainly because we are in a time of deep global climate change, being necessary to consider the possibility that payments for environmental services also acquires this global connotation.

This way, the implementation of a PES program must go through the evaluation of the benefits that would be generated by this program as opposed to the costs of its implementation.

According to Wunder (2008), the current SA programs has worked with four major environmental service groups: 1) Carbon market (where countries with carbon sink deficits pay for other countries to maintain their carbon stocks, for example); 2) protection of biodiversity (in this case companies would buy protection areas, such as); 3) protection of watersheds (users of water resources of this state pay farmers who protect rivers and springs); 4) protection for scenic beauty (in this case car companies would pay for wildlife conservation for local communities).

These programs still present great challenges, once, according to Pria et al. (2013), they are innovative projects, learning from mistakes and successes is inherent to the process.

In this work, a review of the main implemented programs (or under implementation), presented below, was carried out.

PES – México - Projeto SCOLEL TÉ

The project SCOLEL TÉ is being developed in Chiapas, south of Mexico. The use of this model by means of

environmental management has presented satisfactory results according to Araújo Junior et al. (2012).

According to Furlan (2008) the project was initially funded by the European Union by the Mexican government through the implementation of a fund, the Bioclimático Fundo, under the management of farmers' organizations, the local survey institute and also the Edimburg Center for management of carbon (ECCM). Still according to the same author, means called "live planes" implement the project that are plans composed by farmers with technical assistance, which are registered in the Fund in order to become credits of carbon.

PES – Costa Rica

According to Landell-Mills and Porras (2002), Costa Rica is the most developed country in terms of public policy for environmental protection and for the use of mechanisms of PES towards the management of the hydrographic basin in Latin America.

O PES – CR was implemented in 1996 by Costa Rica. This is a national program and it aims at stopping the high rates of deforestation in that country, whose forest area had declined from 75% in 1940 to 21% in 1987 (FONAFIFO, 2016).

The management of financial resources is run by FONAFIFO (national Fund of Forest Financing) and for the regulation of the program it was implemented the forestry law number 7575 of February 13, 1996 that regulates the areas to be protected and the kind of environmental services (PAGIOLA, 2008).

The program pays for the preservation of the hydrological and landscape diversity and for the sequestration of carbon, having as beneficiary the users of water, the Costa Rican society and the global society (FONAFIFO, 2016).

Araújo Junior et al. (2012) show the linking of receipt of the property title as a vulnerable point of this program. Thus, this fact brings about discriminatory and excluding effects, especially referring to the small producers, indigenous group and also Afro-Caribbean people that do not have the property title of their lands and consequently the benefits of PES.

PES – EUA - Nova York

New York City faced the question of maintenance of good quality of the water for public supply through a joint effort. So the Whole Farm Program based on an integrated planning of properties was created. The city municipal administration has begun to finance both the actions of conservation and control of water pollution on the farms and technical assistance to farmers, considering the economic planning of the property. On this program, the areas along the rivers away from the properties and other forest areas began to receive care (PRIA et al, 2013).

According to Araújo et al (2012), thus, New York City chose to determine US\$ 1.5 billion to elaborate and put in practice, for a period of ten years, a plan for environmental protection that guaranteed the quality of the water and so avoided the necessity of filtering the water.

Still according to these authors, this modality of PES has become possible the restoration of the ecosystem of hydrographic basin that provides water to New York , besides benefiting the owners of the properties in the region, bringing forth an economy of more than US\$ 5 billion to the city.

PES – França

In the decades Of 1990, The company Perrier – Vittel (Nestlé nowadays) created a program to finance farmers in order to give them an opportunity to change their practice and technology aiming at reducing the risk of contamination by nitrate and pesticides in the aquifer in the northeast of France (PERROT-MAÎTRE,2006).

The company bought 1,500 hectares of land and offered the right of use to former owners, long-term contracts were signed with rural producers subsidizing their activities and ensuring technical support to use less intensive techniques in the use of pesticides (PERROT-MAÎTRE, 2006).

PES - Brasil

In Brazil , the PES has been discussed more attentively since the launching of the Program Proambiente in 2000. IT was based on an initial experience of PES in the country, however it showed several challenges to be overcome (WUNDER et al., 2008).

Thenceforth several projects of law on this subject started to be proposed by the National Congress and some federal laws already mention them, in spite of not creating a national policy about this. In addition, some states created laws on the theme, although there is not a comparative analysis of how these approved laws approach this subject. (IMAZON,2012).

In the national scope, there is the law 12.512/2011, a supporting program that aims at environmental conservation, called Bolsa Verde Program that was approved in 2011 and it has instituted the Supporting Program to the Environmental Conservation and the Program of Promotion to the farmers' activities.

The Bolsa Verde Program was established , having as example the state of Minas Gerais that, through the law 17.7227/2008, has regulated the concession of financial stimulus to owners and rural landholders (Bolsa Verde) and change the laws 13.199/1999 (State policy of hydrological resources) and 14.309/2002.

In Espírito Santo state, the law that instituted the PES was approved in 2008 .Other states have been following this tendency such as São Paulo and Minas Gerais. In the National Congress the law project number 792/07 on

environmental services is being processed. It aims at instituting a national Policy of Environmental Services and the creation of financial stimulus to the conservation and restoration of natural ecosystems (TNC, 2011).

It is perceived, in some cases, in the state scope, there is not a specific law for PES, but the content in it establishes the rules regarding it. According to ANA (National Agency for Water) (2012) the development of this kind of program at local scope is a very important from the economical point of view, because besides the impact on payment in the job and on the income, it may bring meaningful benefits to economic development associated to the environmental service itself (ANA, 2012). In many cases, environmental problems have brought about several barriers to the economic development and the PES acts a facilitating agent in order to handle these problems.

Nowadays in Brazil, there are some ongoing projects of PES, however, most of them are of regional scope. From now on, we will make a brief report of some programs.

PES Programs – Water Producer

Brazil has been taking the lead in the development and application of projects of payment for environmental services, especially in the last decade. The Agência Nacional das Águas (ANA) has been playing an important role with the creation of the program Producer of Water. This program encourages the payment policy for environmental services and implantation of projects that have as objectives the hydrological resources. In order to receive the title “Water Producer”, the projects must follow the conditions and guidelines established by ANA. With the objective of having a system of supervision of results that aims at qualifying the received benefits with its implantation it is one of the conditions that is considered an essential premise (LIMA et al., 2013).

PROAMBIENTE

PROAMBIENTE, in legal Amazonia, is a project that aims at paying for services destined to the deforestation that was avoided, to the sequestration of carbon, to the soil and water, to the preservation of the biodiversity conservation and to the reduction of inflammability of landscape. The male and female family producer, handmade fishermen, traditional population that live in the Amazon, and meet certain requirements, are beneficiaries of these programs, since the payment is made according to the group and the service provided (ARAUJO JUNIOR et al., 2012).

The implementation of this system as a public policy has become one of the oldest PES experiences in Brazil, since it began in the 2000s and has served as both a conceptual and practical reference for current PES works (ONISHI et al., 2013).

ICMS Ecológico e Bolsa Floresta

According to Araújo Júnior et al. (2012), the ecologic ICMS, also known as “ecologic tax”, has been adopted in many states in Brazil to subsidize and stimulate the actions of conservation. Thus, allowing the Brazilian townships to receive part of the raised financial resources of tax of Imposto Sobre Circulação de Mercadorias e Serviços (ICMS) as a recognition for environmental services done to the society, being this service defined in creation and maintenance of units of conservation.

Still according to the same author, the Bolsa Floresta é destinado to the population that lives in the units’ state of conservation. The author states that the stimulus has as main objective is the conservation of forests and hydric resources, preservation of biodiversity and reduction of greenhouse effect gases. The payment of families that live in these areas is done through an specific card. Each month is paid R\$ 50,00, since the families meet the goals established by the program.

Cajari Carbon – Amapá

According to Superti et al. (2015), the Cajari Carbon Project was implemented approaching traditional extractivist population of a unit of conservation in a federal unit, Cajari River Extractivist Reserve (Resex – CA), located in the south of Amapá in the sentrentional Brazilian Amazon state.

According to this author, the objective of the project is the fixation of carbon to avoid emissions by means of forest conservation and by the biodiversity associated to the amazon biome. Thus, promoting the expansion of natural population of nut trees, the environmental education and investment in productive chain of Brazilian nuts to strengthen the extractivism of forest conservation and also of the biodiversity associated to the Amazon biome.

Still according to the same author, the project had as proponent the Associação dos Trabalhadores Agroextrativistas da Reserva de Cajari (ASTEX-CA)) and the work was done by a hired team and institutional partners Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA/ Amapá, Instituto estadual de Floresta – IE and the Instituto Chico Mendes de Conservação da Biodiversidade – ICM Bio in addition to the non-governmental organization such as Conselho Nacional das populações Tradicionais – CNS, Associações de Mulheres of Alto Cajari – AMAC, Cooperativa Mista dos Trabalhadores agroextrativistas do Alto Cajari and Escolas – Famílias Agroextrativistas do Maracá e do carvão – EFAEX-MA and EFAC).

Water Supply of Extrema –MG

In the program Water Supply implanted in township of Extrema located in state of Minas Gerais, the payment for environmental services related to water has already been made, benefiting small landowners that participate in the project. (JARDIM; BURSTYN,2015).

According to documents of The Nature Conservancy (2011) about the program “ Water Supply of Extrema”, there are different arrangements in order to pay and receive for environmental services. And the most common example as how the system works to encourage the conservation of the environment from the point of view of resource origin are: via hydrographic Basin Committee, through specific legislation or through the free market (TNC, 2011).

It is highlighted that in the township of Extrema the PES was incorporated in the city hall according to its budget and also according to the legal frame created and regulated for this purpose. The payment is made through resources from Fundo Municipal para Pagamentos por Serviços Ambientais (FMPSA). This fund aims at valuing the property as a whole and consequently makes this property suitable environmentally speaking. Thus, the program has three focus: vegetal cover, soil conservation and sanitation.

In addition, the program has the following partners: Secretaria do Meio Ambiente e Desenvolvimento Sustentável of Minas Gerais state (SEMAD), Instituto Estadual de Floresta (IEF), Agência Nacional das Águas (ANA), Nature Conservancy (TNC), the institute SOS Mata Atlântica and Comitê PCJ (EXTREMA ENVIRONMENT DEPARTMENT, 2010).

IV. CONCLUSIONS

The payment for environmental services presents as a potential instrument to promote the sustainable development. Thus, we reach nature preservation and it becomes clear that the maintenance of all the service provided for nature is indispensable to human being. It is also clear that with these programs described in this revision that most of them come from the public administration, specially the cases implanted in Brazil, and although they are of great importance, and fundamental in many regions, they face the necessity of raising the financial resource by public manager. Examples as the program Whole farm Program, from New York – USA, from Itacaré, Bahia – Brazil and Projeto Oasis, Created by Fundação O Boticário de Proteção à Natureza. In these places, the resource is not exclusively from the government. They become examples of programs that could better the implantation of PES in many other regions, inclusive with the association with programs that have already been implanted with public resources. It would increase the area of working of them with the possibility of comprising more properties. It is perceived that the PES is implemented through a stable way. It means it is not only a form of management, but it became an example administration where the conservation of the environment is provided without letting the owners of property, which

have only that means of livelihood, to pay for the costs of conservation. The relationships that regulate the PES are very important too. There is not a regulation that can be applied as a rule for any program to be implanted. That happens because of the local specificities are biome with different characteristics. Local population group with different habits and customs, source of resources from different maintainers (public agency, management committee, among others.). Thus, it is required that the PES has its own regulatory framework in order to meet these specificities. Even being necessary to meet these local characteristics, the examples mentioned in the implanted programs, show that the programs or payment for environmental services can be applied in any region, since there is a maintainer, being it public or private or a consortium between both and they show clearly and objectively the goals to be reached by the owners of the property.

V. CONCLUSION

A conclusion section must be included and should indicate clearly the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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An acknowledgement section may be presented after the conclusion, if desired.

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Numerical Structural Analysis of a Single Girder Crane According to Standard NBR 8400

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Abstract—The use of cargo handling equipment in the industry in general is extremely important for logistics, since their contribution in receipt of material, until the production stages. Since they are subjected to severe mechanical stress, it is necessary for them to resist to these loading. This work aims to verify the structural integrity of a single girder crane designed by “ARPI Engenharia”, according to standard NBR 8400. In order to evaluate the crane structure and compare the mechanical stresses with NBR 8400 yield stress, a 3D model was created in the software Ansys Workbench 17.2 and analyzed through the Finite Element Method. This is one of the most widely used methods by Engineers in order to design or solve engineering problems. This paper shows the solution of the static analysis, presenting the stress outputs from Ansys Workbench 17.2.

Keywords—Ansys Workbench, Cranes, Finite Element Method, NBR 8400, Structural Analysis.

I. INTRODUCTION

Cranes, subject of analysis in the current study, play an important role in the replacement of labor force by the mechanical method, allowing the transport of high loads in situations where manual labor becomes limited [1]. In view of the current engineering scenario of high competitiveness and incessant search for reduction of costs and waste, it is essential that cargo handling equipment be able to resist to several types of loads during their useful life. In order to guarantee operating reliability and safety, as well as optimum performance and cost-effectiveness, is crucial the use of regulatory standards. In this way, the present study presents a numerical structural analysis of a single girder crane subjected to different cases of load combinations required by the standard NBR 8400 [2], using the Finite Element Method through Ansys Workbench 17.2 software. Many engineering problems can be solved by using differential equation. Nowadays, one of the most used method resolution is the Finite Element Method that is among the various numerical methods [3]. It was developed to solve complex engineering problems and is increasingly being

used by many engineers with an aim to simulate components and structures during project, structural reinforcements, among other activities.

In this context, the purpose of this work is to compare stress outputs from Ansys Workbench 17.2 with yield stress requirements established by NBR 8400 [2]. The contribution of this paper is to provide an example of how computational simulation can be useful and effective for a crane structural analysis, in order to simplify and optimize engineering design.

II. TECHNICAL CHARACTERISTICS OF THE SINGLE GIRDER CRANE

An illustration of the single girder crane in study and its main technical characteristics are shown in the Fig. 1 and in the Table 2, respectively.

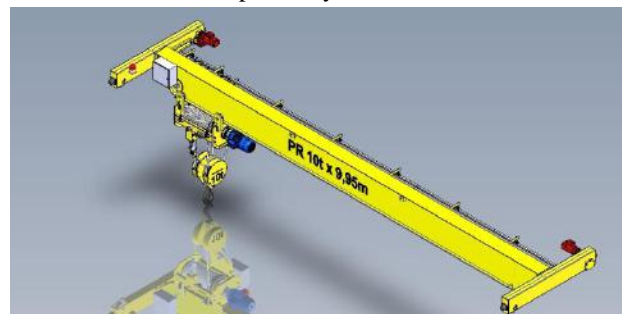


Fig. 1: Scheme of the single girder crane

The material used for the fabrication of the single girder crane is the structural steel ASTM A-36. Its mechanical properties are shown in the Table 2.

Table 1: Technical characteristics of the single girder crane in study

Load Capacity	10 ton
Free Span	9.95 m
Mechanical Group	3M
Translation speed	25 m/min
Electric hoist weight	1028 kg
Single girder weight	1519.5 kg
Braking speed	0.098 m/s ²
Impact deceleration speed	0.6 m/s ²
Lifting speed	0.083 m/s

Table.2: Mechanical properties of structural steel ASTM A-36.

Young's Modulus	200 GPa
Shear Modulus	77 GPa
Poisson's ratio	0.3
Specific mass	7850 kg/m ³
Ultimate Strength	400 MPa
Yield Strength	250 MPa

III. STANDARD NBR 8400

NBR 8400 [2] provides the guidelines for the correct verification of cargo handling equipment in general. These structures are classified in structural groups, according to their operational functions. In accordance with the technical characteristics of the single girder crane provided by "ARPI Engenharia", responsible for designing the structure, we conclude that the crane is classified as group 3 (as determined by the table 4 of NBR 8400[2]). Based on the selected structural group, we come to a security coefficient (M_x) of 1. Due to mechanical loads and shocks caused by vertical movements such as lifting, a dynamic coefficient (ψ) is also adopted. According to table 5 of NBR 8400 [2], the dynamic coefficient for a lifting speed of 0.083 m/s is equal to 1.15. At last, another dynamic coefficient ($\psi_h=2$) is adopted for horizontal loads due to the deceleration of the crane.

According to NBR 8400 [2] the evaluation of structures such as cranes is made by determining the stresses during their operation. Three kinds of loads are considered for the present analysis: Main loads, vertical loads, and horizontal loads. The main loads include the self-weight (SG) of the structure (metallic structure and electric hoist weight) and the operating load (SL) of 10 ton. The vertical load is represented by the dynamic coefficient (ψ) that multiplies the operating load by 1.15. Lastly, the horizontal loads (SH) represent the inertia effects caused by deceleration during translation movement and impact due to shock effects. The horizontal load caused by braking is applied in the Finite Element model through an acceleration and a force directly in the electric hoist support in the beam. The acceleration applied in the model is equal to 0.196 m/s² (0.098 m/s² multiplied by M_x and ψ_h). The force applied in the model is equal to 1960 N (0.098 m/s² multiplied by M_x , ψ , and SL). The acceleration caused by shock effects is equal to 0.6 m/s² (adopted by [4]). Table 3 summarizes all the loads applied in the Finite Element model and their respective directions according to the model coordinate system.

Table.3: Loads and accelerations applied in the Finite Element model

Type	Load	Force/acceleration	Direction
SG	Metallic Structure	14906 N	-Y
	Electric hoist	10084 N	-Y
SL	Operating Load	98100 N	-Y
SH	Direct force	1960 N	-X
	Braking	0.196 m/s ²	-X
ST	Shock	0.6 m/s ²	-X

NBR 8400 [2] set three cases of load combinations:

- Case I: normal operation without wind
- Case II: normal operation with wind
- Case III: exceptional loads

For the current study, only case I and III are considered in the analysis. As ASCE Standard (2005) [6], NBR 8400 [2] also approaches normal loads and exceptional loads. Thus, the following load combinations are established:

- Case I: $M_x(SG + \psi \cdot SL + \psi_h \cdot SH)$ (1)
- Case III: $SG + SL + ST$ (2)

For each case, there are three different positions of the electric hoist to be evaluated for the single girder crane: left, right and center of the beam. The model and respective positions are shown in the Fig. 2.

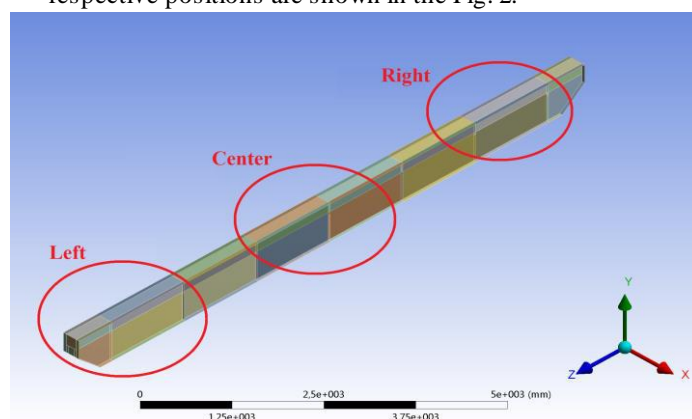


Fig. 2: Three positions of the electric hoist evaluated in the model

Table 4 summarizes the load combinations set for the structural analysis.

Table.4: Load combinations

Number	Combination	Case	Position
1	1.(SG + 1,15. SL + 2. SH)	I	Left
2	SG + SL + ST	III	Left
3	1.(SG + 1,15. SL + 2. SH)	I	Right
4	SG + SL + ST	III	Right
5	1.(SG + 1,15. SL + 2. SH)	I	Center
6	SG + SL + ST	III	Center

According to standard NBR 8400 [2], for Yield Strength/Yield Strength < 0.7, the respective values of allowable stress are:

Table.5:NBR 8400 Allowable stress

Case I	Case II	Case III
$\sigma_a/1.5$	$\sigma_a/1.33$	$\sigma_a/1.1$

The approval criterion for the shell elements used in the Finite Element Model is to present Von Mises stress below the allowable stress in all load combinations. Thus, the allowable stresses for the material of the single girder crane for cases I and III are shown in Table 6.

Table.6:Allowable stress for cases I and III

Case I	Case III
167 MPa	227 MPa

IV. STRUCTURAL ANALYSIS IN ANSYS WORKBENCH 17.2

In the Finite Element Method, the geometry of the component or structure under analysis is subdivided into small elements, in a finite quantity, interconnected by nodes, forming a mesh. This process is called discretization [5]. The analysis is divided into three distinct steps: pre-processing, solution and post-processing [5]. The pre-processing step consists of geometry modeling, definition of mesh, material properties, and boundary conditions. At this stage, the geometry was modelled on ANSYS Discovery SpaceClaim and exported to Ansys Workbench 17.2. For the solution step, the linear static analysis was selected in order to obtain stress and strain outputs. Finally, the structural response of the single girder crane was evaluated in the post-processing step. The model was built with SHELL181 elements in Ansys Workbench 17.2. The different thicknesses of the plates are shown in the Fig.3 in a color scale.

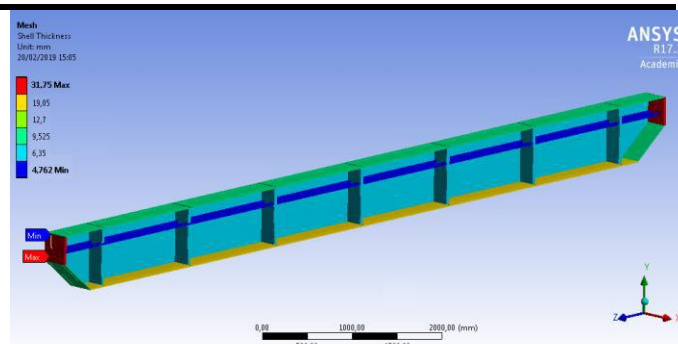


Fig. 3: Different thicknesses of the single girder crane

The model has a total of 49317 nodes and 49635 elements, including Tri3 and Quad4 first order types. Fig.4 shows in detail the defined mesh.

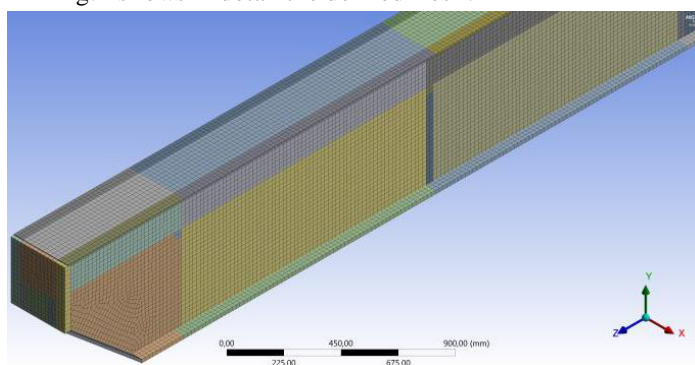


Fig. 4: Details of model mesh

The single girder crane was considered to be simply supported and the most external plates were restricted. One side was considered fixed and the opposite side had Y and Z displacement restricted, while X (longitudinal direction) was set free, according to global coordinate system shown in Fig. 4.

The most critical result of the static analysis occurred in combination 5, where the electric hoist is located in the center of the single girder crane. As previously mentioned, combination 5 includes the following loads: self-weight (SG), operating load (SL), and braking (FH). The Fig. 5 and Fig. 6 show in details, in a color scale, the Von Mises stress.

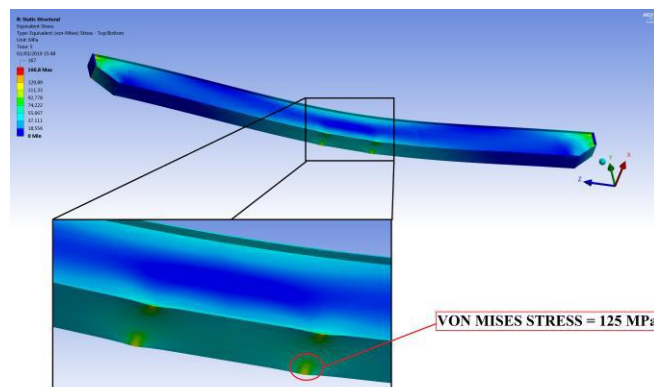


Fig. 6: Von Mises stress for combination 5

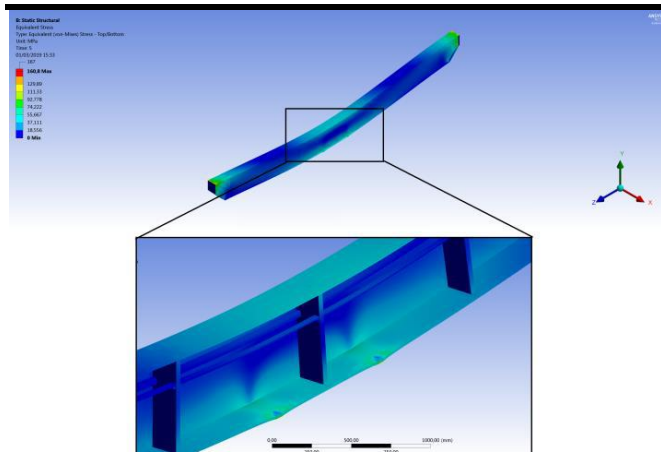


Fig. 5: Von Mises stress for combination 5

Note that the maximum Von Mises stress in the center of the beam (Critical region) is 125 MPa. It can also be noted that there is a stress concentration at the extremity plates, where the constraints were set. It can be viewed in Fig. 7.

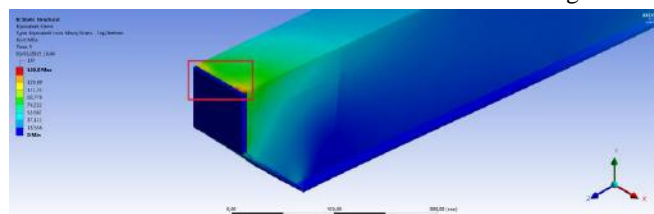


Fig. 7: Stress concentration at the extremity plate

A value of 160.8 MPa is found in this region. It can be explained because of the constraints applied in the area. As the constraints applied simulate a perfect fixed support, consequently it results in a bending moment bigger than the expected in reality, as a rigid joint transfers all the moment thru the joint. Another factor to be considered is that the single girder is connected to the end truck with bolts. It means that the rotational stiffness decreases and actually the connection looks like a semi-rigid joint. Table 6 summarizes the maximum Von Mises stress found for each load combination.

Table 6: Maximum Von Mises stress

Combination	Stress	Allowable Stress
1	124.14 MPa	167 MPa
2	115.85 MPa	227 MPa
3	139.79 MPa	167 MPa
4	115.98 MPa	227 MPa
5	160.8 MPa	167 MPa
6	138.61 MPa	227 MPa

V. CONCLUSION

The structural analysis of the single girder crane using Ansys Workbench 17.2 and according to standard NBR 8400 [2] showed satisfactory results. The results

demonstrated that the single girder crane structure is able to resist to all load combinations from NBR 8400 [2]. Its structure has enough stiffness to operate with safety and reliability, therefore meets the required criteria of NBR 8400 [2]. The maximum Von Mises stress found was 160.8 MPa and occurred in combination 5. This value is below the allowable stress of 167 MPa. The general objective of the article was reached. The results were able to prove how efficient, practicality, and applicable the Finite Element Method is for a single girder crane structural analysis. Future possible applications and extensions could be a fatigue and buckling analysis of the structure, since the current paper only approaches the yield stress criterion. NBR 8400 [2] also provides the methodology to evaluate fatigue and buckling criteria for cranes and cargo handling equipment, therefore can be useful for possible applications.

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Video Tutorial Development as Independent Learning Media in Materials Designing Teaching Based on Multimedia Presentation in IAKN Tarutung

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Abstract—This study aims to develop video tutorials as a medium for independent learning on the material "Designing Multimedia-Based Learning Materials Presentations in IAKN Tarutung. Respondents in this study were sixth grade students of Christian Religious Education study program. This research was conducted in February until November 2017. The research method applied a mixed method, which is a combination of quantitative and qualitative approaches. The step of product development applied by adapting the ADDIE development model modified with R & D procedures according to Borg & Gall. Data collection was carried out by interviews, questionnaires and learning outcomes tests. After the initial prototype was developed further validation was carried out which included expert evaluation, one to one evaluation, small group evaluation and field testing or evaluation of large groups, the purpose which to refine existing deficiencies so that the product was feasible to use. Based on the results of the validation, it is known that the percentage of product feasibility based on expert design evaluations is 87% very feasible, 88% of material experts are very feasible and media experts 82% are quite feasible but still need revision. And based on one to one evaluation, 90% is very feasible, small group evaluations of 90% are very feasible and still need revision, while the results of evaluation of field test of product feasibility is 91% very feasible without need for revisions. Furthermore, based on the learning outcomes test the respondents in the field test, the average test results obtained is $80.57 > 75$ (Value B), which is the Standart minimum criterion, it means that the video tutorial products developed are effective

Keywords— Development, video tutorials, independent learning media, material designing multimedia based teaching material presentations.

I. INTRODUCTION

Based on development of science and technology, society changes, understanding of ways learning and the advancement of communication and information media have given meaning to educational activities. This challenge is one of importance foundations technology and media approaches in management of education and learning. The importance of the technology and media approach in managing education (learning) is to help the learning process in achieving the goals to be achieved. Therefore to create an effective learning process one of the efforts that can be done is a technological approach (Munadi, 2013, p.1). Technology and media approaches can be implemented in the form of audio technology based on media use, visual technology or audiovisual technology in the learning process. However, in the learning process both inside and outside the classroom, the use of technology based on media has not been widely used. The learning process still seems conventional. One of the contributing factors is the lack of ability to create (develop) the media.

In relation to importance of technology based on media, in order to prepare reliable and professional Christian Education teacher candidates who have pedagogical competence, Institut Agama Kristen Negeri, (State Institute of Christianity) (IAKN) has required the sixth semester students of the Christian Religious Education Study Program (PAK). attend learning Process in Technology and Learning Media. The course has 2 credits and integrated to the S1 curriculum of PAK, the aim is students have competence in developing and utilizing technology based on learning media in PAK learning process. One of the material studied in this course is Technology and Learning Media PAK is designing based teaching multimedia material presentations. The aim is the sixth semester students of the PAK Study Program can design or develop their own teaching materials to be taught, especially multimedia-based teaching material presentations.

But the phenomenon that occurs from the observations of researcher, the learning process of Technology and Learning course Media, especially study in "Designing Multimedia-Based Learning Materials Presentations", many students complained that they could not take the maximum learning process, Because the allocation only 100 minutes is still very lacking, and the variety of laptop devices types that students have, so it requires additional time to provide a different explanation. As a result, some of students have difficulty continuing the next stages, because a step stage or procedure that continues hierarchically. So, if one step is poorly understood, then it will interfere with mastery to proceed to the next stage.

Starting from the results analysis that have been done, the researcher are interested to develop instructional products in the form of video tutorials material based on designing multimedia in teaching material presentations. This tutorial video is specifically designed to help students have ability study independently outside the classroom or outside lecture hours without lecturer explanations. So it is expected that the instructional products developed, the problem of time constraints in lectures in the classroom can be overcome so that students are understand to repeat them independently outside the classroom.

II. REVIEW OF LITERATURE

Instructional development (instructional design) is a systematic process that includes the stages of identifying problems, developing instructional strategies and materials, and evaluating their effectiveness and efficiency in achieving instructional goals (Suparman, 2012, p.91). Smith dan Ragan (2005:10) Stated: "*Instructional design models may be defined as visualized depictions of instructional design process, emphasizing main elements and their relationships*" So the instructional development model is an illustration of the instructional design process that is visualized, and emphasizes the main components and their relationship with one another. In an instructional development process model includes three main activities, namely the analysis phase, the development of strategies and evaluation stages.

There are several known instructional development models that are commonly used, among them, namely : *Courseware Development Process* (CDP) Model (Soekanto, 1993,p.60-62), ADDIE Model (Branch, 2009,p.3-61), and *Instructibal Development Institute Model* (IDI) ((Soekanto, 1993,p.52) The development of the tutorial video in this study uses the five steps of the ADDIE Model namely analysis, design, develop, implement and evaluate. The strength of the ADDIE model is to offer a series of critical questions to ensure the identification of instructional goals and the needs of students

at each stage of the design process (Koohang & Harman, 2007, p.361), While the weakness of this model is the limited time and resources in its implementation (Fenrich, 2014, p. 52).

III. RESEARCH METHODOLOGY

The collected data analyzed through development research is the mixed method. Abbas Tashakkori and Charles Teddlie stated that "*Mixed methods or Mixed Methodology which contain elements of the quantitative and qualitative approaches*" (Tashakkori dan Teddlie, 1998,p.5). Both of these approaches are embedded, to analyze and interpret data about the quality of instructional products developed through information, responses, and suggestions for improvement from design experts, material experts and media experts through questionnaire instruments.

Research and development (R & D) is research that is used to develop a product or procedure and then conduct field testing and evaluation of the product to obtain effective results (Borg & Gall, 2007, p.589). This study aims to develop a new product that is effectively used especially in the Technology and Learning Media Courses, after first going through the process of validation and testing in the field.

In developing this video tutorial product, the writer adapted the ADDIE Instructional development model modified by Borg & Gall's research procedure until the fifth step. Then the steps taken in product development for this video tutorial include: (1) analysis, (2) *design*, (3) develop the initial prototype, (4) *implement* / limited initial testing, (5) evaluation:, expert evaluation, one by one evaluation, small group and large group evaluation (6) make product revisions and (7) the final product.

The types of data in this study namely qualitative data and quantitative data. In a research, Interview is a tool for collecting data (Boudah,2011,p.127), questionnaire and test of learning outcomes (Johnson and Christensen, 2014, p.227). The product effectiveness developed criteria were carried out by consulting the value of students towards the complete standard minimum criteria, namely B (Score 75). The to be effective if the average value of student learning outcomes is ≥ 75 (Category B).

IV. RESULT AND DISCUSSION

1. Analysis

- a. The Results of Gap Performance and Needs Analysis

Based on the results of observations and interviews conducted by researcher in the sixth grade students of PAK Study Program when teaching Technology

and Learning Media PAK courses, there were gaps (problems) by some students who had difficulty mastering learning process. Because the allocation of 100 minutes the course has 2 credits is very lacking, moreover there are about 35 students in each group who attend this learning process, so that the time available is very less

- b. The Results of Determine Instructional Objectives
The purpose of this course that the sixth semester students of the Christian Education Study Program have the competence to develop teaching materials that will be taught to students, especially multimedia-based teaching material presentations.
- c. The Results of Students Analysis
Based on the analysis from 50 students found 42 students (84%) stated that it was difficult to master the learning process "PAK Learning Technology and Media" only by relying on books printed and lecturers' explanations in the classroom, while 8

students (16%) states that they can master lecture material without finding difficulties.

- d. The Results of Analysis Resources Needed
The majority of students who take the "Technology and Learning PAK by video tutorial" have their own laptops so it is very possible that the video tutorial products developed can be used to the fullest. In addition, students already have basic knowledge (initial abilities) to operate of computers

2. Design

- a. Task Inventory
Some task need to be done for students to have maximum mastery of this material, which are: determining the material to be developed, outlining the material, images inventorying, videos and films to explain the material and designing slide templates to be made.
- b. The Results of Formulate Instructional Objectives

Table 1: Instructional Objectives

Subject	PAK Technology and Learning Media
Objective	Sixth semester students of PAK Department
General Instructional Objectives	At the end of learning students are expected to have competence in developing technology-based learning media in learning process of Christian Education.
Special Instructional Objectives	Given the tutorial video self-learning media, students are expected to be able to design teaching materials that will be taught to students, especially multimedia-based teaching material presentations.

- c. The Results of Test Development
To measure student mastery of lecture material "Designing Multimedia-Based Learning Materials

Presentations" can be done with performance test instruments as shown in Table below

Table.2: The Grid Performance of Instruments

Number	Rated aspect	Score				Total
		4	3	2	1	
1.	Accuracy material determines					
2.	Accuracy of color arrangement, images, text, movies or video and audio					
3.	Accuracy in carrying out procedures					
4.	Punctuality					
5.	Suitability of results					
Total Score						

3. The Product of Development Results

The results in this study were a prototype video tutorial "Designing Multimedia-Based Teaching Materials Presentations", with the subject matter of the lesson "God Guide to the Life of My Family"

with the literary source of Genesis 2:24; 1 Corinthians 11:23 and John 2: 1-11 as shown in Figure 1 below:

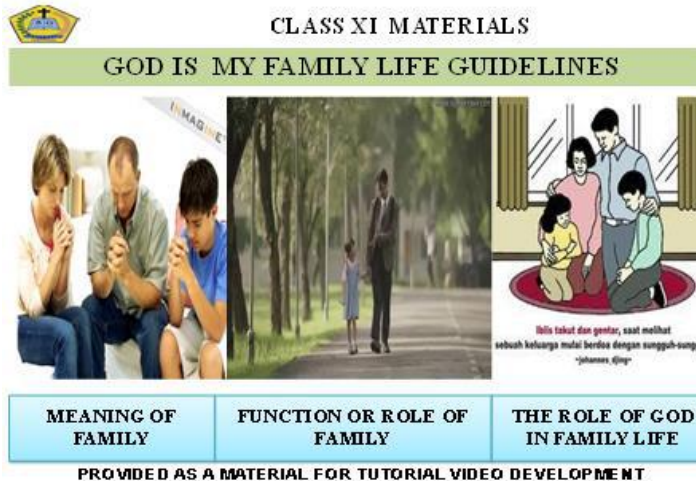


Fig.1: Tutorial video view

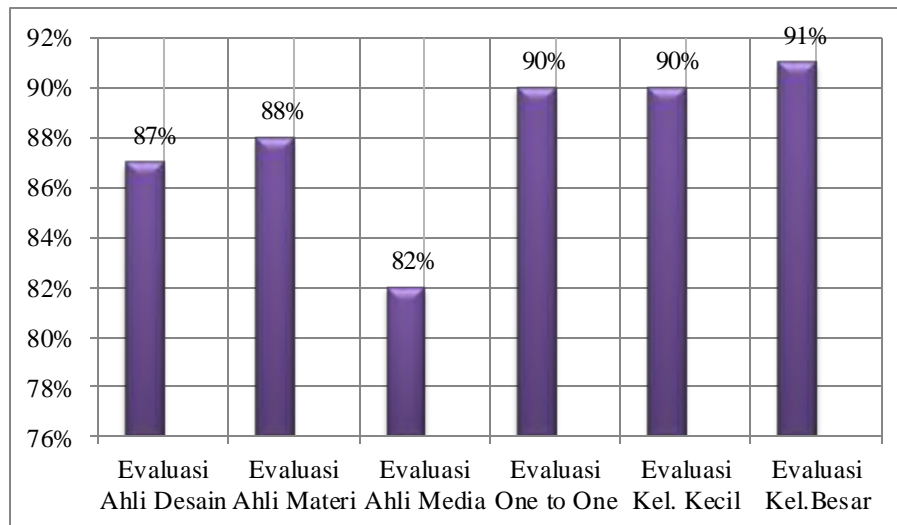


Fig.2: Results of Formative Evaluation of Video Tutorial

- b. Based on the results of test the respondents of the big group research (field test) about 35 students are designing multimedia teaching materials presentations, the average test results obtained were 80.57 B value categories. based on the results of formative evaluations conducted on video tutorial products developed through validation of design experts, material experts, media experts, one to one test, small group test and field test (large group test), indicating that instructional products developed are feasible to use . based on the results of the average final score of student test results in a large group evaluation or field test with a standard set of minimum completeness criteria (KKM) of 75 (Value B). The acquisition of the average value of the results of the big group test

is 80.57 which is greater than the standard value of completeness set 75. So based on the results of the consultation value it can be interpreted that the product of the video tutorial developed was effective.

V. CONCLUSION

The process of video tutorial products is carried out in several stages based on the design stages of the ADDIE Model which include: analysis, design, develop, implement and evaluate which are coupled with the research steps of Borg & Gall. The product feasibility test developed is carried out through several stages, namely expert evaluation, one to one evaluation, small group evaluation and big group evaluation or field test.

Based on the results on product feasibility, it can be concluded that the design evaluation results 87% that

categories are very feasible but revisions still need to be related cover style and clarity of the narrator's voice. , image quality and narrative delivery are still too fast. Similarly, the evaluation results of media experts 82% that categories are quite feasible and need revision of image quality and accompanying music volume. Furthermore, the results of one-to-one evaluation 90% that category are very feasible to use, but need to revise the duration of running text, the results of small group evaluations 90% that categories are very feasible but revisions the duration of running text need to be shortened again. Then the results of a big group evaluation 91% field test category are very feasible to use and without any revisions.

Furthermore, the effectiveness of the video tutorial products is determined by looking at the acquisition of the average score of the overall test results by respondents and consulting with the standard minimum completeness criteria set (KKM) of 75. The acquisition of the average score of the big group test results is 80.57 which is more the value of the completeness standard is 75. So based on the results of the consultation the value can be interpreted that the product of the video tutorial developed is effective.

The results of this study are expected to contribute to improve student learning outcomes, especially students of the sixth grade PAK Study Program who take Technology Courses and PAK Learning Media in terms of mastery of "Designing Learning Materials Based on Multimedia Presentations. In addition, it is also expected to contribute solving learning problems students who have difficulty understanding classical lecture material in the classroom and contributing to develop of specially designed learning resources (learning resources by design), specifically to facilitate independent learning activities.

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Android app for Teaching and Learning Math for Elementary School Children

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Abstract— *The present work has as main focus the demonstration of the use of an android application as mediator and facilitator of the knowledge of mathematics for elementary school children using concepts and techniques of computational intelligence implementing the model of expert systems.*

For this the application will be developed in java using the android platform in order to accompany the great expansion of current technological tools such as games and multimedia applications because they are portable and facilitate the use at any time.

With this, it is expected that the application will be of great use for students and teachers since they have assisted in teaching through methodologies and technological education merged in elementary schools.

Keywords— *application, mathematics, technological education.*

I. INTRODUCTION

Faced with the accelerated growth of information systems in many industries, intensive study is required on existing forms of security to make software more reliable. There are several ways to effectively and efficiently meet these needs. However, the big point in question is the investment needed to use these methods and protocols, and in the last decade the studies have faced an even greater challenge: the search for low-cost technologies, but at the same time a rate high security.

With this, the application will demonstrate the use of knowledge in fundamental level mathematics with technological resources to facilitate the user's learning through the playful and ways to motivate the user to continue through training, tests that will be treated in games situations that is the great with the expansion of Information Technology.

According to Martins, De Souza Rebouças and Alves (2015) "Today's children and youngsters are considered

digital natives because they were born in the digital world and, therefore, feel totally at ease with technology."

Martins, de Souza Rebouças and Alves (2015) also affirm that the Tablet is a resource that is widely diffused in technology and its use is increasingly common.

De Melo Fernandes and De Souza Rebouças (2016) consider that "Mathematics is an area of knowledge of fundamental importance in our lives. [...]".

For Garcia (2009) mathematics develops logical thinking, helps solve problems and is useful in social life. According to Garcia (2009), mathematics is taught to give young people opportunities to compete in the labor market, since they are present in all types of competitions and selection tests.

With this, it is possible to identify ways of improving education through technology since the teaching of learning is outdated and a modern era.

According to the website Todos pela Educação, only 9.3% of students in the 3rd year of high school had expected mathematics proficiency in 2013, while 16.4% of students in 9th grade had expected proficiency in Mathematics.

Thus De Melo Fernandes and De Souza Rebouças (2016) argue that a possible proposal to minimize this problem is the use of educational software in the classroom.

With this the present paper focuses on showing the possibility of using technology in educational environments through applications.

II. MATERIAL AND METHODS

For this tool will be used the programming language java enjoying the resources of the IDE Android Studio where it allows the development of mobile applications for the Android platform.

This can use the hardware features of the various mobile devices that are generally used, thereby ensuring portability, ease of use and flexibility as the technology is found and can be accessed on minimized devices.

2.1 THE DEVELOPMENT ENVIRONMENT

According to AS FAQS (2016) Android Studio was announced in 2013 at the Google I / O conference, based on Eclipse, which is the environment for application development heavily used by developers. So with Android Studio, Google reconciles the IDE to the development of applications, and so develop specific tools adapted to the part with version support.

Currently, Android Studio is the platform postulated as the most complete IDE for developing many feature-rich Android applications that stand out from the other programs used for this work, is based on IntelliJ and can be downloaded for free through the Apache 2.0 license.

2.2 COMPUTER SCIENCE IN TEACHING

Some mathematical educators have been dissatisfied with how content has been worked in the classroom, which has expanded the search for new ways to make its teaching really relevant to the transformation of the individual and of society (Pinho et al. 2008).

Therefore, Pinho et al. (2008) states that computing brings a new way of teaching, through a dynamic in which the student, when interacting with the software, can increase their motivation and achieve a significant improvement in their learning. One way to promote this is through m-learning, or mobile learning, which consists in the use of wireless networking technologies to spread teaching and learning, further facilitating access to information (Oliveira et al., 2007).

The Information and Communication Technologies (ICT) has been seen by several researchers as tools capable of facilitating students' learning, providing critical discussions and analyzes for the construction of knowledge by the learner. (Ponte et al., 2003).

In this way the act of learning is linked to the curiosity and the situations that foment and instigate it. The stimuli are fundamental to make the teaching and learning process come true (SAVATER, 1998).

According to Valente (2003), one does not have to be a "computer expert, technical and pedagogical knowledge, can be built together". "The mastery of techniques happens due to the need and demand of the pedagogic and the new technical possibilities create new openings for the pedagogic". (VALENTE, 2003, p.22).

With this, it is possible to affirm that instructional software does not provide the student with explicit thinking, the teacher needs to use practices that emphasize the formalization of knowledge, accompanying and encouraging the student step by step in the learning process. (ALMEIDA, 1994).

In order for the knowledge to be explained, it is the teacher's duty to measure methodological techniques for student learning and thus to provide information in a clear way, taking into account the current needs where the use of technologies is proposed as an educational tool.

Silander and Rytönen (2005) believe that mobile devices define a new dimension in education, especially by allowing learning in specific contexts, easily extendable to the real world.

The computer is not just another powerful educational tool. He is the only one to allow us the means to address what Piaget and many others identify as the obstacle that must be transposed into the passage from infantile thinking to adult thinking. . . . Knowledge that was only accessible through formal processes can now be concretely addressed (PAPERT, 1997, p.37).

For Brazil (2002, p.117-118):

"To follow critically the contemporary technological development, making contact with the advances of the new technologies in the different areas of knowledge to position itself in front of the current issues" (BRASIL, 2002, pp. 117-118).

With this it is possible to note which technologies become important for teaching and learning in the development process of a child and to incorporate such means in the education system becomes necessary since it has the potential to obtain great results through the ludic.

2.3 CREATE NEW TEACHING METHODOLOGIES

For the adaptation of the tool in elementary education will require the support of the pedagogy that resides in the college that will use the application. In this way new teaching methodologies can be applied satisfying the needs of student evaluation, once the application provides this method.

Soon teachers will be able to teach evidence in view that the tool has a friendly layout of easy understanding and basic functionalities for pedagogical support.

2.4 TOOLS OF LAYOUT

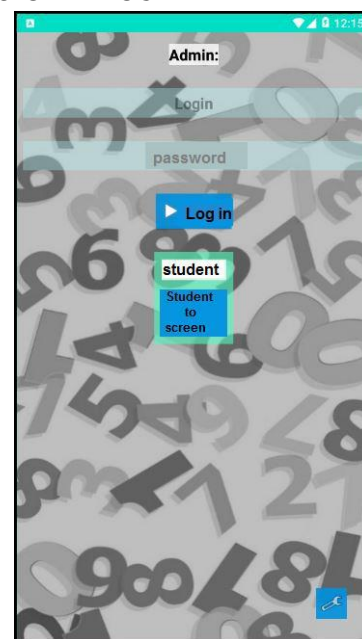


Fig.1: Initial Screen.

Source: The authors.

The initial screen serves to authenticate the different levels of users, the background lists numbers for the user to identify that it is mathematics, a user and password are provided by registering who to use the application.

Soon the application will be enabled to receive registrations of students considering the tests in the classroom with teachers and pedagogues evaluating the performance of the tool

Given that the tool will work with different levels of users, it will be able to show different views as shown in Figure 2, where some items are observed for the student that can perform questionnaires, tests and verify their status (individual performance in relation to their studies).

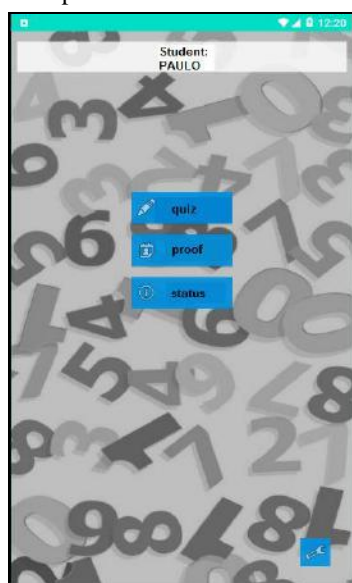


Fig.2: Student Vision.

Source: The authors.

For an autodidact control, a feature is shown as a way of updating the registration data of the person who accesses the tool, in it it is possible to find items such as login, password, name, date of birth both as needed, an example is shown in figure 3.



Fig.3: Change of data. Source: The authors.

This allows the user to have flexibility to manage their data as it is of great importance to the administrators of the tool who need updated data, when it comes to methodologies in public or private schools these details become very important since they will be detailing performance of students who may or may not be linked in a class that is being used in a school.

The administrator who teacher characteristics may have will have a differentiated view in order to grant privileges such as adding and modifying questions, users, classes and tests as well as listing the questions used, users as enrolled in the database the existing classes and also the evidence released by him. An example is shown in figure 4.

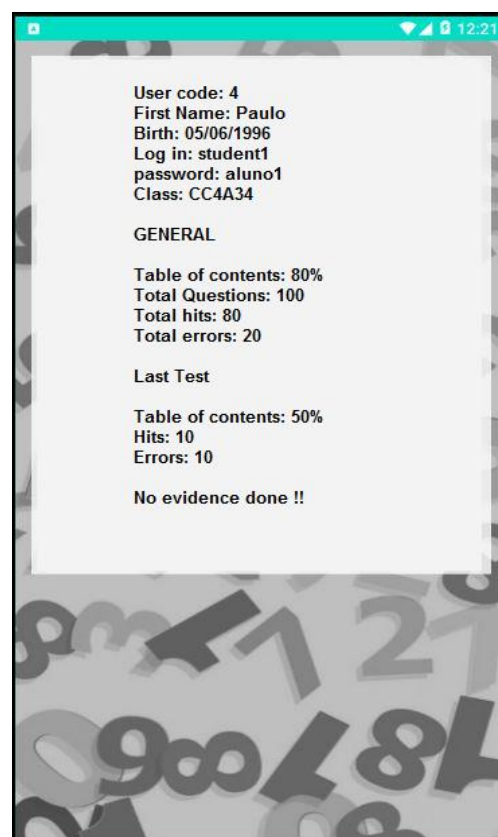


Fig.4: General Indicators.

Source: The authors.

Another very important item that serves as an indicator for pedagogical improvements in the teaching of mathematics at the fundamental level is the general status present in the administrator's view, whose main objective is to balance between classes and students showing performances such as correct questions, wrong with percentages which can define frameworks of methodologies in teaching. An example is shown in figure 5.

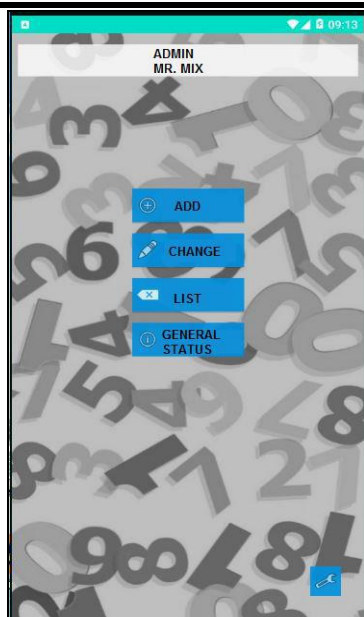


Fig.5: Administrator roles.

Source: The authors.



Fig.6: Student Questionnaire.

Source: The authors.

In order to carry out the tests or tests the student must choose the type registered by the teacher after this will be sent to a screen with the question in the time that will be of multiple choice character, according to the accomplishment of the same it will have commands that will direct to the next question until finalizing and verify their performance. Figure 6 exemplifies how one proceeds in the question screen.

Finally the teacher can consult the test in question and check how many have already done, the number of correct answers, errors and an index of the test, just as each question also has indicators that determine the amount of correctness and errors, based on this it is possible to verify the quality of teaching through the

content administered as well as the level of difficulty of the question elaborated. Figure 7 exemplifies the teacher's vision for examining evidence.



Fig.7: Results of events.

Source: The authors.

III. CONCLUSION

The teaching of mathematics becomes essential for any professional currently and of great importance in basic education, with this new stimuli and motivations must arise to improve learning and ensure the knowledge of those who study, the tool focused on learning and promote ease in the teaching of mathematics at a fundamental level using android technology obtaining success for being of great use in the current era in mobile phones supplying the need of those who use and for a better didactics in the classroom for teachers and pedagogues as a tool to support teaching.

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Work and Successful Aging Process: An Approach to Family Farming

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Abstract—Working outdoors leaves marks on human bodies that are sometimes lasting. In family farming, workers age by consequence of their exposure and work, reaching older ages with serious physical and health problems. Purpose: To analyze the main factors that affects the health and therefore the aging process of family farming workers. Method: The research is characterized as descriptive observational, with data analysis from a qualitative paradigm. A semi-structured interview and the Corlett diagram were also applied. There were 80 participants from the municipality of Linha Nova, in the south of Brazil. Results: The main problems in family farming and that are also related to workers' health are: climate, in which the sun is the main factor in premature aging and the risk of skin cancer; lack of mechanization, demanding that the activities be carried out manually; and heavy work and squatting, resulting in high incidence of lower-back pain among workers as a consequence of poor posture and weight handling. Conclusion: Despite these problems and less physical endurance, the results show that, for the elderly, to continue working on the family farm is a way to stay busy doing what they enjoy, to boost their self-appreciation and to help in the family business.

Keywords—Aging, Health, Mechanization, Pain.

I. INTRODUCTION

The current study on the successful aging process has shown to be relevant considering possible individual and cultural variations. Aging is inherently a process of gains and losses, and its consequences allow us to understand the limits of the human potential. There are seven propositions for analyzing successful aging.^[1] In this study, to understand the relationship between aging and work, we will emphasize the propositions of old age heterogeneity, of plasticity and latent capacities, of loss-gain balance, of one's ability to compensate and of using technology.

The work-aging relationship can be seen from two perspectives: aging through "work" and aging "in relation" to work. In the first case, work and its conditions are active agents on the processes of aging, on

the decline of individual's capacities and on experience building. In the second case, the transformations that occur can either facilitate or hinder work execution under the conditions imposed by the production system, thus causing negative (increased fatigue, low performance, professional disqualification) or positive (conscious rearrangement of work flow, ascending mobility) impacts.^[2]

The first situation, aging through "work", is very present in several areas, which are usually physically demanding, and over time can cause the body to be shaped for the work, leaving marks that are sometimes definitive and that will accompany the workers throughout their lives. These marks may be visible, such as cuts, burns and bruises or invisible, yet they can still act as warning signs as to the worker's health, such as pain or discomfort from activities.^[2]

Family farming is one of the agricultural segments in which body constraints are still strongly present. This sector represents a significant portion of the agricultural production in Brazil. According to the Brazilian Ministry of Agrarian Development, family farming is responsible for producing 70% of the food consumed by Brazilians every day, occupying almost 75% of the farming labor force.^[3] According to data from the 2006 Agriculture Census, 9.4% of the Brazilian territory is occupied by family farms, which employ 6.5% of the population in this segment.^[4] In other words, a contingent of over 12 million Brazilians works in small or medium-sized farms and is submitted to working in often unhealthy and ergonomically critical conditions. Ergonomics is the science that focuses on the conditions in which work is executed; it deals with adapting work conditions to individuals, in order to maintain their health, quality of life and productive capacity.^[5,6]

In a work-ergonomics relationship, even when there is mechanization, farming is still considered heavy-duty. This is due to the fact that the available technology was not created with small plots of land in mind, but for use in larger farms. Even if there are financial conditions available for the acquisition of farming equipment, there

are situations in which it is impossible even to use small machines in family farming^[6], such as type of crop, animal culture and difficult terrain. Many small family plots are uneven, with large slopes and stony soil,^[7] and as a result family farming requires greater physical effort from workers, who have to carry out a large part of their activities manually, thus risking their health. Manual tasks have been the main cause of work-related musculoskeletal disorders (MSDs). Some of which may even lead to permanent disability.^[8]

In addition, very soft soils make activities heavier, increasing energy consumption.^[6] In sectors such as farming, workers' daily energy expenditure is over 5100 Kcal, which, when occurring for consecutive years, is potentially harmful to workers' health.^[8] Therefore, farming is among the most arduous occupations. Moreover, workers develop inconvenient postures in unfavorable climatic environments, and require great application of muscle strength.

Thus, the constraints on the body occur not only due to the precariousness of equipment and machinery used in this sector, but also due to environmental conditions.^[5] Farming work, as it is carried out in close contact with nature, places individuals in situations that complicate the humanization of work. In addition to weight handling, the worker is exposed, among other things, to sunshine, rain and wind, the presence of venomous animals, topographies and soil conditions that demand workloads of different intensities.^[9] In regards to the work-environment relation, when it comes to aging, it is relevant to mention the risks of exposure to climatic factors. There is a tendency for excessive exposure to the sun and heat in the summer period. As to the harmful effects of sun exposure and the need for protection against this risk factor, sunburned farmers are more prone to skin and lip cancer. The risk is between 0.8 and 1.8 for skin cancer and between 1.3 and 3.1 for lip cancer. Likewise, excessive exposure to the sun tends to interfere with workers' early aging^[10]

During the winter, on the other hand, farmers mainly complain of contact with natural products exposed to low temperatures because their hands cool down. When a person is exposed to cold climates, body extremities experience a drop in temperature as a result of the redistribution of blood flow to maintain core heat.^[11] Workers' vulnerability to loss of heat in peripheral tissues, such as hands and feet, causes the reduction of strength and neuromuscular control. As a consequence, errors and accidents are likely to occur.^[12]

Within this context, it is important to establish a relationship between work and health. This is a complex relationship because while work damages health, it is necessary to have health in order to work.^[13] "Worker health is maintained when work and environmental

demands do not exceed their energy and cognitive limitations so as to avoid situations of stress, risk of accidents and occupational diseases" (p. 4).^[12] Therefore, in order to guarantee workers' health, it is necessary to focus the attention on activities' characteristics and to the conditions of the working areas.

Based on the aspects outlined above, the general objective of this research is to analyze which are the main factors that interfere in the health and, consequently, in the early aging of family farming workers. The specific objectives are: to characterize farmers' professional profiles; to identify main problems that interfere with workers' health; to verify areas of the body where there is greater incidence of pain/discomfort during the activities; to investigate the main causes of pain/discomfort from the farmers' point of view; to verify the risks arising from farming activities that affect farmers' health and to investigate the perception of older workers regarding farm work.

II. MATERIAL AND METHODS

This research is characterized as an observational descriptive study, with data analysis and discussion performed from the qualitative paradigm. Data collection used semi-structured interviews, with previously elaborated questions. However, although the questionnaire was originally written in Portuguese, the questions were translated into the Hunsrückisch, a language widely used by the German immigrants and their descendants, especially elders, who resided in the city where the study was conducted. After that, the answers were translated into Portuguese.

The study site was the municipality of Linha Nova, which is located in Rio Grande do Sul's rural area. The municipality's economy is mainly based on family farming, specifically horticulture. The interviews were carried out directly with 34 families of farmers, through a visit to their residences during the month of July 2014, which comprises the winter season in the region.

Parallel to the interviews, the Corlett and Manenica Diagram^[14], as shown in Fig. 1, was applied, which consists of a diagram of a human figure with 29 body areas demarcated and numbered. Each respondent was asked to mark with an "x" the regions of the body in which they felt pain/discomfort when engaging with their activities in family farming or resulting from these activities. These data were computed and can be visualized in Fig. 3.

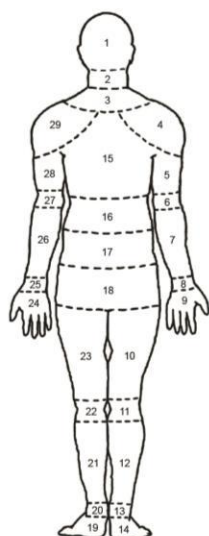


Fig. 1: Corlett and Manenica diagram

Source: Adapted from Corlett and Manenica.¹⁴

In addition, photographic records were made of a few farmers during the performance of different activities. The participants who agreed to be photographed, signed a consent form for use and dissemination of their image.

The data collected during these interviews were analyzed using the triangulation method. In this method, there is a *modus operandi* based on preparation of the collected material and articulation between three aspects: empirical data collected in the research; dialogue with authors who study the subject in question and conjuncture analysis.^[15]

III. RESULTS AND DISCUSSION

The studied group consisted of 34 families, with a total of 80 respondents, all of them active in family farming. Of these individuals, 47 are males and 33 are females. The average age is 45 years, the youngest respondent being 15,

and the oldest, 76-years-old. The average length of time they spent in farming activities is 30 years. Fig. 2 represents the percentage of respondents according to the age group.

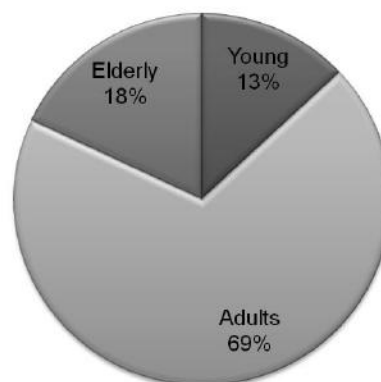


Fig. 2: Percentage of respondents according to the age group

The data analysis show that most people who work in family farming in the region are adults, with a reduced number of young and elderly people working in the sector. The average schooling is the 5th year of elementary school. The average number of working hours is 9 hours per day. However, in the summer, when the days are longer, their working hours reaches over 10 hours per day. In contrast, the respondents reported that farming activities allow flexibility in working hours. They can start activities early in the morning and have a longer break after lunch. In the afternoon, they resume their activities at around 4 pm and work until dark.

3.1 Work-related issues in family farming

When asked about the main problems they perceived in farm work activities, most respondents mentioned issues related to exposure to climatic conditions and the use of rudimentary machinery, which is illustrated in Fig. 3.

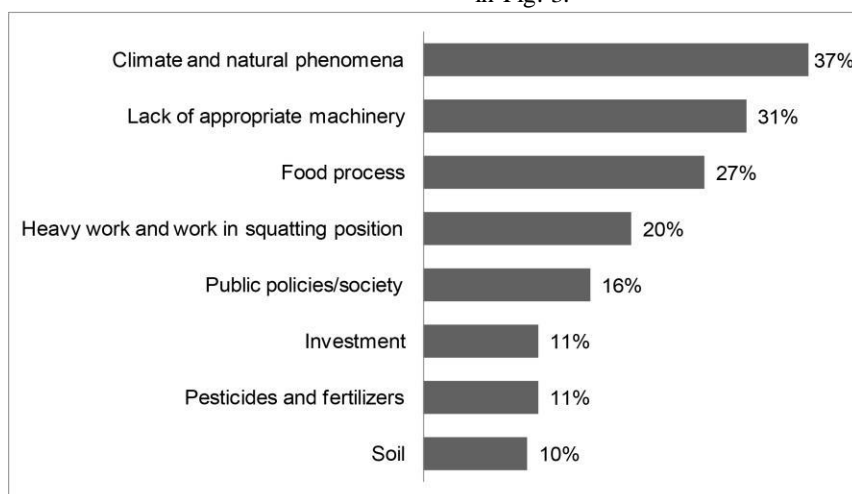


Fig. 3: Problems most mentioned by farmers related to family farming performance

Based on the results presented in Figure 3, there are three problems that are directly related to workers' health

and that interfere with aging: climate and natural phenomena; the lack of adequate machinery; and heavy

work in critical postures, whether because of the posterior flexion of the spine or because of prolonged squats. The three problems are presented separately in the sections below, along with discussion on how they can interfere/affect workers' health.

3.2 Climate and natural phenomena

Climate and natural phenomena were the problems most mentioned by most respondents. Climate effects are detrimental both to the workers' health and to the healthy development of the crops. Climate can influence on the quality of the product grown and, consequently, on the price of the product to be marketed, impacting on their earnings. Its effects become evident in the narratives of the respondents: "the climate does not help, sometimes it rains a lot, and sometimes not enough" (female farmer, 55 years old). "If the weather is good, the strawberries will come in beautifully; if there is fog, they do not" (male farmer, 47 years old). Offering a good product for a good price is key to the family farm's income. Moreover, weather adversities such as hail, drought, wind and very strong sun can result in underdeveloped crops, culminating in huge and worrying financial losses.

When they referred to the climate as detrimental to their health, respondents commented: "The sun is worst, it burns and tires more, the sun seems to be hotter than it used to be years ago; the winter is good for working" (female farmer, 56 years old). "The problem is this hot sun, and when everything is wet it is very bad" (male farmer, 50 years old). These answers show the difficulties of working when the soil and the products are wet, when it is very hot in the summer, or very cold in the winter. These conditions influence farmers' physical effort and health. Although the interviews were conducted during winter, the heat of the summer sun was mentioned by most of the workers as being one of the most damaging factors in their work performance.

The climate of the state of Rio Grande do Sul, where this research was carried out, is humid subtropical, with extremely low temperatures in winter and quite high temperatures in the summer. In addition, during heavier and more muscular agricultural tasks, the body generates additional heat, which tends to be expelled through sweat and dispenses an additional energetic charge that the body uses to perform work activities.^[16] Heavier physical work and in unfavorable external conditions increases body temperature and can cause thermal imbalance.^[5] When the work is carried out in high temperature environments, individuals can suffer fatigue, lower their performance rates and incur errors of perception and reasoning. This can lead to psychological disturbances that can cause exhaustion.^[17]

Corroborating the above, one of the respondents, an elderly woman, commented that she always wears long clothing (pants and long sleeved blouses) to protect herself

from the sun and insects, such as mosquitoes, horseflies, among others. According to the respondent, "once, we were harvesting corn under the sun, around 11 o'clock in the morning, it was very hot, then I began to feel strange, a sense of malaise, dizziness... I was so sick I fainted. I was lucky that my daughter was working nearby and saw me" (female farmer, 76 years old). This report is a clear example that exposure to high temperatures associated with heavy work is detrimental to workers in general and more so for the elderly. Increase in body heat causes a general feeling of discomfort, reduces performance, turns the skin reddish, raises heart rate and weakens the pulse. This is followed by severe headaches, lightheadedness, shortness of breath and, ultimately, unconsciousness. Age is a factor that increases the chances of a thermal collapse.^[6] Thus, in terms of legislation and worker protection exposed to weather, Regulatory Standard 31 - Climate and Topographic Factors, in paragraph C, states that one must "organize the work in such a way that activities that require greater physical effort, when possible, are developed in the morning or late afternoon".^[18]

The cold, like the heat, is also harmful to the body. Cold weather requires more muscular effort, since in a 5°C temperature muscle tension increases by 20%, which accelerates fatigue.^[5] Exposure to cold climates causes temperature at body extremities to fall due to blood flow redistribution so that it is possible to maintain core temperature.^[11] Workers' vulnerability to the loss of heat in peripheral limbs such as hands and feet, causes reduction in strength and in neuromuscular control, which can lead to skin loss, errors and accidents.^[12] In addition, it should be noted that in the winter, in Rio Grande do Sul, farmers are in constant contact with natural products exposed to low temperatures, a factor that puts the hands at risk, and frostbite may occur.

In addition, both in the summer heat and in the winter cold the sun is an extremely harmful factor to workers' health if appropriate protective measures are not taken. Solar irradiation is one of the greatest risks to farmers' health because it can lead to the development of malignant skin tumors and eye damage.^[19] Ultraviolet radiation from the sun can be classified into three types: UVA, UVB and UVC. UVA rays have a longer wavelength and are less energetic. They penetrate deeper into the skin and are the main cause of premature skin aging, photosensitivity diseases and cancer development. UVB rays have a shorter wavelength, but higher energy and lower body penetration, so they are responsible for acute and chronic damage to the skin, such as spots, burns, scaling and skin cancer. UVC rays are almost completely absorbed by the ozone layer.^[20] However, in the southern hemisphere, ozone layer protection is compromised during the spring period. Due to temperature increase in the

Antarctic region, ozone concentration in the atmosphere is drastically reduced and as air masses move eventually the low concentration of ozone is shifted to the southern regions of the American continent, including southern Brazil.^[21] For this reason, the population of this region, especially those exposed to the sun for longer periods, as is the case of farmers, is more vulnerable to ultraviolet rays. As such, UVC rays that are normally absorbed by the ozone layer during this period can also cause serious damage to human health. In UVC rays, the shorter wavelength is associated with a higher energy, which is why they are highly harmful to humans, causing carcinogenic and mutagenic effects.^[20] After years of successive sun exposure, damage from ultraviolet radiation accumulates, but the damaging effects can take 20 or 30 years to become apparent.^[22] In addition to the problems caused by ultraviolet rays, sun rays are the main cause of extrinsic aging, also known as photoaging. According to Carvalho (2014), photoaging is the skin damage process caused by chronic exposure to ultraviolet light and is generally associated with premature aging.^[23] Sun-aged skins are characteristically yellowish in color with irregular, wrinkled pigmentation, atrophic, with telangiectasias (small blood vessels) and pre-malignant lesions.^[24]

Photoaging turns the physical appearance of farmers, and all workers whose activities need to be performed under the sun, older due to damage to the skin. In addition, this damage from excessive exposure to the sun can hide more serious problems, such as skin cancer. Therefore, it is important that protection and prevention measures against ultraviolet rays, such as the use of sunscreen, are implemented. However, in fact, sunscreen is still little used in the daily lives of farming workers. In general, they only opt for wearing a straw hat or cap. Therefore, health and safety public policies with a focus on awareness of the problems arising from sun exposure should focus on farming activities in the same way as health and safety policies are developed for industry workers.

3.3 Lack of appropriate machinery

Another factor that tends to imply a higher demand for energy and higher rates of fatigue due to physical effort, movement and critical postures is the lack of appropriate machinery and tools for the job. Although it is known that farming increasingly relies on more technologically advanced products, machinery and equipment, they require adequate worker training to be properly used. But considering the respondents' profile, low schooling hampers the use of new technologies in family farming enterprises. This was made clear in the answers of one of the respondents, who stated: "machines are becoming more and more computerized, we do not

know how to use them" (male farmer, 52 years old). Some of the respondents would like to receive more training, but the distance between their land and the big metropolis, where it is possible to carry out qualification courses, is a problem. Depending on the region of Brazil and the socioeconomic status of the family, training courses are not feasible. Thus, the low level of schooling can be considered one of the factors that limit the use new technologies in farming activities, so much so that workers continue to perform rudimentary farming practices.

This, however, is not the main problem. When questioned about the problems they identify in farming, many respondents referred to the lack of mechanization and adequate tools that could assist them in daily farming activities, mainly due to the difficulties with field morphology and product characteristics: "[...] corn must be manually harvested, because it [the terrain] has a lot of hills and it is not possible to use a harvesting machine" (male farmer, 42 years old). "The fields are full of rocks, there are machines that can not be used on fields like these. Because of the hills, sometimes a lot of water washes down the fields and carries the crops away" (male farmer, 51 years old).

Thus, the lack of adequate tools and technologies compatible with the reality of family farming require greater physical effort from the workers, implying serious health risks. This problem has already been mentioned in other studies, which also verified the need for the work to be done manually, involving prolonged static postures, load handling and repetitive work.^[7] In this context, the participants provided answers such as: "the crops should be more mechanized, so that we would need to use less strength." (male farmer, 45 years old). These factors can cause pain or discomfort in different parts of the body and may be aggravated if there are no changes in the way the activities are performed.

3.4 Heavy and squatting work

It is relevant to discuss the heavy work and work performed in the squatting position related to the Corlett Diagram results^[14], as there is a direct relationship between the two issues. This approach, additionally, helps us to understand the reason why respondents consider heavy work and work performed in a squatting position a problem. All the participants in the research received a sheet with Corlett's Diagram, in which they indicated the places where they feel pain or any discomfort due to the farming activities. The percentage of pain/discomfort attributed to each body area is shown in Fig. 4.

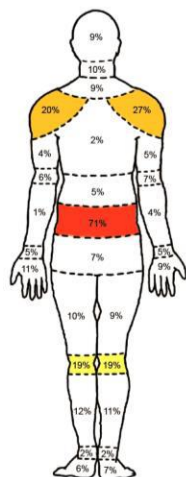


Fig.4: Workers' pain/discomfort areas originated from family farming activities

Source: Authors based it on the Corlett and Manenica Diagram.^[14]

This body scheme shows that the number of agricultural workers who reported pain or discomfort in the lumbar spine region is much higher than other body

regions. Subsequently, and in order of importance, shoulders and knees were indicated as areas of pain. When questioned about the cause of the pain, all workers who pointed those regions out answered that the pain came from the heavy work and the work done in a squatting position. It is important to emphasize that the respondents understood the work performed in a squatting position both as the work done with the knees flexed (sitting squatting) and that performed with the straight legs and anterior flexion of the spine, which are positions adopted for cultivating products on the ground. The definition of heavy work involves not only load handling, but also activities that require high-energy expenditure from the worker.

Discomfort in the lumbar spine (region indicated by 71% of the participants) is mainly due to the anterior flexion of the spine. This posture is widely adopted for cultivating crops close to the ground. Harvesting also usually requires uncomfortable postures. In addition, the workers' hands end up being used as a "tool" as well.^[12] Fig. 5 evidences that the workers often adopt the spine curved forward position.



Fig. 5: Activities that require spinal flexion

A) Cutting/harvesting of cauliflower; B) Harvesting of corn leaves; C) Lettuce planting. Source: Authors (2019).

In all the activities presented in the illustration, the anterior flexion of the spine needs to be maintained for long periods, with small respites in which the worker stands erect to relieve discomfort. "A curvature of the back keeping the knees straight causes a greater load on the discs of the lower back than when the spine is as straight as possible with the knees bent" (2005, p. 104).^[6] When the person bows, it is possible to verify the lever effect, by which a lot of pressure is put upon the discs of the lumbar region.^[6] This posture, in addition to causing indirect aggression on the discs, can cause stretching of the musculature and attacks the blood vessels and nerve roots of the vertebral column.^[25] In the long-term, adopting incorrect postures can cause muscle fatigue and physical constraints, such as spine deformation, tendonitis, among other serious problems.^[26]

The heavy work, which corresponds mainly to load handling, was another reason mentioned by the

respondents, especially elders, for the discomfort in the most marked body regions. Load handling (lifting, lowering, pushing, pulling, loading, holding, and dragging) can be classified as heavy work because it involves a lot of static and dynamic effort.^[6]

Over time, overloading the spine as a result of load handling and transporting results in degradation of bone structures, joints and intervertebral discs. These risks to the vertebral column can be aggravated when the processes are rudimentary and loads and materials transport are still carried out manually.^[27] As such, it can be inferred that, in addition to the hard elements present in the activity, in many cases, there is already a genetic predisposition for joint and musculoskeletal degradation, which is generally aggravated by age advancement and risk exposure. Regulatory Standard 31, regarding ergonomic aspects, states that "the lifting and manual

transportation of loads with weight that is likely to compromise the health of the worker is prohibited”.[18]

Farming is one of the professions that predispose the worker to problems in intervertebral discs. Spinal problems usually result in absences from work and are among the most important causes of premature disability.^[6] The lesions and other physical impairments that may occur due to the adoption of inappropriate postures and load handling may persist until older ages or even be aggravated by the aging process.

3.5 Family farming work in the perspective of the elderly

All characteristics related to farming activities discussed above (climate, sun, inadequate postures and load handling) can influence worker health and, consequently, the aging “through” work. After reaching advanced age, the effects of work begin to become more apparent in the body, making it difficult to perform activities. Some respondents commented on this: “time passes and we become more tired, today I walk with a limp [...]. If I could walk better, it would be easier to work in farming” (male farmer, 67 years old). “The problem is that I do not have the physical disposition to work in farming anymore” (male farmer, 76 years old). It becomes evident in their answers the lack of physical fitness for the work. Working conditions, mainly because there is no mechanization, have increased the body’s requirements for

carrying out activities, compromising the health and the physical disposition on individuals.

However, it is not only the external factors that affect body health, genetic predisposition and the aging process itself play a part in it as well. One of the respondents commented: “I used to like working in the fields, now I cannot work so hard because I have a heart problem [...]. When I hoe the land with the oxen, I feel short of breath.” (male farmer, 64 years old). The structural changes in the heart and the vascular system due to aging can reduce the body’s ability to function efficiently.^[28]

Although they no longer have the same physical strength, and feel pain when performing tasks, the elders who participated in this research stated that they still enjoy working in the farm, mainly as a way to keep themselves busy. This is evident in the words of some workers: “I like to work in farming, it is my hobby, I think it is interesting to be able to keep working a little still.” (male farmer, 75 years old). Another retired worker mentioned: “I take care of the cows, the chickens, the pigs... I feed the animals, milk the cows... I help my daughter and son-in-law when they have to prepare the products to take to CEASA [Central State Supply Company] [...]. I can no longer work hard, I run out of breath quickly” (male farmer, 72 years). Fig. 6 illustrates some of the activities still developed by elderly workers.



Fig. 6: The elderly performing family farming work activities

A) Feeding of livestock with silage; B) Feeding of roosters and chickens; C) Cutting cauliflower leaves; D) Cutting manioc branches for cattle nourishment. Source: Authors (2019)

These characteristics show how central the work in agriculture is for the elderly, since, even after retirement, they continue to help in family farming activities. Work is a means of creating existential sense or of contributing to the structuring of a person’s identity and subjectivity. To breakdown the meanings of their lives, from the worker’s

perspective, can cause suffering and even compromise their mental health.^[29] As such, it can be inferred that by keeping themselves occupied, especially in old age, work becomes a relevant factor for maintaining quality of life. Therefore, the quality of life in old age does not rely only on physical and/or biological conditions, but also in social,

psychological and environmental factors that are relevant and determinant for their well-being.^[30]

Although the body is no longer able to perform farming activities, the elderly who work in agriculture with their family enjoy helping their children in the farm. That is, many do not realize the age and differentiated condition of a body that ages as a hindrance to their work, but use all their physical capacity and their energy as an opportunity to continue working as long and as hard as their bodies will allow them.

From this perspective, increasing longevity leads to changes in the world of work. Whereas work can also influence the way people are getting older. Consequently, work is a structuring point in the lives of older people, thus influencing how they act and think.^[31]

In the study developed by Bajor and Baltes, the relationship between performance at work and strategies for successful aging was analyzed.^[32,1] These strategies include loss selection, elective selection, optimization and compensation (SOC). The farmers who participated in the study demonstrated, through their answers, to use of loss-based selection when trying to adapt to the difficulties encountered both in relation to work and to nature, and even in relation to the typical age-related changes. Consequently, they are able to optimize their work experiences and thus compensate for the difficulties encountered by adapting their strategies to the technology or the innovations that are offered to them. These adaptations, of course, do not occur in a way and at a pace that can provide them with a better quality of life, but it keeps them active and independent.

IV. CONCLUSION

The present article aimed at analyzing the main factors that interfere in the health and, consequently, in the early aging of family farming workers. The results show different factors that directly affect the body and the health of workers, such as climate, long journeys, sun exposure, lack of mechanization and heavy manual labor.

The climate, in the studied location, presented two extremes, low and high temperatures during the winter and summer seasons, which interfere with the work performance. Prolonged sun exposure coupled with lack of protection is not only the main cause of premature aging of the skin, but also tends to pose serious health hazard.

As far as the context of family farming is concerned, it is possible to infer from this study that, although many factors predispose workers to early aging, one of the issues that most affect health and the maintenance of quality of life is heavy work. This condition usually results from the lack of mechanization, which exposes the body to a series of unfavorable conditions, since, in order grow products taking their own

unique characteristics into account, farmers make constant use of their spine, arms and hands as working tools.

It is important to mention that, even if workers are aware that their work is heavy and that they should reduce their workload when they reach old age, they tend to mention work as a central point in their lives. In most interviews, it is perceived that to age while working, despite the present dichotomous condition, and to work with pain or with discomfort, means more than not working. This finding tends to have overlapping cultural issues, since not working implies on not being productive anymore, that is, it can be said that there are cultural interferences that determine surplus value predominance in this case.

Finally, it is possible to affirm that work must be a factor of personal satisfaction and not of physical degradation. It is the work that must be adapted to the physical conditions of the human body and not the opposite, as it happens in family farming, in which workers adapt themselves to the work. Taking into account that the longevity of human beings is rising, working conditions must be improved for continuous health and well-being of individuals.

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Anatomy of Lumbosacral Plexus in Hoary Fox (*Lycalopex vetulus* - LUND, 1842)

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Abstract— The anatomy of wild animals is an involving and interesting area of biological studies in many countries around the world, since the major interest of understands biology, especially animals in extinction risk. Therefore, the objective of this work was dissect and describe the anatomy of lumbosacral plexus of Hoary Fox, a typical and yet little known animal in the Neotropical Cerrado. For this, two male and two female specimens obtained from accidental death on the roadsides of Brazilian Southeast of Goiás were used, both fixed in aqueous solution of 10% formaldehyde and dissected under traditional techniques of macroscopic anatomy. The findings showed that lumbosacral plexus of Hoary Fox is formed by intersecting of L5, L6, L7, S1, S2 and S3. A lumbar plexus and a sacral one are easily identified in this animal. The boundary between them is the trifurcated nerve (L7). The lumbosacral plexus provides three major nerves to the pelvic limb: femoral, obturator and sciatic, besides some small muscular branches. Discussing with specific literature, the present work demonstrated unpublished data about the anatomic standard of Hoary Fox in lumbosacral plexus, an important system in this animal biological system.

Keywords— Comparative anatomy, lumbosacral plexus, Hoary Fox, Wild animals and Cerrado.

I. INTRODUCTION

The anatomy of wild animals is an involving and interesting area of biological studies in many countries around the world, since the major interest of understands biology, especially animals in extinction risk, in this sense many studies aimed understand the anatomy of wild mammals, however few literary quotations was made about neotropical canids biology, including some Brazilian animals in Cerrado biome, like Field Fox, one of seven lesser-known canids in the world [1].

Since wild animal's studies are developed, substantial information is discovered about the fragility of several species, mainly due to the destruction of environment which they live [2] and several species of neotropical mammals are subject of a significant number of studies, meanwhile the scientific world never focused animals that lives in areas of risk, perhaps the face of desire build sustainable development.

Hoary Fox (*Lycalopex vetulus* - LUND, 1842) is native animal of Cerrado, that although the second largest Brazilian biome, some components of its fauna are in danger of entering or already in process of extinction, since anthropic pressure on this biome growing stronger. According to Bocchiglieri *et al.* (2010) [3] the components Cerrado occupy all geographical patterns, composed of savannahs, fields and forests, therefore, Hoary Fox prefers clean fields and altitude. This animal is the smallest Brazilian canid and despite being considered a carnivore, eating small vertebrates or mainly insects, even eats fruits [1].

Is important note that Hoary Fox anatomy not presents the same level of knowledge as other species of the same biome, on the other hand, lumbosacral plexus is responsible for origin of all nerves destined to pelvic limbs and, therefore, the only responsible for movements control and is an important anatomical segment capable of arouses particular interest, especially to understand the related aspect of posture adaptations, locomotion, feeding and reproduction. Thus this work aimed to describe lumbosacral plexus of Hoary Fox, discussing the data obtained with specific literature.

II. MATERIAL AND METHODS

The present paper is a descriptive anatomical study with two male and two female specimens of Hoary

Fox (*Lycalopex vetulus* - LUND, 1842), obtained from accidental death on roadsides of Brazilian Southeast of Goiás, under authorization of SISBIO n° 37072-2. Considering the descriptive approach of this work, statistical analysis is not necessary. All procedures were conducted in accordance with ethical principles and approved by the Institutional Ethics in Research Committee at the Federal University of Uberlândia (CEUA/UFU n° 067/12).

The study was made in the research laboratory of human and comparative anatomy from Federal University of Goiás – RC, where the specimens were fixed in aqueous 10 % formaldehyde solution to conservation and adopted consecrated techniques in Macroscopic Anatomy.

The anterior abdominal wall was opened in median sagittal plane and section of pelvis through pubic symphysis and lateral displacement of limbs, to facilitate access to abdominopelvic cavity. Once exposed the viscera of pelvic and abdominal cavity, it was removed to base of skull and exposed vertebral column as whole that the number of vertebrae could be verified. The next step was clean dorsal wall of abdominopelvic cavity until complete exposure of vertebral bodies and psoas muscles. Next, the muscles were carefully removed until vertebral bodies had been exposed. The lumbar vertebral bodies were carefully removed with the aid of osteotomies, tweezers, scalpel and scissors, until complete exposure of spinal cord involved by dura mater.

The Nikon® D7000 18-105 digital camera was used to photographic documentation and description nomenclature adopted is the standard of Nomina Anatomica Veterinaria (2012) [4], elaborated by the International Committee on Veterinary Gross Anatomical Nomenclature.

III. RESULTS

The lumbosacral plexus of Hoary Fox consists interweaving of ventral branches at last three lumbar spinal roots and three first sacral ones, in thickness of

psoas major muscle. The lumbosacral plexus can easily be divided into lumbar plexus and sacral plexus. The border between them is bifurcated nerve or lumbosacral trunk corresponding to the nerve L₇. The lumbosacral trunk or bifurcated nerve is named due after it shortly emergence and through intervertebral foramen, divides into two branches: cranial and caudal, cranial branch composing lumbar plexus and the caudal branch, sacral plexus. In Hoary Fox, bifurcated nerve would better know as a "trifurcated" nerve, overdue the division into three branches: cranial, middle and caudal. The cranial branch converges with L₆ to form lumbar plexus and femoral nerve; Middle branch joins caudal branch of L₆ to form cranial root of obturator nerve and finally, caudal branch contributes to the formation of sacral plexus (Figure 1 and Figure 2).

The lumbar plexus is restricted to intercommunications between the last three lumbar nerves, which in Hoary Fox are L₅, L₆ and L₇. The cranial nerves at L₅ not contribute to formation of lumbar plexus, although establishes interconnecting loops, frequently between L₃ and L₄, which contribute to form ilioinguinal and genitofemoral nerves, respectively. The root L₂ follows as subcostal nerve and sometimes receives a small contribution of L₁.

Sacral plexus is constituted by interlocking of ventral roots of S₁, S₂ and S₃, receiving strong contribution of L₇. All ventral roots that forms lumbosacral plexus emerges separately through intervertebral foramina and only after traveling considerable space begin the process of interlacing, some closer and other distant (Figure 1 and Figure 2).

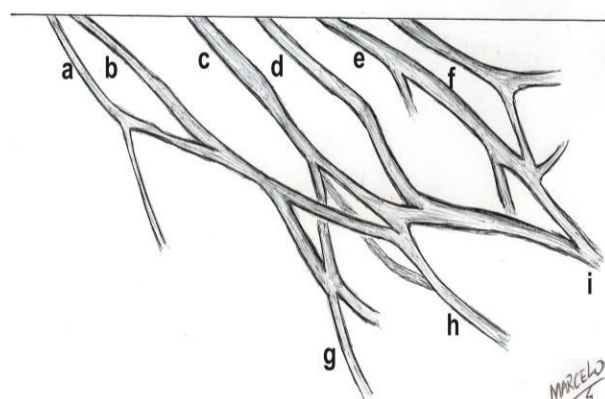
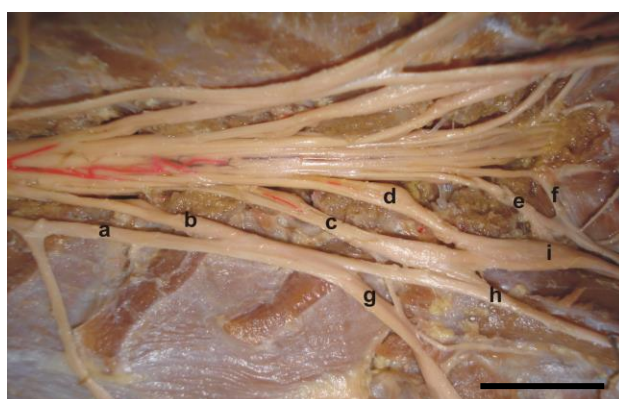


Fig.1: A- Photomicrography and B- Lumbosacral plexus scheme of right Hoary Fox (*Lycalopex vetulus*) antimer: a- L₅, b- L₆, c- L₇, d- S₁, e- S₂, f- S₃, g- femoral nerve, h- obturator nerve and i- sciatic nerve. —20%: 10.8 cm. Photography made by Roseâmely Angélica de Carvalho Barros and scheme illustration by Marcelo Vinícius Costa Amorim.

The root of L₅ forks in cranial branch and caudal branch after leaving the intervertebral foramen. Cranial branch follows as independent nerve to abdominal wall, while caudal branch joins with L₆. In turn born and follows without branching, until joining with L₅ and then divides into cranial branch and caudal branch. The cranial branch follows as the femoral nerve, after receiving contribution of L₇. However, caudal branch follows as cranial root of obturator nerve.

The root L₇ is divided into three branches: cranial, middle and caudal; hence the name of proposed trifurcated nerve. Cranial branch consist in femoral, median, obturator and flow sciatic nerve. The root S₁

follows without dividing until joins caudal branch of L₇ to form cranial root of sciatic nerve.

The roots of S₂ and S₃ follow separate until branching into cranial branch and another caudal. The cranial branch makes sciatic nerve, while caudal branch joins S₃. The pattern lumbosacral plexus formation is similar in four antimeres studied. The main nerves originating from lumbosacral plexus are: femoral, obturator and sciatic. Femoral nerve receives contribution of L₅, L₆ and L₇; as obturator nerve from L₆ and L₇; meanwhile L₇, S₁, S₂ and S₃ contribute to form sciatic nerve. Several small muscular branches are born, also of the Lumbosacral Plexus (Figure 1 and Figure 2).

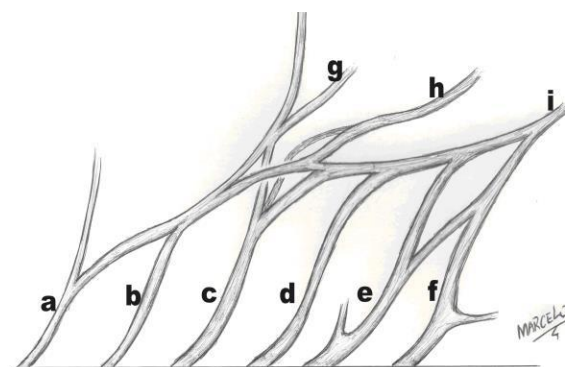
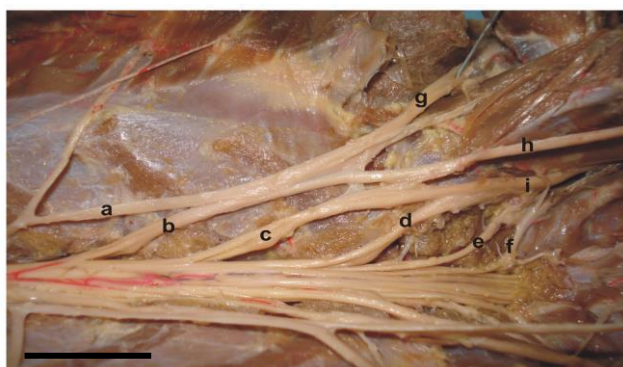


Fig.2: A- Photomicrography and B- Lumbosacral plexus scheme of right Hoary Fox (*Lycalopex vetulus*) antimer: a- L₅, b- L₆, c- L₇, d- S₁, e- S₂, f- S₃, g- femoral nerve, h- obturator nerve and i- sciatic nerve. . —20%: 10.8 cm. Photography made by Roseâmely Angélica de Carvalho Barros and scheme illustration by Marcelo Vinícius Costa Amorim.

IV. DISCUSSION

Regard the composition of Hoary Fox (*Lycalopex vetulus*), the involvement of iliohypogastric, ilioinguinal and genitofemoral nerves in the composition of lumbar plexus as a rule in humans is not recorded [5].

Hepburn (1892) [6] describing lumbar and sacral plexus anatomy in Gorilla, Chimpanzee, Orangutan and Gibbon, notes that lumbar plexus is similar to Man, exhibiting several loops. In Hoary Fox the structure in form of loops or intercommunications is rule, even the characteristic of plexus. In general, the literature do not show "loops" but of interlacing.

In gibbon, the only difference is the absence of loop between L₁ and L₂ [6]. In Hoary Fox there be "anastomoses" between cranial roots at L₅, but do not contribute to formation of lumbar plexus. According to Hill (1972) [7] in Brachyteles, the first component loops of lumbar plexus occur between L₁-L₂ and L₂-L₃; and *Macaca mulatta* cranial limit is T₁₂, but more frequent find between L₃-S₁ [8]. In Hoary Fox cranial limit is L₅, an evident caudal displacement of plexus observed in relation to primates. Caudal displacement of Lumbar Plexus suggests lower characteristic in phylogeny, probably associated with a column formed by a larger

number of free vertebrae. Schultz and Straus (1945) [9] consider the presence of 13 thoracic vertebrae as a primitive trait, since in arboreal Mussaranhos there are 13 vertebrae, which can be considered alive ancestors of primates. Changes in musculoskeletal structure influence adjacent neural system, so the decrease in the number of vertebrae along phylogeny led to shortening of neural system [10-11].

For Howell and Straus (1932) apud Hartmann and Straus (1932) [12] is more convenient consider the Lumbar and Sacral Plexus as single entity, since lumbar and sacral roots contribute their formations. In the case of Hoary Fox, the separation in Lumbar Plexus and Sacral Plexus seems adequate, since the only communication between the two is trifurcated nerve and yet there is clear individuality regarding the branches destined for Lumbar and Sacral Plexus.

Bifurcated nerve is boundary between Lumbar and Sacral Plexuses [13]. Bergman et al. (2001) apud Izci et al. (2005) [14] reported that the border between lumbar and sacral plexuses is made by the presence of bifurcated nerve, as in Tamanduá Mirim [15].

Howell and Straus (1932) apud Hartmann and Straus (1932) [12] consider that Rhesus lumbosacral

plexus involves all seven lumbar nerves and the first two sacral. In dog, the lumbosacral plexus is composed of the last five lumbar and the first three sacral [16], lumbar plexus in dog being restricted to interconnections of L₃-L₅. According to El-Assy (1966) [17], lumbosacral plexus of primates is formed by all lumbar and first sacral; whereas according to Hill (1966) [18], in *Cercopithecus petaurista* there are seven lumbar nerves, but only the last five participate in the formation of lumbosacral plexus.

Urbanowicz and Zaluska (1969) [19] state that lumbar plexus in humans involves L₁-L₄, and in Rhesus and Cynomolgus from L₁-L₅. Wood James (1910) apud Urbanowicz and Zaluska (1969) [19] considers that participation of L₅ in the formation of lumbar plexus is a primitive trait, however, if anthropoids have features more progressive traits than humans, cause some monkeys have plexus formed only 3 or 4 lumbar nerves, therefore, there is cranial migration and reduction of the number of nerves. Zaluska and Urbanowicz (1972) [20] state that humans lumbosacral plexus is formed by the last two lumbar and three first sacral. For Castro *et al.* (2009) [21], in domestic animals, L₃-S₁ make lumbosacral plexus, whereas Schwarze; Schröder (1970) [22] and Dyce *et al.* (2004) [23] related that the same plexus is formed by the last three or four lumbar and two first sacral. In Tamanduá Mirim, T₁₈, L₁, L₂, L₃ and S₁-S₅ contribute to lumbosacral plexus formation [15].

As observed there is no anatomical pattern for lumbosacral plexus, but rather depends on taxonomic group. In Hoary Fox, the lumbar plexus involves L₅, L₆ and L₇, while sacral plexus comprises S₁, S₂, S₃ and the connection between both is made by trifurcated nerve (L₇).

The connection between Lumbar and Sacral plexus always done by bifurcated nerve [7], but according to Krechowiechi *et al.* (1972) [8] bifurcated nerve may be absent, whereas humans and gorillas always present. In Hoary Fox the connection between the two plexuses is always present, however the nerve is trifurcated and not bifurcated and its origin is in L₇.

The connection between lumbar and sacral plexuses is closely associated with shortening of pre-sacral spine, however, lifestyle, especially locomotion strongly influences spinal shortening process, as changes in lumbosacral plexus [11].

Testut and Latarjet (1979) [24] and Piasecka-Kacperska and Gładkowska-Rzeczycka (1972) [11] consider that humans a pattern for lumbosacral plexus given the large number of variations, both in limits and number of component roots. In primates there is great variability in number of roots and nerves from the plexus [25]. In domestic carnivores, the highest number of roots is associated with largest number of lumbar vertebrae [23,

26]. In Hoary Fox six spinal segments, three lumbar and three sacral make up lumbosacral plexus, which is clearly divided into Lumbar Plexus and Sacral Plexus by trifurcated nerve and the seventh lumbar nerve.

V. CONCLUSION

The present study demonstrated that anatomic standard of Hoary Fox presents lumbosacral plexus formed by intersecting of L₅, L₆, L₇, S₁, S₂ and S₃. A lumbar plexus and a sacral one are easily identified in this animal. The boundary between them is the trifurcated nerve (L₇). The lumbosacral plexus provides three major nerves to the pelvic limb: femoral, obturator and sciatic, besides some small muscular branches, showing particularities template compared to other mammals and detailed analysis of Hoary Fox anatomy

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CONFLITS OF INTERESTS

The authors declare no conflicts of interest associated with this manuscript.

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Water Quality Assessment through PCA Analysis

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Abstract— This aim presents the first detailed geochemical data of water of the Jaguari stream, Lavras do Sul-RS. In this study we use Principal Component Analysis (PCA) to establish geochemical grouping that can be related back to likely mining, lithological and anthropic activities in the region. The results indicated that the high concentrations of Cu, Rh and Cd have a close relationship to local anthropic activities and lithological with geochemical changes seasonal fluctuations. The geochemistry results too indicated waters classified as soft and hard (total hardness range from 53.02 to 79.28 mg L⁻¹), neutral pH, and electric conductivity ranged from 157.1 to 184.9 µs cm⁻¹. All measured values met the potability standards for human consumption established by Ordinance Nos. 2914 (2011), 36-GM/1990, and 1469/2000.

Keywords— Jaguari, PCA, Water.

I. INTRODUCTION

In the last few decades, the significant increase of metal extraction in Brazil has caused serious environmental problems. Effluents containing chemical compounds from mining are discharged into waterways without appropriate treatment. Lavras do Sul fits perfectly in this scenario, what makes this region is unique because it suffers from the effects of metals mining in its surroundings and has no sewage treatment of any kind, e.g. domestic or industrial.

The center-south region of Rio Grande do Sul, Lavras do Sul, provides a vast variety of lithologic types and, has an immense metallogenetic importance. This territory is known for its occurrence of mineralization, which combined with sulfites, produces base metals like gold (Au), copper (Cu), lead (Pb), zinc (Zn) and silver (Ag) [4].

The discovery of gold in this area was pioneered by miners arising from Minas Gerais, endorsed by the Portuguese crown, at the time fighting against the Spanish group, whom occupied the south of the country. Although the exploitation of this minerals only began at the end of the XIX century, postponed on account of unleashed

strikes and social movements like the Farroupilha Revolution [4].

In this region, the mineralizations of gold and copper-gold related to the Lavras do Sul Intrusive Complex and igneous rocks originated on the Hilário Formation (Fig. 1). The granitic rocks are composed of several minerals rich in alkali feldspar (KNaAlSi₃O₈), plagioclase (CaNa) Al(AlSi) Si₂O₈, quartz (SiO₂) and micas (biotite and/or muscovite) with accessory minerals as hornblende (Ca₂Na (MgFe)₄ (AlFeTi) AlSi₈AlO₂₂ (OH)₂) pyroxene (CaNa) (MgFeAlTi) (Si₂O₆), zircon and apatite. The mineralization in the granitic rocks have mineralogical prevalent iron disulfide-based on the mineralogical form of pyrite (FeS₂), and those embedded in andesitic and sedimentary rocks from the Hilário Formation have a copper dominant mineralogy [17]. Copper occurs in the form of sulfides, for example, chalcopyrite (CuFeS₂) and chalcocite (Cu₂S), in addition to carbonates in the form of copper hydroxide, like azurite (Cu₃(OH)CO₃). There is also a secondary mineralization in flood, as well as in water resources that roam the region that carry the primary mineralization [17] for example, Jaguari stream that is inserted in Santa Maria basin.

Metals are abundant in natural environments, its dissemination on water is constrained depending on the chemical variables that affect the hydric resource, specifically: flow, water composition and, the geological substrate. Accordingly, the metals can have lithogenic and anthropogenic sources depending on its natural origin. The natural origin, then, depends on the source material ally weathering rates, as well as the surrounding humans that can increase its concentration [5].

Many metals, in the right quantities, are essential to maintaining life [6]. Though, if it fluctuates or suffers unsteadiness, it can cause severe damage to the ecosystem. The universal solvent, water is very easily polluted, therefore becoming unfit for public consumption [7] by affecting human health through direct intake, food preparation, personal hygiene, agriculture or leisure activities [8]. Consequently, the knowledge of the water's chemical composition provides subsidies for the possible

contamination of the water resource, once a certain capacity is exceeded the metal has the potential to leachate [9]. So, those concentrations of metals can be greater than authorized as they have a cumulative impact on the environment [10].

In order to improve the understanding of the water quality, assessment through the geochemistry analysis and quantification of metals and non-metals present in samples of the Jaguari stream on Lavras do Sul.

1.1 Study area

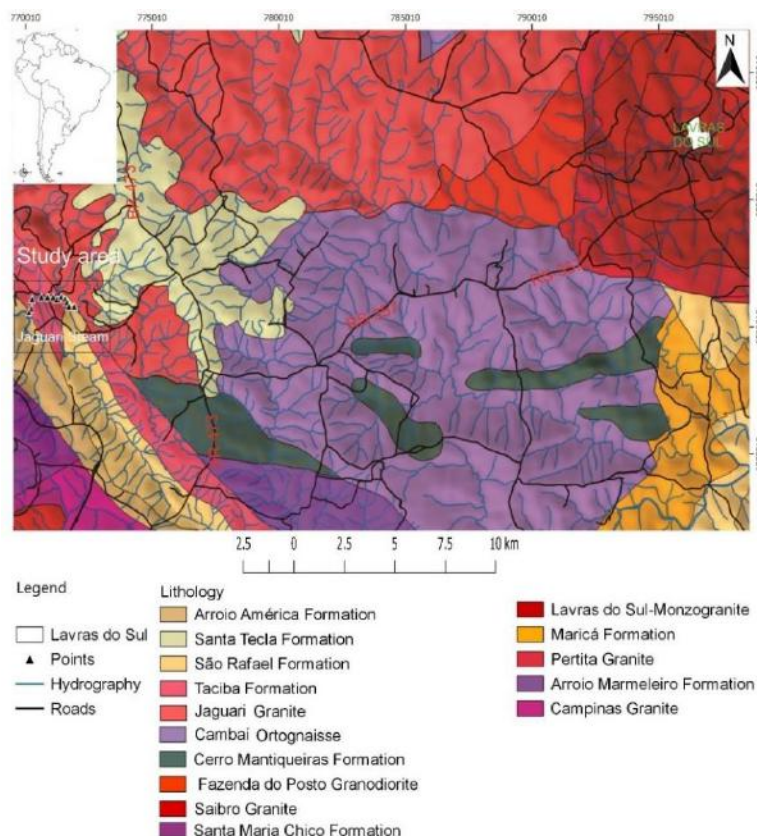


Fig.1: Geological map of the region Lavras do Sul [12].

The study area is inserted in the Escudo Sul-riograndense, that represents Província Mantiqueira's southern portion [12], being constituted by both Archeans and Neoproterozoic lands (2.26 Ga, 535 Ma) [14], [15] and represented by igneous, sedimentary and metamorphic rocks. It presents a rocky soil, whose origin dates from the Pre-Cambrian. The local vegetation varies along the district, from mixed pastures to bushes, clean and even plain fields, with rice cultivations. The climate is subtropical humid, with four very defined seasons, in the summer the temperatures can arrive at 30°C, and in the winter, standards are from 6°C to 12°C, easily decreasing to 0°C with frequent occurrence of frosts. The rains are distributed regularly throughout the whole year, although drought periods eventually happen.

The Lavras do Sul Intrusive Complex is a circular body with dimensions of 216 km². This body has

Lavras do Sul is located in the Rio Grande do Sul State of Brazil, 342 kilometers from Porto Alegre, between Caçapava do Sul and Bagé, with access at BR-290, BR-392, and at RS-357 (Fig. 1). The municipal district of Lavras do Sul is located amongst the coordinates 30°48'46 "S and 53°53'42 "W, its altitude reach 277 meters, with an area of 2.600.611 km² and, in 2016, the population was estimated at 7,820 inhabitants [11].

intrusive behavior in orthogneisses and pre-and sin-tectonic granitoids in the W-SW and N-NW portions. It is delimited to S-SE and NE by the Maricá Formation, whose contact is controlled by the São Domingos fault zone with direction NE-SW, and to the east by Hilário Formation [15].

The main body of the Lavras do Sul Intrusive Complex, Lavras granite, presents zonation of reverse facies between alkali-calcic (core) and alkaline facies. In the central portion are included biotite-granodiorite circumscribed by hornblende-biotite monzogranite, which progresses to hornblende-biotite sienogranite. The edges are composed of biotite-hornblende sienogranite and alkaline-granite feldspar [16]. It is known that the deposit configuration of the area fits in the system of copper porphyries, in which porphyritic igneous rocks subjected to intense hydrothermal processes end up

enriching themselves in sulphides. The Tapera monzonite (Fig. 1) is a half-moon shaped intrusion consisting of monzonite, monzonite, monzodiorite and diorite quartz. It has its limits comprised by the abundance of intermediate and acid dykes, which include the andesites belonging to Hilário Formation. The monzodiorite arroio dos Jacques (Fig. 1) is characterized as an elongated and narrow body located to the northeast, between the Tapera monzonite and the Lavras granite [16].

The mineralogy of these granitoids is composed of alkali feldspar ($\text{KNaAlSi}_3\text{O}_8$), plagioclase (Ca,Na) $\text{Al(Al,Si)} \text{Si}_2\text{O}_8$, biotite ($\text{K}_2(\text{Mg, Fe}^{2+})_{6-4}(\text{Fe}^{3+}, \text{Al,Ti})_{0-2}\text{Si}_{6-5}\text{Al}_{2-3}\text{O}_{20}(\text{OH,F})_4$, quartz (SiO_2) and oxides, with accessory minerals as hornblende ($\text{Ca}_2\text{Na}(\text{Mg,Fe})_4(\text{Al,Fe,Ti}) \text{AlSi}_8\text{AlO}_{22}(\text{OH,O})_2$) pyroxene (Ca,Na) (Mg,Fe,Al,Ti) (Si_2O_6), zircon and apatite. The alkaline feldspar (possibly orthoclase) is euhedral, prismatic up to 1 cm in length, with a reddish-beige coloration and alteration for white mica and iron oxides. The plagioclase is euhedral, prismatic of up to 0.9 cm in length, with light to white beige coloration and alteration for kaolinite ($\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$) and/or gibbsite ($\text{Al}(\text{OH})_3$). The biotite is anhedral, lamellar, with dimensions of up to 0.2 cm, black coloration and alteration for reddish oxides and metallic blacks. The quartz is anhedral, equidimensional up to 0.3 cm in length and colorless. The oxides are anhedral, black metallic, concentrated in fine textured aggregates.

Along the outcrops it is possible to observe the occurrence of differential changes in the rocks. These changes are marked by the filling of fractures of the rock with euhedral quartz, which forms pyramidal prisms of 0.5 cm in length. Along with this, there are films of pervasive iron oxide (probably hematite) and generalized changes to sericite and white micas. This configures the alteration processes responsible for argilization, chloritization and carbonation in the rocks.

II. MATERIALS AND METHODS

2.1 Sampling procedure and analysis

The sampling place was strategically selected due to the proximity with areas of mineral exploitation (Fig. 2) and to reflect the condition of the environment in terms geochemical.

Bottles of polyethylene were used to collect the samples of water. Those flasks were previously decontaminated with nitric acid at 10% for 48 hours and, soon afterward, washed with distilled water and put to dry in the incubator (25°C). Thirteen samples of water were collected in the summer of 2017 (Fig. 2) and one of public distribution (P14). All of the samples were preserved and analyzed within seven days starting from the date of the compilation with standard criteria [18], [8]. The analyses were performed at the Laboratory of Chemistry of the Federal University of the Pampa - UNIPAMPA.

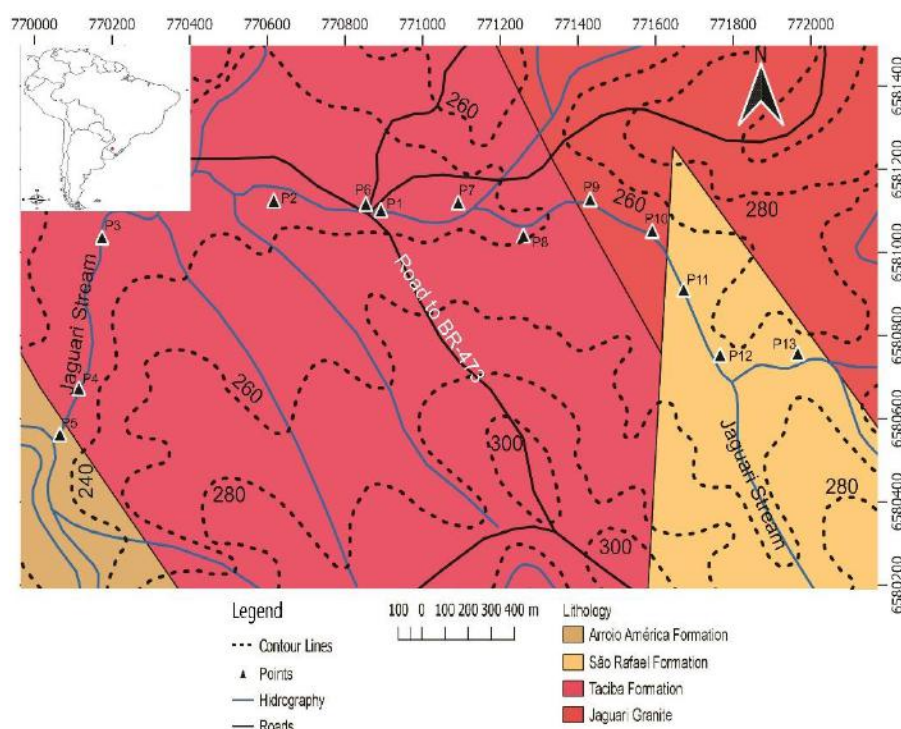


Fig.2: Map of location of the points of sampling of the stream Jaguari in the district of Lavras-do-Sul RS, Brazil.

Immediately after the samples were collected, the pH was checked by using a pH meter at the Laboratory.

The conductivity of the samples was measured by a GEHAKA CG1800 apparatus. The electric conductivity is a measure of the aqueous solution capacity to drive an electric current due to the ions presence. The higher the number of dissolved ions, the greater the electrical conductivity of the water. The electrical conductivity is an indirect measure of the pollutants concentration.

To determine the hardness of the samples, the EDTA served as titrant and the eriochrome-T as an indicator [1], [2]. The reagent's blank titration was done simultaneously using distilled/deionized water. The hardness levels were determined to verify any constraints on potability and, for human consumption. The hardness is one of water's natural characteristics and, it indicates the total concentration of alkaline earth ions in water. This property can be quantified when water comes into contact with rocks enriched with calcium and magnesium minerals, in which the calcium and magnesium salts dissolve. These salts excessively aggregate to the water composition, as bicarbonate (HCO_3^-), nitrate (NO_3^-), chlorides (Cl) e sulfates (SO_4). Calcium analysis was performed using the same titrant of the total hardness and murexide indicator.

Approximately 50 ml was isolated from each sample for the Elemental Analysis by Energy Dispersive X-ray Fluorescence (EDXRF). The analyses of the chemical elements and their present amounts in the water occurred in the Laboratory of Mineralogy and Petrography (LMP - Unipampa). The Equipment model S1 Turbo SD was calibrated with a tension of 15 keV (Na to Sc) and 50 keV (Ti to U) with a current in the tube of 184 and 25 A respectively; and 120 s of real-time integration.

PCA was selected as the method as it is a multivariate statistical technique commonly used to investigate variability in large geochemical data sets [29]. All analyses were conducted using XLSTAT statistical software package, statistical analysis, 2018.

PCA is a method of variable reduction that produces a lower number of artificial variables, known as Principal Components (PCs). Each PC represents a certain amount of variability in the data, and the first two PCs usually answer for most of the variations inside of the whole group of data [29]. When using PCA, only the PCs with values > 1 are used, therefore they are responsible for most of the variation in the data.

III. RESULTS AND DISCUSSIONS

The physico-chemical characteristics of the water are a reflection of the means by which they are percolated. Aside from the lithologic aspects, the existing amount of dissolved salts reflects the variation of geochemical behavior as a whole [21]. Thus, a close relationship is expected between the composition of the water and the rocks surrounding the investigated area, as well as of the influence anthropic activity.

The results presented in Table 1 correspond to the analyses to determine the total hardness, pH, conductivity, temperature, calcium and EDRXF.

The electric conductivity results at the chosen locations ranged from 157.1 to 184.90 $\mu\text{S cm}^{-1}$ (Fig. 3A). Along these lines, levels above 100 $\mu\text{S cm}^{-1}$ indicate impacted environments and high values sometimes indicate water traits [19]. Thus, these points may be more greatly impacted by the mining activity or perhaps this is a result of the predominant soil in the area, which contains a great number of minerals. Both calcium and magnesium have great mobility and are easily leached, and it is possible that their presence may lead to high conductivity at these points.

The hardness analysis results (Fig. 3B) indicate that Jaguari stream water is inferior to 75 $\text{mg L}^{-1} \text{CaCO}_3$, indicating soft waters [23] (Fig. 4). The presented data does not deviate from Rio Grande do Sul and Brazil's average hardness on urban and rural waters [20],[21].

The pH of the samples at temperatures from 17,20 to 21,30° C ranged from 7.75 to 8.62 (Fig. 3C), indicating alkaline waters. This may be due to carbonate dissolution from the nearby limestone extraction area collection and to the increased concentration of carbonates in the low-rainfall months when the samples were collected. The public distribution sample presented neutral pH (7,0).

The calcium levels ranged from a minimum of 10.83 mg L^{-1} in the T14 sample and, to a maximum of 41.31 mg L^{-1} in the P13 sample (Fig. 3D). At Jaguari stream, it varied between 18.27 and 41.31 mg L^{-1} . Comparing these results to those found by [22], where results show 1.07 mg L^{-1} and, also, [21] where the result show 11.20 mg L^{-1} both for the calcium, accordingly, the tenor of calcium calculated in this study was ~2.6 and ~2.5 times bigger.

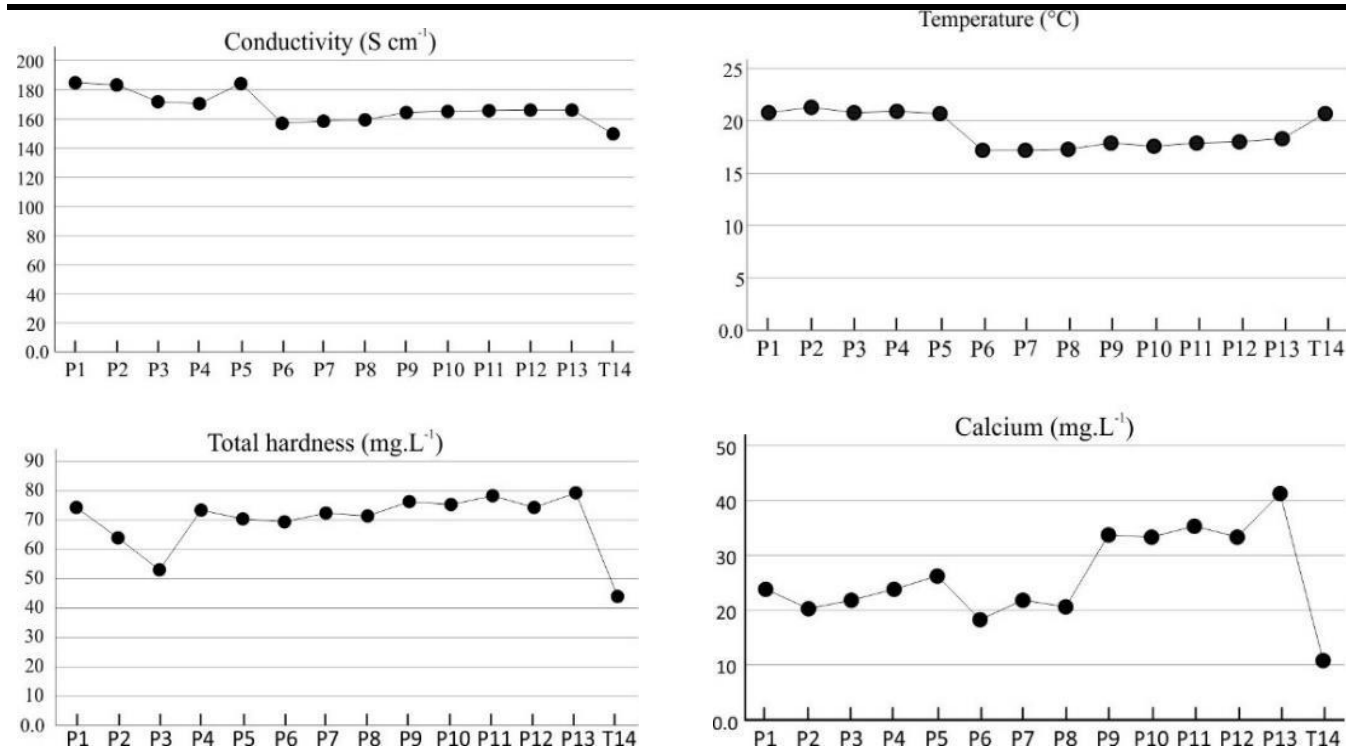


Fig.3: A) Conductivity ($\mu\text{S cm}^{-1}$), B) Total hardness (mg L^{-1}), C) Temperature ($^{\circ}\text{C}$), and D) Calcium (mg L^{-1}) of the sample's unit showing that the P5 sample presented higher conductivity and temperature than the other water samples. The P1, P2, P3, P4 and P5 samples presented the highest values in terms of conductivity and temperature. The P3 sample showed the lowest total hardness along with T14.

The EDRXF analysis attested that the largest values are made of magnesium, varying between, 4.12 and 7.19% and correspond up to 39% higher than the public distribution sample results (T14). The high values of Cu, Rh, Ag, and Cd (up to 0.12, 6.56, 0.97, mg L^{-1} respectively) draw awareness.

When there is Rh ingestion in large proportions, it can lead to the occurrence of carcinomas or cancer in individuals. This element has no biological role in human

beings. Second [24], cadmium is a non-essential element and highly toxic to plants and animals. Prolonged exposure to this element has caused severe chronic effects, predominantly in the lungs and kidney. Exposure by inhalation causes emphysema and other chronic lung effects. According to [3], to be potable for human consumption the cadmium values cannot exceed 0.005 mg L^{-1} and for Cu, it cannot exceed 2.0 mg L^{-1} .

Table 1: Jaguari stream water analyses results

Samples	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	T14
Conductivity	184.90	183.40	171.80	170.50	184.30	157.10	158.60	159.50	164.50	165.30	165.70	166.10	166.20	149.8
Temperature	20.80	21.30	20.80	20.90	20.70	17.20	17.20	17.30	17.90	17.60	17.90	18.00	18.30	20.7
Ca	23.83	20.26	21.85	23.83	26.21	18.27	21.85	20.65	33.76	33.36	35.35	33.36	41.31	10.82
Total hardness	74.32	63.92	53.02	73.33	70.36	69.37	72.34	71.35	76.31	75.32	78.29	74.32	79.28	44
pH	7.95	8.52	8.62	8.55	8.58	7.81	7.82	7.79	7.75	7.79	7.84	7.83	7.77	7
Mg	6.41	4.42	4.54	5.36	4.26	5.71	4.12	6.90	4.82	6.78	7.19	5.30	4.77	4.35
Al	0.00	0.00	0.00	0.53	0.00	0.60	0.00	0.00	0.00	0.58	0.71	0.00	0.00	0.66
Si	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.18	0.01	0.00	0.00	0.00	0.00	0.39
K	0.18	0.20	0.26	0.23	0.23	0.26	0.30	0.27	0.31	0.24	0.25	0.28	0.26	0.056
Fe	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.01
Cu	0.10	0.10	0.10	0.10	0.10	0.08	0.12	0.07	0.08	0.00	0.07	0.06	0.07	0
Rh	1.15	1.12	1.14	1.13	1.16	5.94	6.56	6.50	5.49	6.25	6.23	5.99	6.23	0
Ag	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0
Cd	0.00	0.78	0.82	0.92	0.00	0.00	0.00	0.91	0.00	0.97	0.00	0.00	0.00	0

As shown in Fig. 4, it is possible to observe a positive correlation linking the calcium values to the total hardness in water. That suggests a correlation between the

total hardness in the water and calcium-rich minerals of the study's area lithology. The equation shows that the coefficient for total hardness in the calcium is 0.9155 mg

L⁻¹. The correlation between the amount of calcium and the hardness was of $r = 58\%$ (Fig. 4). This confirms that the total hardness in Jaguari stream is mainly due to calcium bicarbonate and the dissolution of minerals originating from another calcium-rich minerals

dissolution from near lithologies. Thus, the mineral's dissolution during the process fluid/rock interaction is responsible for the calcium bicarbonate presence in shallow waters.

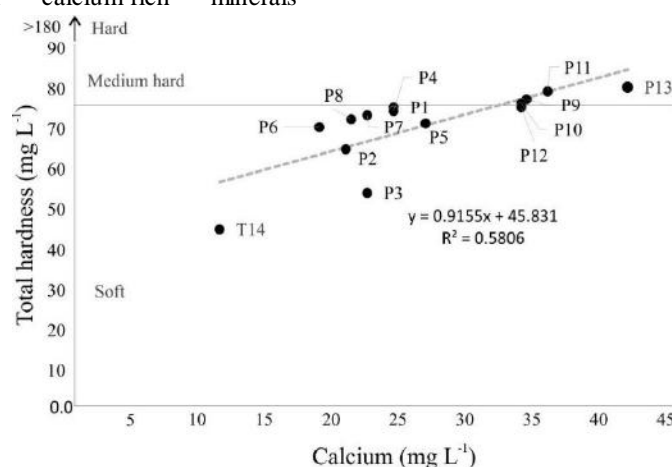


Fig.4: Relationship of calcium (mg L^{-1}) with the Total Hardness (mg L^{-1}). Classification of water as to its hardness in accordance with [23].

The analysis exhibits other elements in lower percentages and, or with less, such as silica, chlorine, and iron (Table 1).

Using the Pearson coefficient, it is possible to summarize the relationship between two variables. For a better analysis of the data, a statistical study was accomplished starting from the analysis of correlations, where values with a strong Pearson correlation were outstanding in the table [26]. The most common way to introduce and analyze groups of Bivariate Data is through X and Y axes, the correlation measures, the similarity among two different variables. Therefore, the value can be calculated accordingly to the equation (1).

$$\rho = \frac{\frac{1}{n} \sum (X_i - M_x)(Y_i - M_y)}{\sigma_x \sigma_y} \quad (1)$$

where, X_i being the variable X value, M_x the average values of X, Y_i the variable Y value, M_y the average values of Y, σ_x the X standard deviation and σ_y the Y standard deviation.

Table 2 shows strong positive correlations between **electric conductivity** and temperature (0.60), pH (0.76); **calcium** and total hardness (0.76); **total hardness** and K (0.67) and Rh (0.64); **pH** and Cu (0.68); and **Rh** and K (0.70). Also, demonstrate strong negative correlations between **electric conductivity** and Si (-0.65); **temperature** and K (-0.62), Rh (-0.97); **Ca** and (-0.66); **total hardness** and Si (-0.65); **pH** and Si (-0.66); Si and K (-0.62).

Table.2: Pearson's correlation matrix for the investigated parameters and elements

Variable	Conductivity	Temperature	Ca	Total hardness	pH	Mg	Al	Si	K	Fe	Cu	Rh	Ag	Cd
Conductivity	1	0.60	0.17	0.22	0.76	-0.07	-0.46	-0.65	0.02	-0.46	0.52	-0.47	-0.28	0.14
Temperature	0.60	1	-0.40	-0.53	0.48	-0.40	-0.10	0.00	-0.62	-0.30	0.19	-0.97	-0.38	0.20
Ca	0.17	-0.40	1	0.76	0.05	0.26	-0.15	-0.66	0.55	-0.40	-0.02	0.55	0.00	-0.17
Total hardness	0.22	-0.53	0.76	1	0.11	0.45	-0.14	-0.65	0.67	-0.05	0.26	0.64	0.14	-0.14
pH	0.76	0.48	0.05	0.11	1	-0.19	-0.35	-0.66	0.32	-0.21	0.68	-0.37	-0.18	0.45
Mg	-0.07	-0.40	0.26	0.45	-0.19	1	0.39	-0.03	0.12	-0.30	-0.30	0.42	-0.04	0.23
Al	-0.46	-0.10	-0.15	-0.14	-0.35	0.39	1	0.42	-0.39	-0.01	-0.54	0.01	0.11	0.05
Si	-0.65	0.00	-0.66	-0.65	-0.66	-0.03	0.42	1	-0.62	0.35	-0.55	-0.17	0.14	-0.11
K	0.02	-0.62	0.55	0.67	0.32	0.12	-0.39	-0.62	1	0.18	0.47	0.70	0.32	0.05
Fe	-0.46	-0.30	-0.40	-0.05	-0.21	-0.30	-0.01	0.35	0.18	1	0.19	0.15	0.45	-0.19
Cu	0.52	0.19	-0.02	0.26	0.68	-0.30	-0.54	-0.55	0.47	0.19	1	-0.12	0.09	-0.10

Rh	-0.47	-0.97	0.55	0.64	-0.37	0.42	0.01	-0.17	0.70	0.15	-0.12	1	0.28	-0.16
Ag	-0.28	-0.38	0.00	0.14	-0.18	-0.04	0.11	0.14	0.32	0.45	0.09	0.28	1	-0.30
Cd	0.14	0.20	-0.17	-0.14	0.45	0.23	0.05	-0.11	0.05	-0.19	-0.10	-0.16	-0.30	1

To gather water's chemical properties, it was applied the Principal Component Analysis (PCA) based on the correlation matrix between the components and padronized variables. The 11 PCs represent 100% of the variance in the obtained results (Table 3). The first three

PCs have > 1, representing 80.83% of the variance (Table 3). The first and second main components are the result of the linear combination of 14 studied variables, and both explained 36.99% and 63.98% of the variance, respectively.

Table 3: Eigenvalues of correlation matrix and related statistics

PC	Eigenvalue	Total variance%	Cumulative Eigenvalue	Cumulative %
1	4.07	36.99	4.07	36.99
2	2.97	26.99	7.04	63.98
3	1.85	16.85	8.89	80.84
4	0.82	7.50	9.72	88.34
5	0.49	4.49	10.21	92.83
6	0.39	3.57	10.60	96.41
7	0.20	1.80	10.80	98.20
8	0.09	0.83	10.89	99.03
9	0.06	0.59	10.96	99.62
10	0.03	0.30	10.99	99.92
11	0.09	0.07	11.00	100

The PCA also produces Eigenvectors, also referred to as coefficients or main components loads (Fig. 5). They describe the relative significance of a component, for example, a chemical element and its variability amongst a group of data. The eigenvectors automatically calculate the punctuation for each PC. The values of the element charges determine the score from a sampling point. So

that the grouping of elements of high charges provides high punctuations, and the grouping of low charge elements supplies low punctuations. In this regard, the number of calculated Eigenvectors will be equal to the number of used variables, which in this study is the number of chemical elements and analyzed parameters [29].

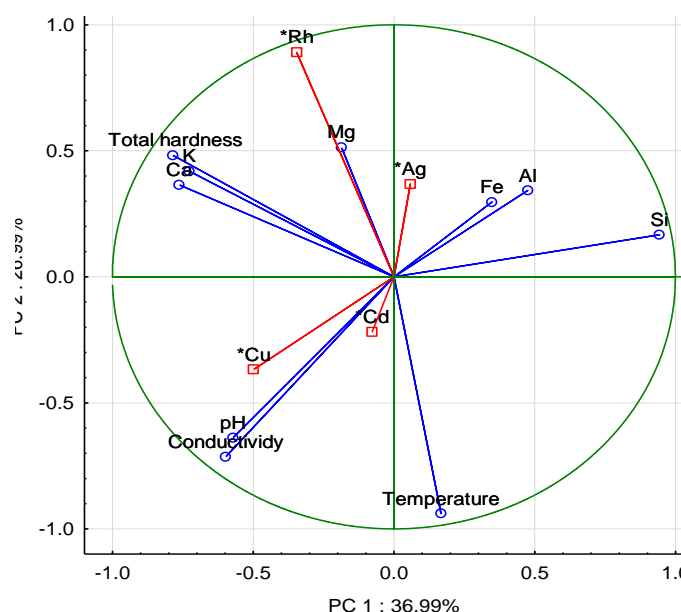


Fig.5: Multivariate analysis of geochemical characteristics of Jaguari stream water using PCA to extract the principal components.

For PC1 (36.99% variance) high scores are equivalent to elements of high charges (> 0.2), for example, temperature, Fe, Al and Si (Fig. 5). the lowest scores are equivalent to the lowest charges (< 0.19), such as conductivity, pH, the Cd observed in the anthropogenic contribution and Cu.

High scores for PC2 are related to strong positive charges (> 0.2) to the elements Fe, Ag, Ca, Mg, Rh, Al and K. Negative charges and low scores appear in Cd, Cu, pH and total hardness (Fig. 5).

IV. CONCLUSION

The water samples collected at Jaguari stream from Lavras do Sul-RS showed water's total hardness ranging from soft to intermediate. The Ph values indicated slightly alkaline to alkaline waters, with electrical ranging from 157.1 to 184.90 $\mu\text{S cm}^{-1}$ and calcium levels fluctuate between 18.27 and 41.31 mg L^{-1} .

The multivariate statistical methods showed positive and negative correlations that can be interpreted as derived from interaction with the lithology (for instance, granite, volcanic) and anthropogenic activity.

The distribution of the scores for PC1 and PC2 shows that changes can happen in the geochemistry composition of the waters, principal to Cl, conductivity, temperature and, pH followed by Fe, Ag, Ca, Cu and K. This suggest lithological influence in the composition of the waters. The Cd was associated with anthropic interference because its correlation was secondary.

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Anatomy of Abdominal Aorta in Tatu Peba (*Euphractus sexcinctus* - Linnaeus, 1758): A Descriptive and Comparative Study

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Abstract— *Tatu Peba* is an animal from *Euphractus* genus whose anatomy and/or systemic description are little studied, a fundamental understanding of biological system knowledge of this animal. Thus, this work aimed perform an anatomical description of abdominal aorta and *Tatu Peba* branches through a comparative study using 2 male and 2 female specimens. In this sense, the present work showed unprecedentedly discovery about this animal as the first major branch of abdominal aorta is celiac trunk and the second branch is a. Mesenteric cranial. From ventrolateral face, a. Phrenic caudal, by ventral small face Aa. Accessory Mesenteric and five pairs of Aa. Lombares. Medium distance, between Celiac Trunk and Aa. External Iliacs, born Renal arteries. A. Caudal Mesenteric emerges ventrally to caudal part of large intestine. In the final part of aorta, Aa. External Iliacs borns ventrolaterally and caudally projected. After Aa. External Iliacs origin, the aorta undergoes a drastic reduction of caliber and forms a short trunk that divides into terminal branches of aorta: right internal iliac, Left Internal Iliac and a. Median sinsacral in sagittal plane which emits an a. Lateral to each side, following three caudally. In view of these findings, the present study showed that abdominal aorta of *Tatu Peba* presents smaller number of branches bought from other mammals and contributes to anatomical description and understanding of important blood vessels in this animal biological system.

Keywords— *Anatomy, Euphractus sexcinctus, Brazilian fauna, Cerrado biome and Wild animals.*

I. INTRODUCTION

There are 21 species of armadillos described, which 11 are from Brazilian fauna [1]. *Euphractus*

sexcinctus (*Tatu Peba*) specie is the only of *Euphractus* genus and belongs *Daypodidae* family inserted in Cingulata order and Xenarthra superorder [2]. This animal is regionally known as *Tatu Peba* or *Tatu Peludo* [3] and the carapace has a variable coloration from yellowish-brown to light brown, formed by 6 to 8 moving bands. The head is conical, the tail long and protected by horny rings and it whitish and long hairs [4], giving rise to the popular name of this species. It is widely distributed in South America, including Brazil where it habits several biomes such as Amazon, Caatinga, Cerrado, Pantanal, Mata Atlântica and Campos [5], savannas, dry forests, semi-deciduous forests and forest edges [6,7].

The general food habit of *Tatu Peba* involves invertebrates (mainly insects), organic plant material (fruits and tubers, etc.), decomposing animals [8,9] and small vertebrates (mainly rodents of the species *Calomys* sp.) [10]. Its activity is mainly diurnal, but eventually has nocturnal activities [1].

This specie is frequently victim of road crashes [11] and although its meat has a strong and singular flavor, so much appreciated and constantly hunted [12]. Despite trampling deaths, hunting and disturbances caused by anthropic activities, this species is not threatened with extinction [13].

Xenarthra superorder presents some anatomical peculiarities, such as additional joints between the caudal vertebrae, allowing erect posture in some situations. Some authors reports the presence of caudal cavae pair of veins, undifferentiated external genitalia, low metabolism and body temperature ranging from 32.7 ° C to 35.5 ° C [14,15].

The anatomical, topography and systemic descriptions of any specie are fundamental for biological

system knowledge, as well its importance in clinical veterinary practice. However, even the importance of anatomy of wild animals for the eco-sustainability in biome; as well the value of species in the ecosystem, the anatomy of Tatu Peba is little studied. Considering the importance of circulatory system in animal anatomy as an internal mean of transport and an important access route in clinic, where provides data in clinical intervention or preservation programs, the objective of this work was investigate and describe the anatomy of Abdominal Aorta and its branches in Tatu Peba as a literary subsidy for different areas of knowledge.

II. MATERIAL AND METHODS

The present paper is a descriptive anatomical study with two male and two female specimens of Tatu Peba (*Euphractus sexcinctus* - Linnaeus, 1758), obtained from accidental death on the roadsides of Brazilian Southeast of Goiás, under authorization of SISBIO n° 37072-2. Considering the descriptive approach of this work, statistical analysis is not necessary. All procedures were conducted in accordance with ethical principles and were approved by the Institutional Ethics in Research Committee at the Federal University of Uberlândia (CEUA/UFU n° 067/12).

The study was made in the research laboratory of human and comparative anatomy from the Federal University of Goiás – RC, as previously described by our group [16], where the arterial system was dissected and inject with Latex Art Glue, colored with red pigment Wandalor, through the carotid artery. Subsequently was made a fixation with aqueous 10 % formaldehyde solution to conservation. The preparation of anatomical pieces was performed under consecrated techniques in Macroscopic Anatomy. For this, after trichotomy of anterolateral abdomen region, an incision was made along Linea Alba, from xiphoid process to cranial extremity of the pubic symphysis. Other incisions were performed laterally, accompanying costal border of each side and inguinal region approximated of inguinal ligament. The abdominal wall was laterally open to visceral exposure, then all abdominal part and digestive system secluded, exposing the dorsal wall of abdomen. With an anatomical forceps, the adipose tissue and other tissues were removed to

expose abdominal aorta artery and its branches. A stereomicroscope MOTIC SMZ-168, with magnification of 10X was used to dissection procedure.

The Nikon® D7000 18-105 digital camera was used to photographic documentation and description nomenclature adopted is the standard of Nomina Anatomica Veterinaria (2012) [17], elaborated by the International Committee on Veterinary Gross Anatomical Nomenclature.

III. RESULTS

The diaphragmatic pillars of Tatu Peba (*Euphractus sexcinctus*) are long and protrude caudally to level of iliopsoas muscles origin. The aortic gap comprises an space delimited by diaphragmatic pillars through Aorta enters abdominal cavity approximate from level of L₁ and runs along dorsal wall of abdomen, slightly to left of vertebral bodies. The first major branch of abdominal aorta is the *Celiac Trunk*, being the largest branch of abdominal aorta and characterized as unpaired vessel, short and large caliber vessel, originating in ventral aspect of Aorta at level L₂ between the pillars of diaphragm. Soon after its origin, *Celiac Trunk* trifurcates in *Common Hepatic a.* sideways to right, *Left Gastric a.* laterally to left and posterior to *Lienal*.

The second branch of abdominal aorta is *Cranial Mesenteric a.* with unpaired characteristic and large caliber vessel, originating from ventral face at level L₃ near *Celiac Trunk* origin directed to intestines. Near *Cranial Mesenteric a.* origin borns *Left Caudal Phrenic Aa.* as a unique vessel by left ventrolateral face at L₃ level, which is directed to left diaphragmatic pillar and already on diaphragm surface divided into right and left branches, there being no *Caudal Phrenic a.*. Four small accessory mesenteric arteries were identified, one arising from *Left Gastric a.* and the others from aorta.

Five pairs of *Lumbar Arteries* are present in Tatu Peba, which arise from dorsal surface of *Abdominal Aorta*. These arteries are arranged equidistantly from diaphragmatic pillars to final bifurcation of aorta, the fifth pair being already located within pelvis.

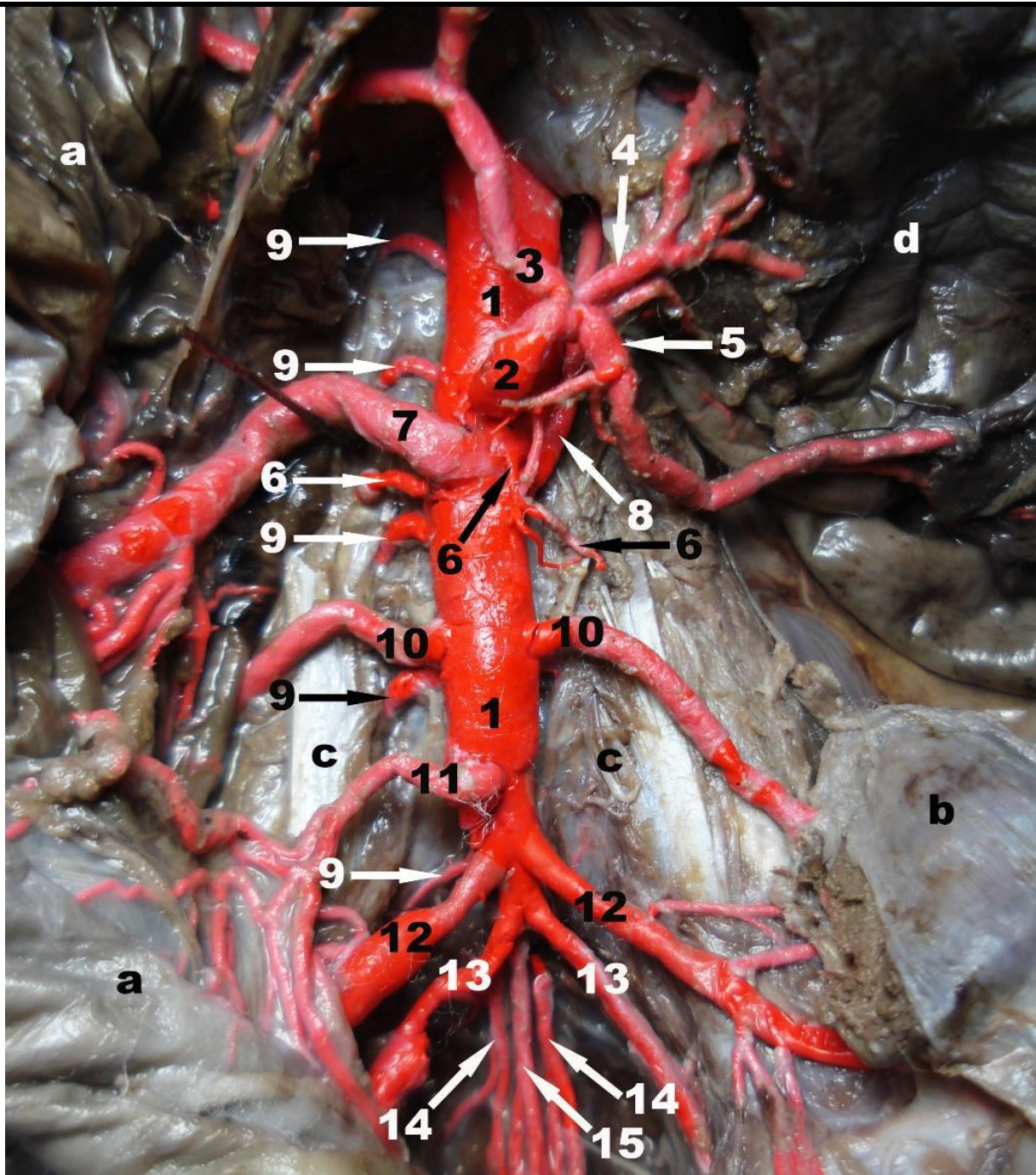


Fig.1: Abdominal part of Aorta. 1- Abdominal Aorta; 2 - Celiac Trunk; 3- Common Hepatic Artery; 4- Lienal Artery; 5 - Left Gastric Artery; 6- Mesenteric Accessory Artery; 7- Cranial Mesenteric Artery; 8- Phrenic Caudal Artery; 9- Lumbar Artery; 10- Renal Artery; 11- Mesenteric Caudal Artery; 12- External Iliac Artery; 13- Internal Iliac Artery; 14- Lateral Sinsacral; 15 - Median Sinsacral Artery.

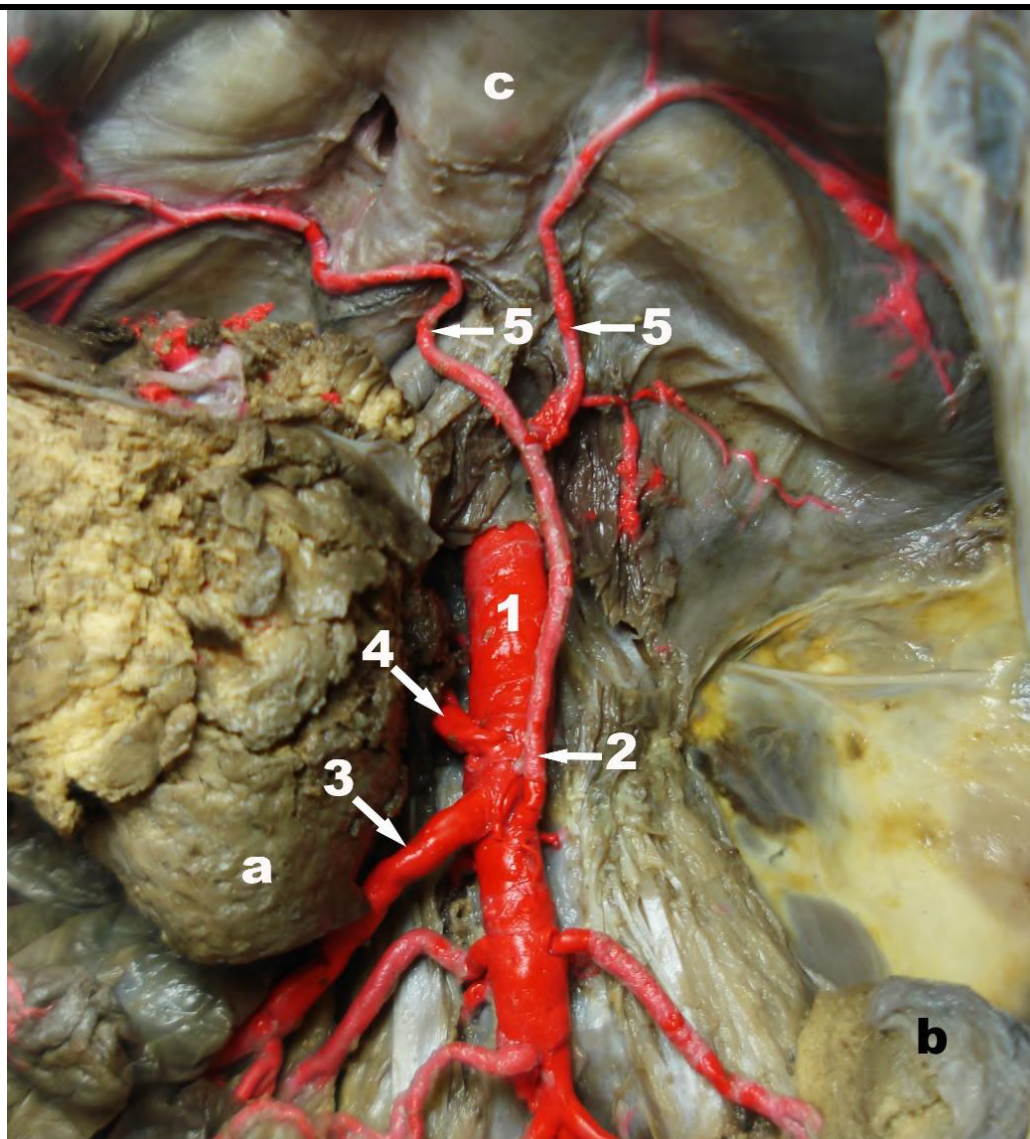


Fig.2: Abdominal part of Aorta. a- Left Liver Lob; b- Kidney; c- Diaphragm; 1- Abdominal Aorta; 2 – Phrenic Caudal Artery; 3- Mesenteric Caudal Artery; 4- Celiac Trunk; 5 – Phrenic Artery Branch.

The average distance between *Celiac Trunk* and *External Iliacs Aa.* at L₃-L₄ level, *Renal Arteries* born laterally, the right being relatively longer than left. In variable numbers, adrenal arteries are branches of *Renal Arteries*. Then, caudally at L₅ *Caudal Mesenteric a.* emerges ventrally to caudal part of large intestine. In final part of aorta (abdominopelvic transition), the *External Iliacs Aa.* borns ventrolaterally and caudally projected.

After *External Iliacs Aa.* origin, aorta undergoes a drastic reduction of caliber forming a short trunk and divides into terminal branches of aorta: the *Right Internal Iliac*, *Left Internal Iliac* and in sagittal plane *Median Sinsacral a.* that borns dorsally. *Aa. Internal Iliacs* supply intra-pelvic structures and provide *Gonadais Arteries*, while *Median Sinsacral* emits an *Lateral Sinsacral a.* to each side, following three caudally.

Table.1: Main branches origin of abdominal aorta from Tatu Peba (*Euphractus sexcinctus*)

Structure	Artery of Origin	Vertebra of Origin
<i>Celiac Trunk</i>	<i>Abdominal Aorta</i>	L ₂
<i>Cranial Mesenteric Artery</i>	<i>Abdominal Aorta</i>	L ₃
<i>Phrenic Caudal Artery</i>	<i>Abdominal Aorta</i>	L ₃
<i>Mesenteric Accessory Artery</i>	<i>Abdominal Aorta</i>	L ₃
<i>Lumbar Arteries</i>	<i>Abdominal Aorta</i>	L ₁ - L ₅
<i>Artérias Renais</i>	<i>Aorta abdominal</i>	L ₄

Artéria Mesentérica Caudal	Aorta abdominal	L ₅
Artéria Ilíaca Externa	Aorta abdominal	Sinsacro
Artéria Ilíaca Interna	Aorta abdominal	Sinsacro
Artéria Sacral Mediana	Aorta abdominal	Sinsacro
Artérias Sinsacrais	Aorta abdominal	Sinsacro

IV. DISCUSSION

Although anatomical comparisons between domestical and wild animals, literature research reveals shortage articles of Tatu Pebá anatomy and discussions of large Xenarthras group are not prioritized, which require correlation of the present study with pertinent literature in other groups.

The first visceral branch of *Abdominal Aorta* of Tatu Pebá is the *Celiac Trunk*, which emerges ventrally at L₂ vertebra after aortic gap and formed by right and left diagrammatic pillars. The *Celiac Trunk* is unique and large caliber vessel originates ventrally from *Abdominal Aorta* and trifurcates in *Left Gastric a.*, *Lienal a.* and *Common Hepatic a.*. When compared to Tamanduá Bandeira (*Myrmecophaga tridactyla*) [18] is possible identify close similarity with regard to ramifications of *Celiac Trunk*.

Other representatives of Xenarthras group, similarity Tatu Pebá can be viewed with Sloth Bug (*Bradypus variegatus*), since *Celiac Trunk* presents the same origin and branching pattern in least 75% of individuals, occurring 25% of variations when *Celiac Mesenteric Trunk* formation occurs [19], unverified pattern in Tatu Pebá. On the other hand, Albuquerque et al. (2017) [20] describe that 50% of females and $\cong 33.3\%$ of males present similar disposition to found in Tatu Pebá, while formation of *Celiac Mesenteric* occurs in other females and $\cong 66.7\%$ of males.

However Albuquerque et al. (2017) [20] identify *Phrenic Caudal a.* as the first branch of abdominal aorta, discordant data with findings in Tatu Pebá, Macedo et al. (2013) [21] mention that Tamandua-mirim (*Tamandua tetradactyla*), *Celiac Trunk* emerges separately maintaining the branching pattern observed in other Xenarthras, but only one female of their study a bifurcation of *Celiac Trunk* in *Left Gastric a.* and *Lienal a.* were observed, the *Common Hepatic a.* collateral branch of *Cranial Mesenteric a.*. In relation to pattern of origin and branching of *Celiac Trunk* in other taxonomic groups, Bavaresco et al. (2013) in New Zealand rabbits [22], Faria (2016) in Macaco-da-noite [23], Pinheiro et al. (2014) in Jaguatirica [24] and Culau (2008) in Nutria [25], identify pattern similar to that verified in Tatu Pebá.

Described by da Silva et al. (2011) that Macaco-de-Cheiro *Left Adrenal a.* born from *Celiac Trunk*, since Culau et al. 2010 [27] describe that in gambá 87.5% of have a *Common Mesenteric Celiac Trunk* formation.

Machado et al. (2002) [28] also analyzed vascular system of Nutria and observed that in 70% of cases *Celiac Trunk a.* emerges separately and 30% in a common trunk with *Cranial Mesenteric a.*. In the study of Amadori et al. (2012) [29] which the object of study was Veadó Catingueiro (*Mazama gouazoubira*) the group identified that the first branch of *Celiac Trunk a.* is *Phrenic Caudal a.* and after this, *Hepatic a.* and *Left Gastric a.* and *Lienal* issuance.

The same standard is observed in ruminants and equines [30,31] and carnivores [32] and identified in 16.6% of swine [33] and 10% Nelore cattle [34], contrary to observations of Tatu Pebá when a single *Phrenic a.* originates directly from *Abdominal Aorta* and divides into right and left branches.

The second major branch of *Abdominal Aorta* in Tatu Pebá is *Mesenteric Cranial a.*, as occurs in Tamanduá Mirim and Tamanduá Bandeira [21,35]. In this context, only Bicho Preguiça present the formation of *Celiac Mesenteric Trunk* between components of Xenarthra Superorder, in the others *Celiac Trunk* and *Mesenteric Cranial a.* originate separately. As most Xenarthras other species share same said arteries independent organization, when *Mesenteric Cranial a.* emerges from ventral face of *Aorta* and caudally to *Celiac Trunk*, such as: Macaco-de-Cheiro (*Saimiri sciureus*) [26], Macaco-da-Noite (*Aotus azarae infulatus*) [23], Nutria (*Myocastor coypus*) [25], New Zeland Rabbit (*Oryctolagus cuniculus*) [22], Queixada (Tayassu pecari) [36], Paca (*Cuniculus paca*) [37], Cat (*Felis catus*), S.R.D. [38] and Jaguatirica (*Leopardus pardalis*) [24]. However, the formation of *Mesenteric Celiac Trunk* of some groups can occur, although isolated form of origin predominates in bovine fetuses, Sheep [39,40], Bubalinos [41], Goats [42], Felines [43] and finally humans [44], and the formation of *Celiac Mesenteric Trunk* in Tatu Pebá is not found.

Immediately after *Celiac Trunk* origin cranially to *Cranial Mesenteric a.* born *Phrenic Caudal a.* and a single medium caliber artery recedes cranially to the left, which reaches caudal face of diaphragm that divides into right and left branches, and there is no right *Phrenic Caudal a.*. Tamanduá Mirim there is two caudal arteries, one left and other right [21] and in Bicho Preguiça occurs in unique way, emerging before *Celiac Trunk* [20], in this way the first branch of aorta.

The literature have little data regarding *Accessory Mesenteric Arteries*, but in Tatu Peba four of them can be counted with variable origins and arise from *Left Gastric a.* or directly from Aorta. Five pairs of *Lumbar Arteries* are present in Tatu Peba, whose origins occur on dorsal aspect of aorta and equidistant from each other, from diaphragm to sinsacral cavity. In Bicho Preguiça it can be identified between two to ten pairs of *Lumbar Aa.*, with higher number in female specimens [20]. Six pairs can be observed in Nutria [25] and Jaguatirica [24], whereas in New Zealand Rabbits seven pairs are observed and three pairs in Tamandua Mirim [22,21].

In Tatu Peba at fourth lumbar vertebra emerge *Right* and *Left Renal a.* in ventrolaterally and independent origin. This pattern is similar to other represents of Xenarthra group such Tamanduá Bandeira [35] and Tamandua Mirim [21]. However the level origin of Tamanduá mirim, the *Right Renal a.* is cranial in relation to the left. As in other groups, *Renal Arteries* of Tatu Peba eventually gives branches to adrenal glands [21].

The number of *Renal Arteries* in Tatu Peba specimens studied is constant, always on each side and with branching only inside the organ. In Bicho Preguiça *Left kidney a.* occurs in half female specimens [20] and arises bifurcation of *Renal a.* before arrive hilo, similar condition was identified by Silva *et al.* (2013) in Macacoprego [45]. Culau (2008) reports in Nutria [25] that *Renal Artery* arises laterally from Aorta, 70% asymmetrical and single and 30% double. Faria (2016) states in Macaco-da-noite [23] that *Renal Artery* can arise in common trunk, a particularity not observed in Tatu Peba.

In Tatu-peba, caudally to *Renal Arteries* arise *Mesenteric Caudal a.* from ventral aspect of aorta, whose distribution occurs in the final part of large intestine. This condition is present in Tamanduá Bandeira [35], Tamanduá Mirim [21] and Bicho Preguiça in 75% of females and \cong 83.3% of males [20]. With regard to origin and distribution of Caudal Mesenteric a., a strong similarity can be identified between observations in Tatu Peba and Cats S.R.D. [38], as well Paca [37] and Queixada [36].

At abdominopelvic transition, *Abdominal Aorta* of Tatu Peba origin laterally to *External Iliac Aa.*, two large vessels destined to pelvic limbs. After the origin of *External Iliacs Aa.*, aorta undergoes drastic reduction of caliber and follows caudally by short distance and emits terminal branches, being laterally to *Internal Iliac Aa.* e median the *Median Sinsacral a.* The *Internal iliac Aa.* are intended for structures of pelvic cavity, while *Medial Sinsacral* trifurcates in flowing branches that follow caudally on ventral surface of sacrificial. This condition is observed in other animals: horses, cattle and swine [28],

cats [46] and dog [47]. The internal Iliac emerges at the same level following caudolaterally into pelvis, in agreement with the descriptions of Tatu Galinha (*Dasypus novemcinctus*) [48]; however, in some animals was observed that *External Iliac* branched to *Internal iliac a.*, where *Median Sacral a.* is a branch of *Left Internal iliac a.*. In Gambá [49] and Nutria [25] is described a formation of a common trunk between *Internal* and *External Iliac Aa.*, at the same level of *Internal Iliac Aa.* that born from Aorta, dorsally to *Median Sinsacral a.* and paired by two Lateral Sinsacral Aa., following then in direction to the tail.

V. CONCLUSION

The present study demonstrated by unprecedentedly relates that *Abdominal Aorta* of Tatu Peba (*Euphractus sexcinctus*) presents smaller number of branches, different from other mammals. When compared to other components of Xenarthras Superorder and great similarity with regard to number and vascular distribution. Thus, this work contributes to anatomical description and understanding of an important blood vessel in Tatu Peba biological system.

VI. COLABORATORS

Thalles Anthony Duarte Oliveira, Kadija Mohamed Santee, Tarley Santos Oliveira, Vinícius Gonçalves Fontoura and Bruna Silva Lopes were responsible for acquisition, analysis and interpretation of data.

Thiago Sardinha de Oliveira, Roseâmely Angélica de Carvalho Barros and Zenon Silva were responsible for concept, design and preparation of manuscript.

All authors read and approved the final version of manuscript.

CONFLIT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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Accidents Analysis of Kandahar-Spin Buldak Highway in Afghanistan

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Abstract— The study aims to identify and prioritize the accidental blackspots locations on Kandahar – Spin Buldak highway located in Afghanistan. The hazardous locations (blackspots) are identified by the APW (Accident Point Weightage), EPDO (Equivalent Property Damage Only), and RQC (Rate Quality Control) methods. In the first step; APW and EPDO methods identified Km 7th, Km 20th, Km 47th, Km 62nd and Km 90th as blackspot locations on Kandahar – Spin Buldak highway, however, integrating all three methods (RQC, APW and EPDO); the Km 7th and Km 20th are recognized as critical hazardous locations alongside this highway. While practically and theoretically high number of crashes occur in locations where there is higher AADT, surprisingly, this paper found critical blackspots locations alongside Km 7th and Km 20th segments of the highway (having almost equal and less AADT in comparison with 47th, 62nd and 90th Km).

Keywords— Blackspot, EPDO method, APW method, Rate Quality Control method and Crashes.

I. INTRODUCTION

Afghanistan is one of the developing countries having high level of traffic accidents. Increase in the number of vehicles on the roads results high accident rates. Hence, comprehensive studies are required to take place in order to address problems and propose solutions for the accident rates that cause not only health loss but also social and economic loss in developing Afghanistan. The total number of accidents in Afghanistan were 4,397 in 2014, in which 6,448 were fatalities. The age adjusted death rate is 21 per 100,000 of population ranked 23rd in the world (WHO, 2014; CSO, 2015).

Rapid economical and industrial rise all over the country directly contributes to higher number of individual car ownerships, which leads increasing accidents frequency and severity as shown in “Fig. 1” (MTCA AFGHANISTAN, 2017).

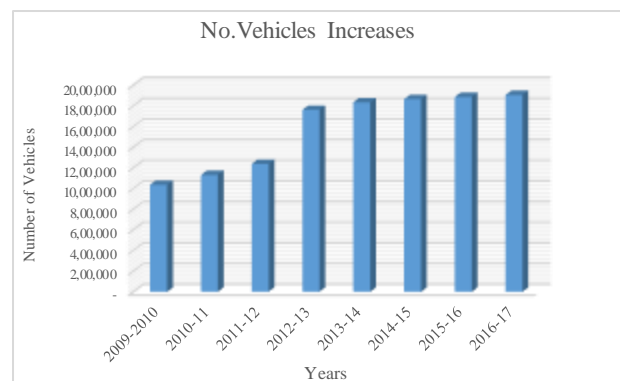


Fig. 1: Growth of vehicles (2010-2017)

“Fig. 1” Shows the number of vehicles increases after each year. The average world fatality rate per 10,000 vehicles is 19 and is 2 per 10,000 vehicles in developed countries (Aung S. N., 2014). Whereas, the fatality rate in Afghanistan is above 30 per 10,000 vehicles for the past five years (from 2010-2014) (WHO, 2015).

Kandahar is the second biggest province of Afghanistan and its Spin Buldak district is the second major entry between Afghanistan and Pakistan which named Wesh-Chaman border crossing. It is also a major transporting and receiving site between the two neighboring countries. Kandahar to Spin Buldak is one of highways of Kandahar province which connects Wesh-Chaman border to the city of Kandahar province. Many people always cross and go through this highway by land transport in terms of cars, vans, and buses.

Its design speed is 90 Kilo meters per hour and its reconstruction work was started in 2008 and ended on 2010. The pavement width is 25 ft. and with 6 ft. of shoulders. In this route, there are many accidents taking place recently because of many people use this highway for many purposes such as business, offices work, diplomacy and leisure time. There are 347 vehicles crashes with 311 fatalities and 784 injuries from November 2012 to December 2015 (KMRH, 2015). The reasons behind these accidents rates are inadequate capacity of roads, speeds and human errors.

II. STUDY AREA

Kandahar -Spin Buldak highway is located in the East of Kandahar city. It is one of the main highways of

Kandahar province which links Wish Chaman border to the city of Kandahar. Many people always cross and go through this highway by land transport in terms of cars, vans, and buses. In the other hand, it is the core highway between the southern of Afghanistan and the topography is generally plain and rolling surface but some parts are also mountainous region. 5 years accident data (2012-2016) has been used for this highway and the considered total length of the study area is about 105 Kilometers along this highway as shown below.

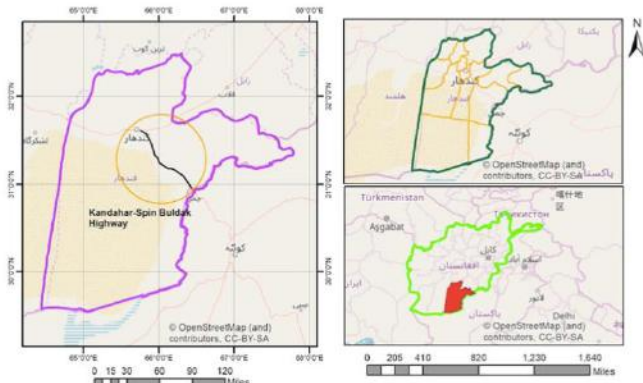


Fig. 2.1 Vicinity map of Kandahar-Spin Buldak Highway

III. METHODOLOGY

The study is conducted in two parts:

- ✓ To identification and analysis of accidental blackspots through EPDO, APW and Rate Quality control methods.
- ✓ To Prioritize the blackspots through comparison of EPDO, APW and Rate Quality Control methods

3.1 Framework

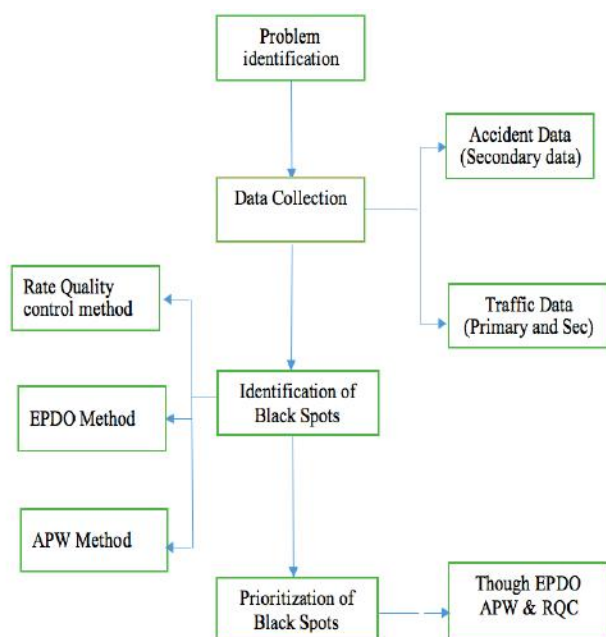


Fig.3.1: Flow chart of the research

3.2 Data Collection

Related accident data collected from highway department, traffic police department, Kandahar Mirwais Regional Hospital, WHO, UN-Habitat and international organizations. Fig.3.1 shows the number of accidents and fatalities over the past four years.

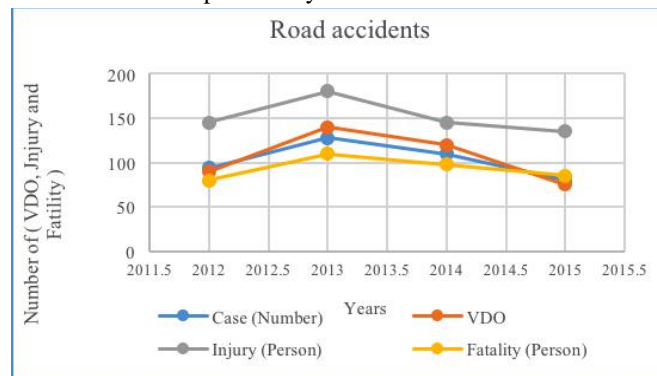


Fig. 3.1 Accidents Cassese with fatality, Injury and PDO
Source: Kandahar police traffic department data 2017

3.3 Methodology for blackspots Analysis

In this study, three methods have been used to identify and prioritize the blackspot locations namely accident point weightage method (APW), equivalent property damage only method (EPDO) and Rate Quality control methods.

3.3.1 Accident Point Weightage (APW) Method

Identification and prioritization of blackspots location were carried out by using ranking accident point weightage method. In this method, the accidents were divided into three groups. For property damage only it was multiplied with 0.2 while multiply with 3.0 and 6.0 injury and fatality respectively.

$$APW = KF + KI + KP \quad (1)$$

Where, W = Coefficient of Weight

F = Fatality Frequency

I = Injury Frequency

P = PDO Frequency

K values for Fatality is 6, Injury is 3 and PDO is 0.2

3.3.2 Equivalent Property Damage Only (EPDO) Method

Another method which has been used to identify the blackspots location was equivalent property damage only method (EPDO). In this method considered weights of an accident is based on its severity of accident. The weight of fatality is higher than injury and vehicle damage only. The severity index is calculated based on using the equation of Campbell and Knapp (Campbell, 2005). The following mentioned procedure have been used for EPDO method. The EPDO Severity is mentioned by equation:

$$SI = [WK + WI + WP] / T \quad (2)$$

Where,

SI = severity index

W = weight coefficients

K = frequency of fatality

I = frequency of injury

P = frequency of property damage only

T = total accidents

The EPDO index is mentioned by equation:

$$\text{EPDO Index} = (\text{WK} + \text{WI} + \text{WP}) \quad (3)$$

* total accidents

The EPDO rate is mentioned by:

$$\text{EPDO rate} = [\text{EPDO Index}] \quad (4)$$

/ [(Exposure per day) * Days]

Or EPDO rate = [EPDO Index] / [(Exposure per day) * total days during analysis period]	
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The exposure per day times days is called and the exposure rate that is the total days during the analysis period which is equal to 1,460 days (365*4).

3.3.3 Rate Quality Control (RQC) Method

The rate quality control method is used in the hazardous locations which compare the traffic crashes rates for roadway segments with similar characteristics to determine the critical and average crashes rate for all specified locations of road. The formula to find the critical crash rate at highway is follows:

A section *j* is considered to be a blackspot, from the accident rate point of view, if:

$R_j > R_c$, Where the R_c

$$= R_a + K \sqrt{\frac{R_a}{M_j} + \frac{1}{2M_j}} \quad (5)$$

$$R_a = \sum_{j=1}^n (A_j / M_j) \quad (6)$$

R_c : Critical crashes rate for a particular location (crashes per million vehicles or crash per million vehicle-km)

R_a : Average crashes rate for all road locations (crashes per million vehicles or crash per million vehicle-km).

K: Probability factor determined to be the level of statistical significance desired for R_c ,

$\alpha = 10\%$ considered, then the K value is 1.28 from normal distribution

M_j : Number of vehicles traversing particular road section (millions of vehicle-km) or number of vehicles entering particular section.

R_j : is the accident rate on section *j* during that time period (not for all section).

A_j : is the number of accidents on section *j* during a certain time period.

IV. RESULT AND DISCUSSION

For the result, three methods have been used to identify the blackspots locations namely accident point weightage (APW), equivalent property damage only (EPDO) and Rate Quality control as shown below 4.1 tables.

4.1. Accidents Cases

Average occurred accidents cases during 4 years have been shown in below table 4.1.

Table 4.1: Illustrates the average occurred accidents cases during 4 years (2012-2015)

No	Name of Location	location (Km)	Cases (Average/year)	VDO (Average/year)	Injury (Average/year)	Fatality (Average/year)
1	Shorandam	7	12	13	37	10
2	Torkotal	39	8	10	16	5
3	Airport Entrance	20	14	16	52	6
4	Intjergai	56	6	8	9	7
5	Mandah	47	5	6	5	13
6	Bazo Chaki	72	6	8	8	6
7	Milpole	62	5	6	21	3
8	lagak Manda	90	7	8	17	8
9	Sharano	80	3	4	6	3
10	Tarnak	28	6	9	10	2
	Total (Average for four year)		72	88	181	63

4.2. Result by Accident Point Weightage Method (APW)

Identification and prioritization of blackspot locations were carried out by using ranking Accident Point Weightage method. In the result, Km 7th, Km 20th, Km 47th, Km 62nd and Km 90th were the hazardous locations.

The Km 20th was the first, Km 7th is second, Km 90th is third, Km 47th is fourth and Km 62nd is the fifth hazardous locations on Kandahar to Spin Buldak highway. The remain five also categorized according to APW ranks as shown in table 4.2.

Table.4.2: Identifying and Ranking of blackspots locations by APW Method.

Location (Km)	Accident Types						APW	Rank
	Fatality	Fatality x Factor (6)	Injury	Injury Factor (3)	PDO	PDO x Factor (0.2)		
7	10	60	37	111	13	2.6	173.6	2
39	5	30	16	48	10	2	80	6
20	6	36	52	156	16	3.2	195.2	1
56	7	42	9	27	8	1.6	70.6	7
47	13	78	5	15	6	1.2	94.2	4
72	6	36	8	24	8	1.6	61.6	8
62	3	18	21	63	6	1.2	82.2	5
90	8	48	17	51	8	1.6	100.6	3
80	3	18	6	18	4	0.8	36.8	10
28	2	12	10	30	9	1.8	43.8	9

4.3 Results by Equivalent Property Damage Only Method (EPDO)

In Equivalent Property Damage Only method result that, the Km 47th, Km 62nd, Km 20th, Km 7th and Km 90th had

the high values of EPDO rate compared to the rest five locations. Therefore these five locations Km 47th, Km 62nd, Km 7th, Km 90th and Km 20th were in the hazardous locations as shown in table 4.3.

Table.4.3: Identifying and Ranking blackspots locations by Equivalent Property Damage Only (EPDO) Method.

Location (Km)	Ave Acc/KM	Fatality	Fatality x Factor (6)	Injury	Injury Factor (3)	PDO	PDO x Factor (2)	SI	Acc(to t)	EPDO Index	Days	EPDO Rate	Rank
7	12	10	60	37	111	13	2.6	14.47	347	5019.93	1460	3.44	3
39	8	5	30	16	48	10	2	10.00	347	3470.00	1460	2.38	9
20	14	6	36	52	156	16	3.2	13.94	347	4838.17	1460	3.31	5
56	6	7	42	9	27	8	1.6	11.77	347	4083.03	1460	2.80	7
47	5	13	78	5	15	6	1.2	18.84	347	6537.48	1460	4.48	1
72	6	6	36	8	24	8	1.6	10.27	347	3562.53	1460	2.44	8
62	5	3	18	21	63	6	1.2	16.44	347	5704.68	1460	3.91	2
90	7	8	48	17	51	8	1.6	14.37	347	4986.89	1460	3.42	4
80	3	3	18	6	18	4	0.8	12.27	347	4256.53	1460	2.92	6
28	6	2	12	10	30	9	1.8	7.30	347	2533.10	1460	1.74	10

4.3 Rate Quality Control Method

Table 4.5 illustrates the result by rate quality control method. As the accident rate (R_i) on Km 7th and Km 20th are greater than Critical accident rate (R_c) therefore, Km 7th and Km 20th are the blackspot locations and the rest of three are not included in blackspots. In this method, the accident critical value and accident rate for a section is

depending on entering of vehicle to the section during specific time period and accidents number occurred on that section at the same period of time.

Table.4.5: Identifying and Ranking blackspots locations by Rate Quality Control method.

location (Km)	Ave Acc/Km	Mj (Veh/y in Million)	Aj (Ave Acc/Year)	Rj (Acc rate in Million-Km-year)	Ra (Ave Acc rate) = $\sum (A_j / M_j)$	K Value ($\alpha = 10\%$)	RC (Critical value) = $Ra + K (\sqrt{Ra/Mj}) + 1/(2Mj)$	Comparison Rj and RC	Result
7	12	3.6792	12	3.262	2.002	1.280	3.082	$R_j > RC$	Blackspot
20	15	4.9056	15	3.058	2.002	1.280	2.922	$R_j > RC$	Blackspot
47	5	5.5188	5	0.906	2.002	1.280	2.864	$R_j < RC$	Not
62	5	3.6792	5	1.359	2.002	1.280	3.082	$R_j < RC$	Not
90	7	4.9056	7	1.427	2.002	1.280	2.922	$R_j < RC$	Not

Rc: Critical rate for a particular location (crashes per million vehicles or crash per million vehicle-km)

Ra: average crashes rate for all road location of like characteristics (crashes per million vehicles or crash per million vehicle-km).

K: Probability factor determined to be the level of statistical significance desired for Rc.

Mj: number of vehicles traversing particular road section (millions of vehicle-km) or number of vehicles entering particular intersection (millions of vehicles) during the analysis period.

Aj: is the number of accidents on section j during a certain time period.

Rj: is the accident rate on section j during that time period (not for all section).

4.4 Result by comparison of EPDO, APW and Rate Quality Control methods

By EPDO and APW methods five common from ten locations were included in blackspots but in Rate Quality control method only Km 7th and Km 20th were included. In EPDO and APW method the main considered factors were fatality, Injury and property damage but in Rate quality method the main factors which considered were number of accidents on specific section, period of time and entering of vehicle number to a specific section and the same specific time of period.

Table.4.6: Result by comparison of APW, EPDO and RQC Methods

Location (Km)	APW Rank	EPDO Rank	Rate quality Control Rank
7	2	3	Blackspot
90	3	4	Not
47	4	1	Not
62	5	2	Not
20	1	5	Blackspot

V. CONCLUSION

This study identifies the high crashes locations on the Kandahar – Spin Buldak highway in Afghanistan. High crash locations can be defined as any highway location which has a higher frequency of crashes compared to other roadway locations. The identification of road sections characterized by high risk accidents is the first step for any successful road safety management.

In this study, the hazardous locations (blackspots) are identified by the APW (Accident Point Weightage), EPDO (Equivalent Property Damage Only), and RQC (Rate Quality Control) methods. In the first step; APW and EPDO methods identified Km 7th, Km 20th, Km 47th, Km 62nd and Km 90th as blackspot locations on Kandahar –

Spin Buldak highway, however, integrating all three methods (RQC, APW and EPDO); the Km 7th and Km 20th are recognized as critical hazardous locations alongside this highway.

While practically and theoretically high number of crashes occur in locations where there is higher AADTs, surprisingly, this paper found critical blackspots locations alongside Km 7th and Km 20th segments of the highway (having almost equal and less AADT in comparison with 47th, 62nd and 90th Km).

The total number occurred crashes along highway were 347 cases with 412 vehicles damages only, 784 injuries and 311 fatalities. The feature of accident cases was increasing except year 2015 due to applied government

law enforcement on vehicle speeds and controlled the driver's license.

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Topography, irrigation, and histology of the thyroid gland of New Zealand rabbits (*Oryctolagus cuniculus* Linnaeus, 1758)

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Abstract—The objective of this study was to describe the topography, arterial irrigation, and microscopy of thyroid glands of thirty male specimens of New Zealand rabbits (*Oryctolagus cuniculus*). The aorta-thoracic system was analyzed by aorta thoracic cannulation and fixed in a 10% aqueous formaldehyde solution. Right and left lobes, and the isthmus of the thyroid gland were collected from only three rabbits for microscopic analyses. The procedure followed usual histological routine and histological sections were stained with Hematoxylin/Eosin. The thyroid gland consists of two flat, elongated lobes located ventrolateral to the trachea. Topographically, there is a close relationship between this gland and lateral surfaces of the first five tracheal rings, just below the cricoid cartilage and between the right and left common carotid arteries. The arterial supply to the thyroid gland in both antimers is performed by the thyroid artery, a branch of the common carotid artery. Following its origin at the level of the first tracheal ring, the thyroid artery continues in a caudocranial path. It reaches the cranial part of the thyroid gland and is divided into several branches that are distributed in this organ. The histological sections reveal that the cellular aspect of the isthmus region maintains the same organization and characteristics observed in the thyroid lobes. The thyroid gland in *Oryctolagus cuniculus* is small, consisting of two bilateral lobes united by an isthmus that presents glandular tissue.

Keywords— *Irrigation, Thyroid artery, Histology.*

I. INTRODUCTION

The endocrine system consists of several glands and tissues that secrete chemicals responsible for

controlling most biological functions. These substances are hormones that act on target tissues binding to specific receptors [1].

The thyroid gland was the first described endocrine gland. It is present in all vertebrates, is bilateral, and is attached to the trachea through a loose connective tissue [2].

In dogs, the thyroid gland has two lobes that lie on the lateral surface of the first six tracheal rings [3]. Miller (1979 [4], described the vertical and lateral location of the trachea on the cranial surface, ranging from the fifth to the eighth tracheal ring. A glandular isthmus connecting the caudal pole of each lobe may be present; this may be related to the consumption of iodine in the diet, or size of the dog [3]

Blood supply to the thyroid gland in dogs is from the cranial and caudal thyroid arteries [3-5]. Getty (1986) [3] reported that in bovine this gland is irrigated by the cranial and caudal thyroid arteries. The caudal thyroid artery is a small and inconstant vessel originated from the common carotid artery, caudally to the cranial thyroid artery.

Studies of topography and blood supply to the thyroid gland in domestic dogs Miller (1979 [4], Evans e la Hunta, (200) [5] and Rodrigues et al. (2016) and bovine are Getty (1986) [3] found in scientific literature. However, these studies have not been found for rabbits. Thus, the objective of the present study was to describe the topography, arterial irrigation, and histology of the thyroid gland of New Zealand rabbits (*Oryctolagus cuniculus*).

II. MATERIAL AND METHODS

Thirty male specimens of New Zealand rabbits (*Oryctolagus cuniculus* Linnaeus, 1758) were examined. These animals were property of the Animal Anatomy Laboratory of the Faculty of Veterinary Medicine of the Federal University of Uberlândia, Minas Gerais, Brazil.

The present study was approved by the Ethics Committee on the Use of Animals under the registration protocol CEUA/UFU 076/16).

The thoracic part of the aortic artery was isolated and filled with red latex through a small dorsoventral incision at the ninth intercostal space. The animals were then dosed with intramuscular, subcutaneous, and intravenous solutions of 10% formaldehyde and submerged in containers containing the concentration solution. A ventral midline incision, and two more transverse incisions were made for the dissections. The ventral midline incision was made radially across the mandibula and thyroid cartilage, extending to the cranial margin of the sternum bone. The transverse incisions were made at the levels of the cranial part of the thyroid cartilage and cranial margin of the sternum bone. The perioperative subcutaneous junctions were identified, allowing visualization of the topography and arteries that nourish the thyroid gland. An 8x magnifying glass was used to

better visualize the structures when necessary. The nomenclature adopted for the descriptions of anatomical structures is in agreement with [7].

The documentation was made by means of a digital camera (Nikon 18 mega pixels) and sketches depicting the origins and distribution of the vessels.

Histological processing was performed at the Laboratory of Cell Biology, Histology and Embryology of the Institute of Biomedical Sciences (DBHEM/ICBIM/UFU). The isthmus and lobes of the thyroid glands were collected from only three rabbits. The samples were fixed in a 10% formaldehyde solution for 72 hours, processed following usual histological routine and embedded in paraffin.—Histological sections (5µm) were stained in Hematoxylin/Eosin (H.E.) and analyzed by a histologist.

III. RESULTS

In New Zealand rabbits (*Oryctolagus cuniculus*), the thyroid gland is composed of two elongated flattened lobes located ventrolateral to the trachea. Topographically, there is a close relationship between the gland and the first five tracheal rings, immediately caudal to the cricoid cartilage and medially to the right and left of the common carotid arteries.

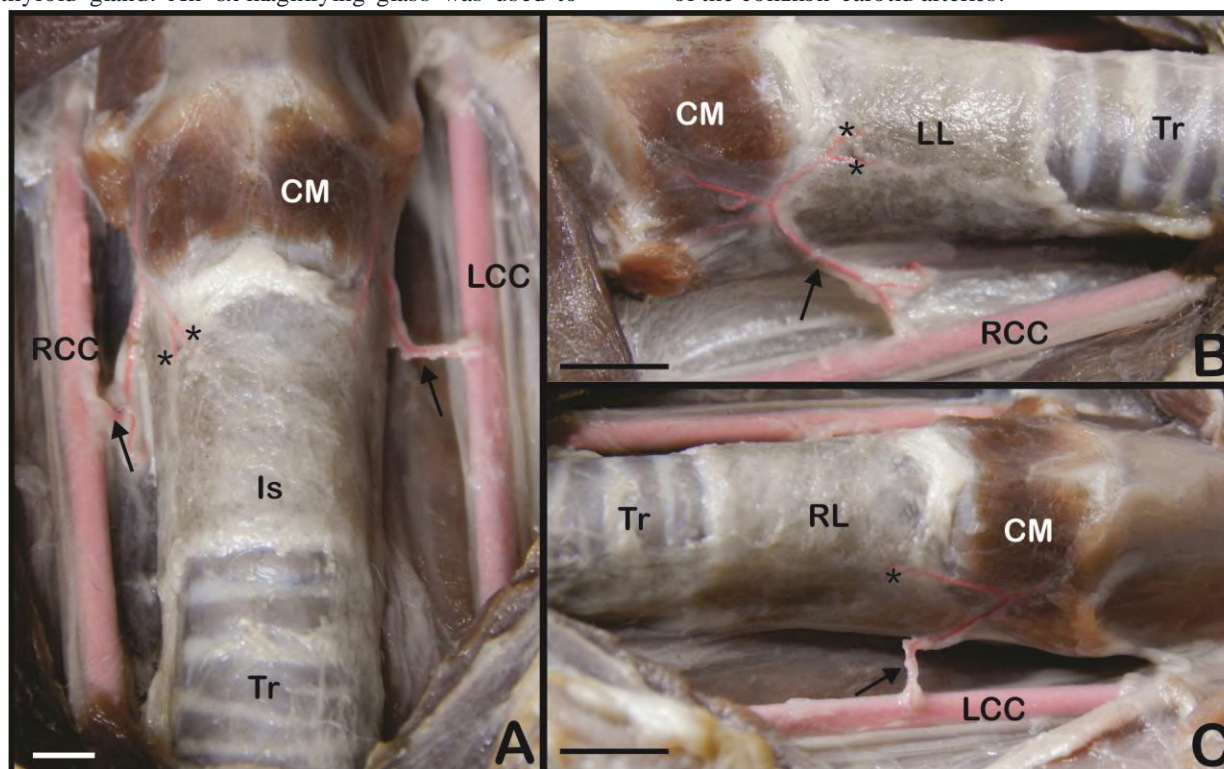


Fig. 1: Ventral view of the thyroid gland (A), right antimer (B), and left antimer (C) of New Zealand rabbits (*Oryctolagus cuniculus*). RCC = right common carotid; LCC = left common carotid; CM = cricothyroid muscle; Is = isthmus; RL = right lobe; LL = left lobe; TR = trachea. → thyroid artery; * thyroid artery branches. Bar: (A-C) 1 cm.

The arterial supply of the thyroid gland in both antimers is performed by the thyroid artery, a branch of

the common carotid artery (Figure 01). Following its origin, at the level of the first tracheal ring (Figure 02A-

F), the thyroid artery continues in a caudal cranial path and reaches the cranial part of the thyroid gland. Then, it divides into several terminal branches, ranging from three to ten. An irrigation pattern of the thyroid gland was found, however, in one of the specimens (3.33%), the

thyroid artery first reached the cricothyroid muscle and then passed through two ventral and dorsal branches to nourish the gland (Figure 02 D-F). In another animal (3.33%), the origin of the thyroid artery occurred from the ninth tracheal ring level (Figure 02 G).

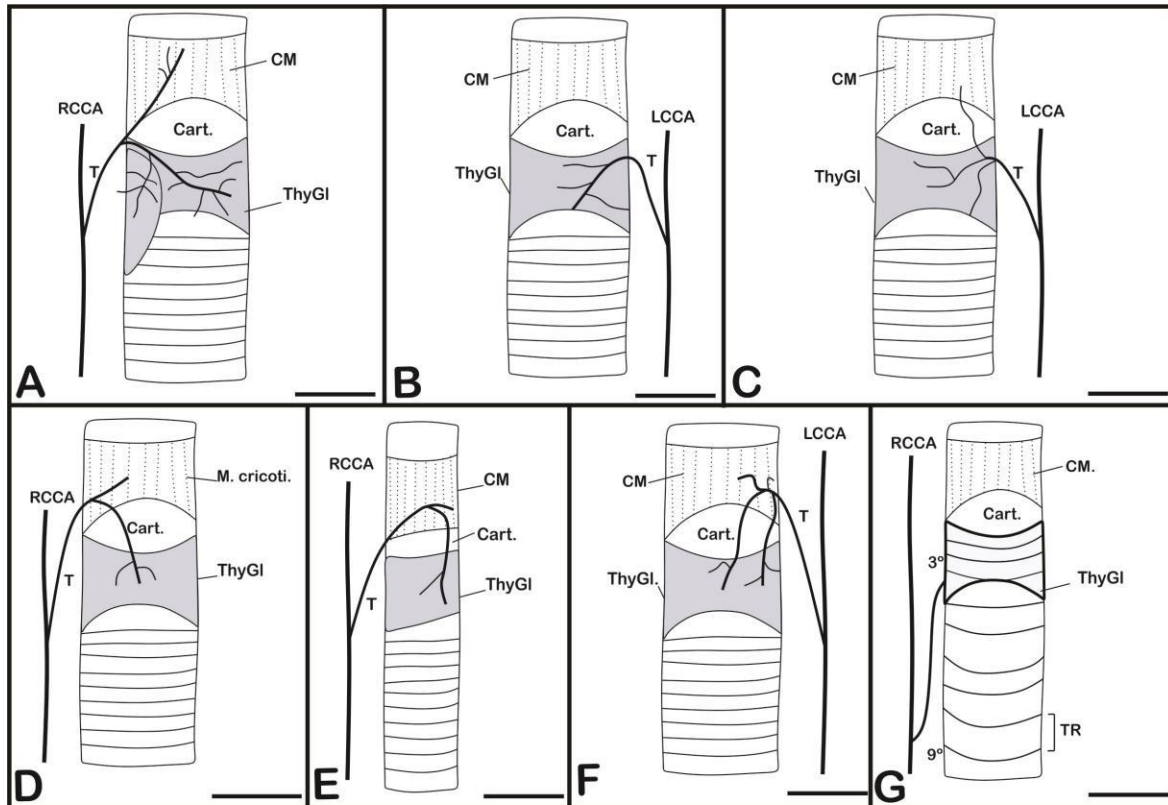


Fig. 2 Ventral view of the trachea (A, B, C, D, F, and G); Dorsal view of the trachea (E). RCCA = right common carotid artery; LCCA = left common carotid artery; Cart = cricoid cartilage; CM = Cricothyroid muscle; T = thyroid artery; ThyGl = thyroid gland; TR = tracheal ring. Bar: (A-G): 1cm.

The histological sections of the isthmus and lobes of thyroid glands presented glandular parenchyma consisting of thyroid follicles of varied sizes. Most of these follicles were filled with acidophilus amorphous secretion compatible with colloid. There were several groups of parafollicular cells and many unilocular adipocytes interspersed with the thyroid follicles. In the

focal area, some multilocular adipocytes were found permeated by unilocular adipocytes.

The histological sections of the isthmus of the thyroid gland revealed the presence of thyroid follicles permeated by unilocular adipocytes, as well as groups of parafollicular cells. The histological aspect of the isthmus region maintained the same organization and the same characteristics found in the thyroid lobes.

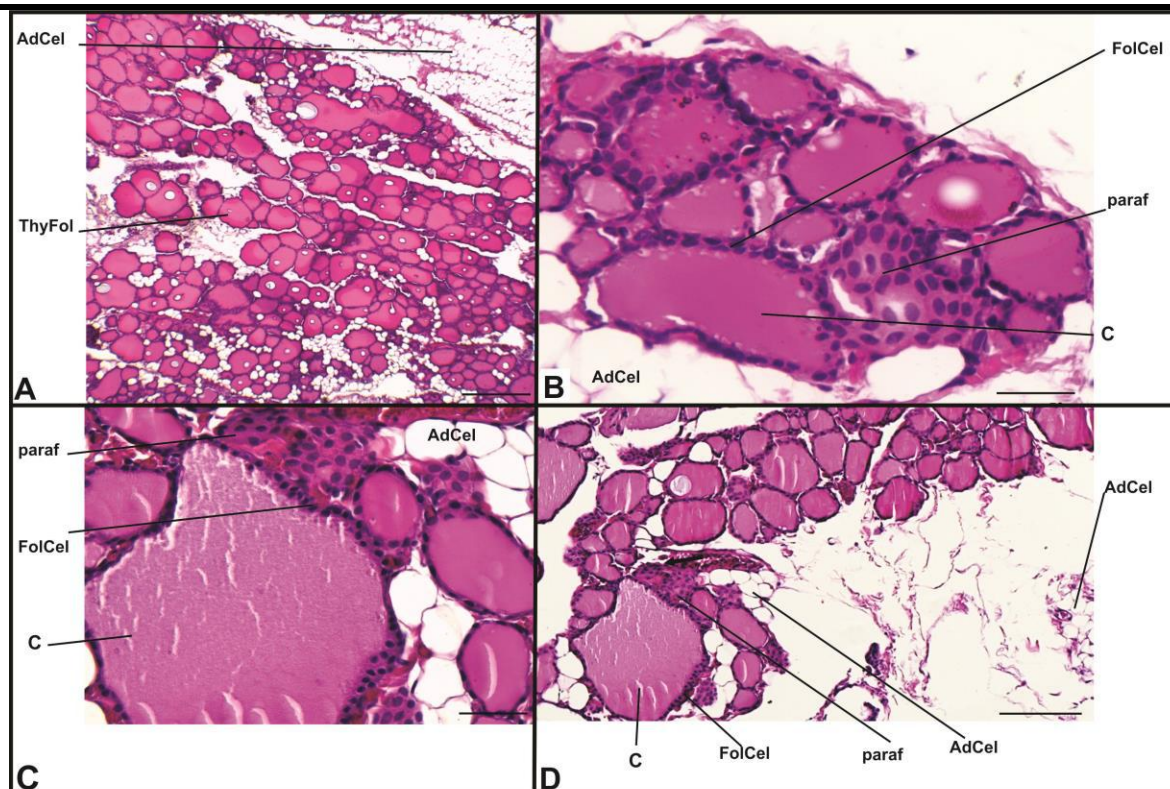


Fig. 3 Histological sections of the isthmus and lobes of the thyroid gland. Overview of one of the lobes (A); Lobe of the gland (B); Isthmus of the thyroid gland (C); Overview of the isthmus (D). C = colloid; AdCel = adipose cells; FolCel = follicular cells; paraf = parafollicular cells; ThyFol = thyroid follicle. Bar: (AD), 200 μ m; (BC), 50 μ m.

IV. DISCUSSION

The thyroid gland of New Zealand rabbits (*Oryctolagus cuniculus*) is smaller when compared to Santa Inês sheep and Saanen goats [8, 9]. Getty (1986) [3] reported that the reduced size of this gland in bovine might be related to the size and the diet of the animal.

The rabbit thyroid gland is located ventrolateral to the trachea, similar to dogs [4], domestic cats [10], and *Herpailurus yagouaroundi* [11], and dorsolateral to trachea in ruminants [12, 13]. It is constituted of two caudal lobes in goats [8, 9], and bovines [3].

In *O. cuniculus*, the irrigation of the thyroid gland occurs through only one artery called the thyroid artery. However, the thyroid gland of some species is supplied by cranial and caudal thyroid arteries, as observed in dogs [4,5,6], *Herpailurus yagouaroundi* [11], ruminants [12]. These studies reported that the cranial thyroid artery originates from a branch of the common carotid artery.

The caudal thyroid artery in dogs is derived from the brachiocephalic artery [4,5]. However, the caudal thyroid artery in bovines [3] and *Herpailurus yagouaroundi* [11] originates from the common carotid artery. Godino et al. (1987) [12] also found this result for bovine, and variable results for goats and sheep. Getty (1986) [3] reported that the caudal thyroid artery is a

small and inconstant vessel in bovine. In *O. cuniculus* there was no evidence of the caudal thyroid artery.

According to Carvalho et al. (2003) [11], the thyroid gland of *Herpailurus yagouaroundi* receives branches from the cranial thyroid and caudal thyroid arteries. According to Dyce et al. (2010) [13], this gland is supplied mainly by the cranial thyroid artery in ruminants. Bruni and Zimmerl (1947) [14] reported that the path of the cranial thyroid artery of pigs is towards the cranial pole, whereas the path of the caudal thyroid artery is towards the caudal pole of the gland, both are direct branches of the common carotid artery.

The caudal thyroid artery is inconstant in bovine [3] and in other ruminants [13]. In *O. cuniculus*, it is not present. Regarding the vessels that supply individually the lobes of the thyroid gland Dicy et al. (2010) [13] Bruni and Zimmerl (1947) [14], Sisson and Grossman (1947) [15] and Schwarze and Schroder [16], were not specific, but they reported that these lobes receive branches from the common carotid artery.

Histological analysis confirmed that the isthmus of the thyroid gland in New Zealand rabbits has the same organization and characteristics of the thyroid lobes. Thus, isthmus and thyroid lobes constitute a glandular tissue, according to [2].

Ellenberger and Baum, (1977) [17] reported that the isthmus has a parenchymal constitution in domestic

animals, confirming the results found for *O. cuniculus*. According to [9], the thyroid isthmus of goats has a fibrous constitution that joins the middle third of the right and left lobes of the thyroid gland. Contrastingly, the thyroid isthmus in bovine is glandular [3].

Dyce et al. (2010) [13] reported that the isthmus is not present in all individuals of small ruminants, but when present it is characterized as a simple connective tissue. Dukes (1999) [18] stated that the thyroid gland of most mammals has two lateral lobes that may or may not be connected by an isthmus. In *O. cuniculus*, the isthmus was found in all analyzed animals and it makes a connection between the cranial and caudal poles of the thyroid gland.

V. CONCLUSIONS

The thyroid gland of New Zealand rabbits (*Oryctolagus cuniculus*) is small, located ventrolateral to the trachea and is constituted of two bilateral lobes united by an isthmus that presents glandular tissue. Blood is supplied by the thyroid artery that originates from the common carotid arteries in both antimers and emits three to ten terminal branches.

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Effects Cytotoxic and Genotoxic of Aqueous Extract of Fennel (*Foeniculum vulgare* var. *vulgare* Mill.)

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Abstract— Fennel (*Foeniculum vulgare* Mill), originating in the basin of the Eastern Mediterranean and Caucasian, is now cultivated in many varieties selected by the sweetness and low concentrations of anethole, which allows consumption in salad dressings and condiments. Other varieties were selected to obtain high concentrations of essential oils and are used in folk medicine pharmaceutical industry. Despite the long history of application ethnomedicinal *F. vulgare*, no reports of serious side effects, several studies have shown that they can present cytotoxic and genotoxic activity. Therefore, this study aimed to analyze the cytotoxic and genotoxic effects of aqueous extract of fennel (*Foeniculum vulgare* var. *vulgare* Mill.), Prepared in 2%, 4% and 8%, compared to bioindicators (*Allium cepa* L. and *Mus musculus* L.). The aqueous extract of *F. vulgare* concentration of 2% cytotoxic effects caused significantly inhibiting mitotic division and genotoxic effects, providing chromosomal damage induced micronucleus formation in meristematic cells of *Allium cepa* L. In experimental animals in vivo genotoxic potential was found in cell bone marrow of mice. In this way, fennel tea should be consumed with moderations and medical care, especially for infants who have not yet developed the digestive tract, it may be harmful to health.

Keywords— Cytotoxicity, genotoxicity, *Foeniculum vulgare* var. *vulgare* Mill.

Key Contribution: In many homes in Brazil it is possible to find fennel, this in turn, is widely used in traditional Brazilian medicine indiscriminately, it is expected that from this publication encourage new research with this plant, since, it is notorious its toxic effects.

I. INTRODUCTION

Determined in 2009 by the Ministry of Health of Brazil as a herbal medicine for antiseptic use, from 71 medicinal plants, *Foeniculum vulgare* Mill, popularly known as fennel or fennel, in folk medicine is indicated, especially in relieving problems digestive, to eliminate gases, combat cramps and stimulate lactation (1). Botanical drugs are very complex sources of bioactive substances that can act on different “druggable” targets (2).

Although there are different nutritional values in different organs, upper parts are the most used for therapeutic and culinary purposes. Since pharmacological compounds are very volatile, such as anethole, estragole, trans-anethole and camphor, which give flavor and characteristic smell of fennel. In these compounds, the upper parts contain major metabolites such as flavonoids, coumarins, phenolic tannins and acids (3).

In foliar aqueous ethanolic extracts of fennel is extracted several phenolic compounds, and specifically in aqueous, phenolic acids are identified six (3-O-, 4-O- and 5-O-caffeoylquinic; acid The 1,3- - 1,4-O- and O-1,5-dicaffeoylquinic) three flavonoids (eriodictyol-7-Orutinósido, quercetin-3-Orutinósido and quercetin-3-O-glucuronide) and rosmarinic acid, all considered pharmaceutical interest (4).

Several pharmacobotanic work have demonstrated the medicinal efficiency of fennel, both to treat simple diseases (respiratory and digestive tract), and treat more complex diseases, such as cancers.

The common effects on diseases of the respiratory and digestive tracts can be explained by antispasmodic actions of volatile compounds that stimulate the contraction of smooth muscles of their bodies. Since the effects on tumor cells have been linked

to the action of caffeic acid 5-O-caffeoylquinic, that can display inhibition of cell growth, inducing cell cycle arrest in the G1 phase (3).

Researchers describe antifungal and antibacterial activities of aqueous leaf extract of *F. vulgare* on *Candida albicans* and *Staphylococcus aureus* (5).

A long history in etnomédica application without any reports of serious side effects, suggests that *F. vulgare* can be considered safe (6). However, no work described above on the phenotypic plasticity, which *F. vulgare*, can be provided for different concentrations of metabolic compounds according to the environment in which it is planted.

Several studies performed with *F. vulgare* from different geographical origins and different varieties indicate that the contents of estragole in fruits can vary from 2% to 86% and the trans-anethole from 0% to 89% (7). According to Simões *et al.* (1999), the environment in which the plant grows exerts great influence on production and the composition of the chemistry included in the essential oils (8). Temperature, relative humidity, duration of sun exposure and wind regime can have a direct influence, especially on species that have histological structures of oil storage on the leaf surface, such as *F. vulgare*.

According to Gross *et al.* (2009) compounds, phenylpropanoids, estragole and trans-anethole the main constituents of the upper parts of *F. vulgare*, and their concentrations can vary during plant development, but the greatest quantities of these compounds independent of the time is in the flowers and the fruits (9). Diaz-Maroto *et al.* (2006) examined 42 strains of *F. vulgare* different geographical areas of central Spain and found that the concentration of the major volatile component, trans-anethole, presented phytochemical variability in the locale (10).

Phytochemical phenotypic plasticity and failure to identify varieties is likely to be a major cause of disputes found in the scientific literature regarding the toxic effects of *F. vulgare*.

In acute toxicity tests *F. vulgare*, Ostad *et al.* (2001) determined the median lethal dose (LD50) of 1,326 mg/kg, with the occurrence of prostration, sedation, respiratory discomfort, movement disorder, apathy to external stimulation, weakness, tremors and fasciculations in the dorsal muscles of the guinea pigs during the first 24 hours of treatment (11).

The Unified Health System (SUS), said in its medicinal plant program publications Central medicines (CEME) that *F. vulgare* is toxic in preclinical toxicology studies (Brazil, 2006).

Detection of potentially cytotoxic and genotoxic substances and their likely effects on organisms, it is important in the sense of the impact that they can bring to people, animals, plants and humans.

Considering the wide use of *F. vulgare* in Brazilian folk medicine and in cooking; and little information on their potential cytogenotoxic and genotoxic effects, the use of bioassays are needed to provide reliable information to the public.

Thus, this study aimed to assess and verify the cytotoxic effects and genotoxic effects of aqueous leaf extract *Foeniculum vulgare* var. *vulgare* Mill. on bioindicators.

II. RESULTS AND DISCUSSION

2.1 System Test plant

In Table 1, it appears that aqueous leaf extract of fennel to 2%, relative to the CN, significantly inhibited mitotic division of meristematic cells of *A. cepa*, as the analyzed index (IMT, IP, IM, IA, IT) demonstrated in this way possible to prepare substances extracted in the aqueous extract can be actuated by inhibiting the cell cycle. One possible explanation for this result could be the action of various phenolic compounds found mainly in parts of areas *F. vulgare*, such as those derived caffeoylquinic, 3-O-caffeoylquinic acid, 4- and 5-O-caffeoylquinic (12, 13); and according to Krizman *et al.* (2007), they can be easily extracted from the preparation of the aqueous extract of fennel (4).

Table.1: Mean values of Mitotic indices (IMT) prophase (IP) of metaphase (MI) of anaphases (IA) and the telophases (IT) of negative control (NC), positive control (PC) and treated with aqueous extract of *Foeniculum vulgare* var. *vulgare* Mill. to 2%.

Treatments	IMT	IP	IM	IA	IT
CN	0.549	0.293	0.110	0.071	0.036
2% *	0.025	0.015	0.014	0.002	0.004
CP	0.023	0.017	0.020	0.009	0.007

* (P < 0.01)

With respect to IMT, IP, IM, IT IA and the control group (1% glyphosate), it was found that the aqueous extract of fennel 2% showed similar results (p > 0.05) in reference to inhibition of cell cycle.

According to Zablotowicz and Reddy (2004), glyphosate mechanism of action is rather unique because it is the only herbicide capable of specifically inhibiting the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), which catalyzes the condensation of shikimic acid and pyruvate phosphate, thus preventing synthesis of three essential amino acids - tryptophan, phenylalanine and tyrosine, which are precursors of phenolic compounds (14).

In specific literature allelopathy, there are several studies that show the phenolic compounds act affecting the germination and growth of plant species test, by

interfering with cell division, enzymatic activation, and membrane permeability (15-19).

The cytotoxic activity of fennel was verified studies Tanira *et al.* (1996), in which the authors found a significant decrease in significant IMT in animal testing system of mice, indicating a significant antimitotic activity, furthermore, the ethanolic extract of the fruits of the plant at doses of 0.5, 1.0 and 3.0 g.kg⁻¹ administered orally, did not cause any deaths in mice (20).

Apart from causing potential cytotoxic effects of the substances extracted in the aqueous extract of fennel 2% promoted damage on the chromosomes, inducing the formation of micronucleus (0.25%) in total analyzed blades, the roots of *A. cepa* (FIGURE 1). Other chromosomal abnormalities were observed, probably the small number of cells in the mitotic division in this concentration (TABLE 1).

With regard to the percentage changes found, the CP group (1% glyphosate), who has caused the largest percentage of damage to chromosomes (0.87%) significantly different from the other treatments studied, as expected ($p < 0.05$). Similar results were also observed by Souza *et al.* (2010) (21).

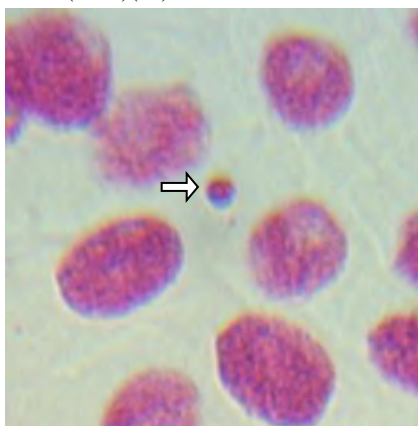


Fig.1: Micronucleus (arrow) in meristem cells of *Allium cepa* treated with aqueous extract of *Foeniculum vulgare* var. *vulgare* Mill. to 2%. total increase of 1000 \times .

The micronuclei usually result in production or acentric chromosome fragments entire chromosomes in which lag anaphases. When the cell enters telophase, these are included in the daughter cells.

Was one of the first investigators who demonstrated the relevance of tinea system strain for the assessment of cytotoxicity and genotoxicity of organic substances, claiming the cells of roots strain have an important system of enzymes necessary for the activation of mutagens (22).

The same author also demonstrated that the sensitivity of the *Allium* test is on par with other systems, such as algae or human lymphocytes. In the case of mercury toxicity test, *Allium* test, demonstrated similar values to the test performed in humans in vivo (22).

Currently several studies have proven the test efficiency *A. strain* for monitoring the cytotoxic and

genotoxic effects of various organic substances (23) Çelik and Aslantürk, 2010; (24-26), as observed in the present study with aqueous extract of *Foeniculum vulgare* in 2%.

2.2 Animal Testing System

The results within and between groups were analyzed by ANOVA and Tukey test ($p < 0.05$) for comparison of means. After analysis it was found that there was a significant difference in the mean micronuclei (MN's) of the treatments tested for the groups CN and CP. Among the averages MN's concentrations of 4% and 8%, there was no significant difference, but the same were significantly higher than the average of the CN group to 2%; and smaller, as expected, that the CP, showing, in this way, the average number NM increased as the concentration increased the aqueous leaf extract *Foeniculum vulgare* Mill (TABLE 2).

Table.2: Total and mean number of micronuclei (MN's) erythrocytes in mice (*Mus musculus* L.) induced by treatment of the aqueous leaf extract *Foeniculum vulgare* var. *vulgare* Mill.

Repetition	Treatments				
	CN	2%	4%	8%	CP
I	1	11	34	33	68
II	3	13	19	29	57
III	3	8	27	27	70
IV	2	13	30	39	64
Averages	2.25	11.25	27,50ns	32,00ns	64.75
	*	*			*

* Significant difference at 1% probability by Tukey

ns - there is no significant difference

These results indicate that the aqueous extract of fennel, at the concentrations tested, have potential clastogenic to promote chromosomal damage or damage to the mitotic apparatus in the formation of erythroblasts in bone marrow of mice.

The NRBC mammalian Extrude its core in the terminal stage of maturation, which are subsequently phagocytized by macrophages. However, when the nuclei of erythroblasts DNA is damaged by clastogenic substances are formed and remain micronuclei in polychromatic erythrocytes and are readily identified after staining (FIGURE 2).



Fig.2: Micronucleous (arrow) in mice erythrocytes (*Mus musculus* L.) gives Swiss strain exposed to aqueous extract of *Foeniculum vulgare* var. *vulgare* Mill. in 8% (500 mg.kg^{-1}) orally single dose. Total increase of $400\times$.

Regarding the presence of many active biological constituents in *Foeniculum vulgare*, Devika and Mohandass (2014), studied the apoptotic activity of the crude extract methanolic fennel leaves in cell lines of cervical cancer (HeLa)(27). Induction of apoptosis was determined by analysis of DNA fragmentation in cervical cancer cells treated with active fraction of the crude methanol extract using agarose gel electrophoresis. The DNA fragmentation was observed at different concentrations of the extract and morphological features of apoptosis bodies were observed in a concentration of $125 \mu\text{g.ml}^{-1}$ extract. The results suggested *F. vulgare* could probably induce apoptosis in cell lines of cervical cancer and inhibit cell proliferation by DNA fragmentation.

DNA fragmentation was also verified in the present study through the micronucleus test in mice erythrocytes (FIGURE 2 AND TABLE 2).

Tang and Edenharder (1997) showed that the fennel leaves extracts show moderate activity mutagenic in strains of *S. typhimurium* TA98(28).

Sharopov et al. (2017) found the cytotoxic effect of essential oil *F. vulgare* various cancer cell lines, HeLa (human cervical cancer), Caco-2 (human colorectal carcinoma), MCF-7 (human breast adenocarcinoma), CCRF-CEM (human T lymphoblast leukemia) and CEM / ADR5000 (adriamycin resistant leukemia). The researchers show that the essential oil is rich in *F. vulgare* lipophilic secondary metabolites, which can easily cross cell membranes by diffusion and react with free amino groups of amino acid residues of proteins or nucleotides of DNA, forming Schiff bases(29).

Mirfendereskiet et al. (2012) found the toxic effects of decoctions of fennel seeds traditionally used in Iran as a herbal remedy(30). The genotoxicity and cytotoxicity was assayed in vitro using *Allium cepa* L. roots and human cells. The decoctions seeds were prepared in the traditional method commonly used in Iran (DC) to 10 times concentration (10C). Although both extracts have decreased IMT cells nose root of *A. cepa* L., only 10C extract significantly increased chromosomal aberrations. Furthermore, dilutions 1:30, 1: 62.5, 1: 125

and 1: 250 10C 100% extract were cytotoxic to human lymphocyte cells, however, to extract the DC only showed 1:30 dilution cytotoxic effects.

Several studies suggest beneficial effects and adverse *F. vulgare* in relation to this work, such as effects antioxidants and anti-clastogenic(31-34) however, all these studies were performed with essential oil, whose substances are not extracted in aqueous and alcoholic extracts and / or seeds.

One of the great controversy with ethnomedicinal studies are related to species identification difficulties and / or varieties that may present physiological phenotypic plasticity of secondary metabolites in addition to the main problem, which is the study of crude extracts, which do not indicate what substances are really bioactive and in what concentrations they act.

Pimenov and Leonov, (2004) reported that there are some morphologically similar species to *F. vulgare*, which make it difficult to identify(35). Simoes et al. (1999) report the *Foeniculum vulgare* Mill similarity between *Pimpinella anisum* L. and which are commonly known as fennel(8).

Fennel originated in the basin of the Eastern Mediterranean and Caucasian, is now cultivated in many varieties (36) selected by the sweetness and low concentration of anethole, which allows consumption in salads. Other varieties were selected to obtain high concentrations of essential oils and are used for perfumery and for the production of flavorings.

By way of exemplification we present some variety: *Foeniculum vulgare* Mill. subsp. *vulgare* var. *azoricum* (Mill.) Thell; *Foeniculum vulgare* Mill. subsp. *vulgare* var. *dulce* (Mill.) Batt.; *Foeniculum vulgare* Mill. var. *azoricum* (Miller) Thell.; *Foeniculum vulgare* Mill. var. *Juice* ALCF.; *Foeniculum vulgare* Mill. var. *Duke* Alef.; *Foeniculum vulgare* Mill. var. *duke* Batt. & Hold.; *Foeniculum vulgare* Mill. var. *Duke* (Mill.) Battand. & Trabut and *Foeniculum vulgare* Mill. var. *salivum* Presl.

Despite the long history of application ethnomedicinal *F. vulgare*, no reports of serious side effects, the present study and other above, one can not consider it a safe species, particularly for infants who do not have the digestive tract developed. However, the diverse and proven pharmacological activities *Foeniculum vulgare* show there is still a huge scope to chemical exploration.

In many homes in Brazil it is possible to find fennel, this in turn, is widely used in traditional Brazilian medicine indiscriminately, in several places is also consumed as food, it is expected that this document will awaken several researchers to deepen their knowledge regarding this plant.

III. MATERIAL AND METHODS

3.1 Collection of botanical material

Parties flights *Foeniculum vulgare* var. *vulgare* Mill. (Stems and leaves) were collected at the site of medicinal plants of the Center for Biological Studies - UNEC (19 ° 47 '23 "S, 42 ° 08' 21" W), in May, the morning in shaded conditions. Immediately after collection, the upper parts were packed in sterile plastic bags and brought to the lab pharmacobotanics UNEC to prepare the aqueous extract, the sample specimen is deposited in the UNEC-0305042016 * and was identified by.

3.2 Preparation of the aqueous extract of fennel

The aqueous extract was prepared according to popular Brazilian ethnobotany 20g of fresh leaves in 1L of boiled water, making up the extract at 2%, after reaching room temperature Later, using the same methodology, the extracts a4% and 8%, aiming the determination of the dose response relationship.

3.3 System test plant (*Allium cepa* L.)

Experimental units composed of 8 repeats of bulbs of similar size and weight, A. *strain* newly rooted were placed for 24 hours in distilled water (negative control - CN), the concentration of the aqueous extract of fennel commonly used by people (2%) and glyphosate in a 1% solution (positive control - CP). Posteriormente, the roots of approximately 5 mm were collected and fixed in Carnoy and stained in Schiff reagent. 2.000 meristematic cells were analyzed on 5 plates per treatment were determined and the mitotic index (IMT) prophase (IP) of metaphase (MI) of anaphases (IA) and the telophases (IT) per slide. All meristematic cells of all slides per treatment were analyzed to check alterações cromossômicas (37).

It took only the concentration of the extract to 2%, this test system, because it did not occur cytotoxic and genotoxic changes, the test animal's system would not be realized, avoiding in this way the use of guinea pigs.

3.4 System Test Animals (*Mus musculus* L.)

mice were used in the Swiss strain, Adults with an average weight of 28g. The animals spent 6 days adjustment period, with water and food ad libitum commercial environment with a photoperiod of 12h light and 12h dark, average temperature of 23 °C mice Groups of 4 rats were treated with aqueous extracts of fennel, orally, in acute treatment, the three experimental concentrations (2%, 4% and 8%). For the negative control (NC) was used distilled water and the positive control (PC) was used cyclophosphamide, 24 hours before euthanasia. The genotoxicity was evaluated by counting all erythrocytes micronuclei (MN) in the bone marrow smears from each femur in each treatment, comprising two blades repeats (38).

All solutions (extracts, CN and CP) were administered by gavage a single dose of 50mg/kg, introducing special needle through the mouth into the stomach of the animal, and the like via the accidental or intentional ingestion of the test substance. This research is duly authorized by the CEP/UNEC.

3.5 Statistical analysis

The experimental design for each evaluation test system was randomized (DIC) using variance analysis method (ANOVA) and subsequent Tukey test for the comparison of averages, at 5% probability.

IV. CONCLUSIONS

- The aqueous extract of *Foeniculum vulgare* var. *vulgare* Mill. At a concentration of 2% cytotoxic effects caused significantly inhibiting mitotic division and genotoxic effects, providing chromosomal damage induced micronucleus formation in meristematic cells of *Allium cepa* L.
- *Foeniculum vulgare* var. *vulgare* Mill., in the vivo experimental model used, it shows genotoxic potential in bone marrow cells of Swiss strain mice.
- The fennel tea should be consumed with moderations and medical care, especially in infants, it may be harmful to health.

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The Eng. Kevim Corkum

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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Antimicrobial activities of *Irvingia gabonensis*

Leaf against diarrhoea Causing Agents

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Abstract—Antimicrobial effect of *Irvingia gabonensis* leaf extracts was tested against bacteria and fungal agents that causes diarrhoea (*Salmonella typhi*, *E.coli*, *Staphylococcus aureus*, *Shigella dysenteriae* and *Candida albicans*). Fresh tender leaves of *Irvingia gabonensis* was collected, air-dried, grounded and soaked in n-hexane, methanol and aqueous solvents. The Antimicrobial activities were determined using agar well diffusion assay, then the MIC, MBC and MFC were determined by agar dilution assay. The results revealed that the crude methanol and n-hexane extracts of *Irvingia gabonensis* produced the highest antifungal effects against *Candida albicans* with the MIC of 25 mg/ml and MFC of 50 mg/ml. The crude aqueous extract of *I.gabonensis* had no antifungal activity on *Candida albicans*. The crude methanol extracts of *Irvingia gabonensis* produced the highest antibacterial effects with MIC ranged of 6.25 mg/ml to 25 mg/ml and MBC of 12.5 mg/ml to 50 mg/ml. These results suggest that *Irvingia gabonensis* leaf extract is recommended as a diarrhoea disease remedy.

Keywords— Antimicrobial activity, *Irvingia gabonensis*, diarrhoea.

I. INTRODUCTION

The search for newer sources of antibiotics is a global challenge pre-occupying research institutions, pharmaceutical companies, and academia, since many infectious agents are becoming resistant to synthetic drugs (1). Emergence of resistant strains of pathogenic microorganism has also continued to pose a major health concern about the efficacy of several drugs, most importantly antibiotics in current use (2). The importance of herbs in the management of human ailments cannot be over emphasized.

It is clear that the plant kingdom harbours an inexhaustible source of active ingredients invaluable in the management of many intractable diseases. Furthermore, the active components of herbal remedies have the advantage of being combined with other substances that appear to be inactive. However, these complementary components give the plant as a whole a safety and efficiency much superior to that of its isolated and pure active components (3).

Irvingia gabonensis (Ugiri) is a genus of African and south-east Asian trees in the family Irvingiaceae. Other names commonly attributed to it are Wild Mango or Bush Mango (4). In Nigeria, where both the seeds are well consumed, it is commonly called Ugiri or Ogbono by Igbo (5), Mbukpabuyo by the Efik and Ibibo, Aapon by the Yoruba, Ogwi by the Benin area, Apioro by the Deltians and Goronor by the Hausas (Oral communication). The genus, *Irvingia* comprises of seven species which include *Irvingia gabonensis*, *Irvingia excels*, *Irvingia gradifolia*, *Irvingia malayaria*, *Irvingia giorobur*, *Irvingia smithii* and *Irvingia wombolu* (6). The plant *Irvingia gabonensis* bears edible mango- like fruits, and is especially valued for their fat and protein rich nut (7). Ethno medicinal treatments utilize the bark, kernels, leaves, or roots for a variety of ailments (8). The bark is mixed with palm oil for treating diarrhoea and for reducing the breast-feeding period. The shavings of the stem bark are consumed by mouth to treat hernias, yellow fever, and dysentery, and the boiled bark relieves tooth pain. Also, in certain parts of Africa, the bark extract is ingested to produce an analgesic effect (9). The seed have been found to reduce fasting blood glucose levels in obese subjects (10). The powdered kernels act as an astringent and are also applied to burns (5). The stems of the tree have been used as chewing sticks to help

clean teeth(11). In Nigeria and Cameroun, the seeds of *Irvingia gabonensis* are used as a condiment in soup(12). Preliminary phytochemistry screening of the aqueous leaf extract of *Irvingia gabonensis* revealed the presence of saponins, tannins, phenols and phlobatanins. It has been reported that saponins are of great pharmaceutical importance because of their relationship to compounds such as the sex hormones, diuretics, steroids, vitamins D and cardiac glycosides(13).

Antimicrobial is a substance that acts to inhibit the growth of harmful microorganisms or acts to destroy them, such as bacteria, virus, fungi, and protozoa. The discovery and development of antibiotics are among the most influential and successful achievements of modern science and technology for the

control of infectious diseases. However, the rate of resistance of pathogenic microorganisms to conventionally used antimicrobial agents is increasing with an alarming frequency (14,15 and 16).

However, the past record of rapid, widespread emergence of resistance to newly introduced antimicrobial agents indicates that even new families of antimicrobial agents will have a short life expectancy while there are some advantages of using medicinal plants, such as often fewer side effects, better patient tolerance, relatively affordable treatment, profound therapeutic benefit, acceptance due to long history of use and being renewable in nature. For these reasons, researchers are increasingly turning their concentration to herbal products, looking for new leads to develop better drugs against multiple drug resistant microbial strains. Herbal medicine is still the stronghold of about 75-80% of the whole population, and the major part of traditional therapy involves the use of plant extract and their active constituents (17).

In the work of Unaeze et al [18] they observed that the inhibitory action of the plant extracts could be attributed to the presence of the phytochemical constituents in the plant extracts such as alkaloid, flavonoid and saponin.

The objective of the study was to determine the antimicrobial activity, minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC) and minimum fungicidal concentration (MFC) of this plant extract on the tested organisms causing diarrhoea.

II. MATERIALS AND METHODS

2.1 Plant collection:

Irvingia gabonensis leaf was collected from Lilu town in Ihiala L.G.A of Anambra State, Nigeria in March, 2017. The plant was identified and authenticated in the Department of

botany, Nnamdi Azikiwe University, Awka Nigeria where the sample was deposited. The leaf spread out and dried on a clean surface under a shade at room temperature to exclude direct Sunlight in order to prevent the active constituents of the leaf from being degraded due to photochemical reactions. It was air dried for about eight days after which, the dried leaves were gathered, and crushed with grinder. The powder was weighed using an electric weighing balance by Kern ALS 220 – 4. The powder was then stored in an air tight bag at room temperature and used for further extraction.

2.2 Preparation of plant extract

The ground leaf was prepared in three ways to get the extracts.

2.2.1 Aqueous extract (Maceration Method)

Maceration method was used for aqueous extraction and powdered leaf of *Irvingia gabonensis* was used. Then, 150 g of the plant was weighed and put in 375 ml of distilled water and allowed to stand for 48 hrs, agitate or shake for 45 mins. The extract was filtered using British standard mesh filter and first muslin cloth and concentrated by using air drying under constant air current and water bath at 50 °C. The extract was then transferred into a clean container and stored in the refrigerator at -4° C for 10 days, until required for use.

2.2.2 Organic solvent extraction by maceration

This was carried out at Pharmacognosis Department, Faculty of Pharmaceutical Sciences, Agulu. Then, 150 g of the plant leaf powder was transferred into 1000 ml volumetric flask, then 375 ml of solvent (methanol and n-hexane) were added. This was covered and allowed for 48 hrs with continuous shaking, filtered and transferred to rotary evaporator for concentration. The extract was then transferred into a clean container and stored in the refrigerator until required for use.

2.2.3 Extraction by Soxhlet method

This method was carried out by continuously extracting a sample with a non polar organic solvent (hexane) for about 4-6 hrs.

2.3 Antimicrobial Screening of Plant Extracts.

From the stored extract in the refrigerator, the concentrated aqueous extract of the plant was weighed 1200 mg of extract (1.2 g) as the stock. The extract was dissolved in 3 ml of distilled water to obtain 400 mg /ml as our interest. This was done for aqueous extract of the plant.

1200 mg (1.2 g) of methanol and n-hexane extracts of the plant were weighed and dissolved in 3 ml of DMSO to make a concentration of 400 mg /ml.

2.3.1 Control Organisms used for Antimicrobial screening of Plant.

Standard organisms were used for the antimicrobial / antifungal sensitivity testing.

Four of these organisms were typed organisms and were collected from Department of Pharmaceutical Microbiology, Faculty of Pharmaceutical science, Agulu, Nnamdi Azikiwe University. The organisms were subcultured in different selective media for colony morphology confirmation of the typed organisms. All the organisms were re-confirmed through biochemical tests: catalase, coagulase, motility, indole, urease and Triple sugar iron agar (TSI).

<i>Salmonella typhi</i>	NCTC 10950
<i>E.coli</i>	NCTC 10418
<i>Staphylococcus aureus</i>	NCTC 6571
<i>Shigella dysenteriae</i>	ATCC 14420
<i>Candida albican</i>	

These organisms were control organisms and were stored in agar slants in a refrigerator at 2-4°C until used.

Prior to use, these organisms were sub-cultured on Nutrient agar plates, or Sabouraud dextrose agar plates at 37°C for 24 h.

2.3.2 Determination of Susceptibilities of Organisms to Crude Extract

Prior to testing, each organism was sub cultured from the nutrient agar slope (storage system) into a nutrient agar plate. This was incubated at 37°C for 24 hrs. After 24 hrs incubation, a colony of each tested organism was inoculated into 5 ml of sterile Nutrient broth and incubated at 37°C for another 24 hrs. Thereafter, turbidity was checked.

The turbidity was adjusted to 0.5 Macfarland standard and diluted to obtain a final turbidity in approximately 1×10^8 cfu / ml. The agar diffusion method was employed for this procedure.

Muller Hinton agar was used for bacteria while Sabouraud dextrose agar was used for fungal cultivation. These media were sterilized in an autoclave at 121°C (15 lbs pressure) for 15 min before use. Petri dishes were sterilized in a hot air oven at 175°C for 1 hr and was labelled appropriately.

2.3.3 Agar Diffusion Method:

From the first concentration (400 mg /ml) that was gotten from the stock i.e 1200 mg extract dissolved in 3 ml, further doubling dilution was prepared to give 1:200, 1:100, 1:50, 1:25, 1:12.5, 1:6.25, 1:3.125. Then, 0.1 ml of broth culture of each tested organism or fungi was placed at the centre of a sterilized petri dish and 20 ml of prepared Muller Hinton Agar or Sabourand's dextrose agar poured into it. The dish was swirled gently to ensure even distribution of the bacteria or fungi and the mixture was then allowed to gel. When gelled, six wells of 7 mm in diameter were bored in

each petri dish using a sterile cork borer and each well was labeled appropriately for each crude extract or dilution of crude extract, the wells were carefully filled with 2 drops of a 2 ml pipette of both stock solutions(crude extract) and different dilutions of the extract, which is equivalent to 0.04 ml starting with the highest dilutions, the control drugs were added. DMSO, Methanol and conventional antibiotic (ciprotab) were used as controls. Ciprotab was used at a concentration of 200 mg/ml. This was achieved by dissolving 500 mg of the tablet in 2.5 ml of sterile water. The plates were kept for 30 mins on the bench for diffusion of the extract to take place before incubation. The dishes were incubated at 37°C for 24 hrs and observed for inhibition. The fungi were inoculated in Sabourand dextrose agar and incubated at room temperature (25°C) for 24 - 48 hrs. The zones of inhibition were measured and the results noted. This was done for aqueous, n-hexane and methanol extracts of the plant in the tested organisms. The whole process was repeated in triplicate.

3.3.4 Agar Dilution Method:

Then, 1200 mg /ml(1.2 g) of the extract each was weighed as stock solution, Muller Hinton agar and Sabourand dextrose agar was prepared. Then, using formula:

$$C_1 V_1 = C_2 V_2$$

Because we want to get 400mg /ml as first dilution.

Where ,

C_1 = Concentration of stock (1200 mg/ml)

V_1 = Unknown

C_2 = 400 mg / ml (our interest)

V_2 = Final volume of agar to prepare (5 ml)

It was allowed to gelled, the petri dish was divided, then from the adjusted 0.5 Macfarland broth culture of tested organism, with a loopful of diluted tested organism was streak with wireloop on top of the gelled mixture of extract and agar. Incubated at 37°C for 24 h for bacteria and at room temp for fungi. Observed for growth or absence of growth.

Presence of growth was indicated using positive (+) sign or negative (-) sign. From here, the tentative minimum inhibitory concentration (MIC's) was obtained, that was the last or minimum dilution of the extract which inhibits the visible growth of organisms. Also the tentative minimum bactericidal concentration (MBC) was obtained, that was the last or minimum dilution of the extract in which there was no growth after subculture onto fresh media. These were indicated using (-) sign.

3.3.5 Minimum Bactericidal Concentration (MBC)

From the tubes showing no visible sign of growth in MIC determination, test microorganisms were inoculated onto sterile nutrient agar plates by streak plate method. The plates

were then incubated at 37°C for 24 hrs. The least concentration that did not show growth of test organisms after subculture was considered as the MBC.

III. RESULTS

Results of fig 1 to 3 showed the antimicrobial activities of crude n-hexane, methanol and aqueous extracts of *Irvingia gabonensis* against test organisms. In Fig 1, Methanol crude extract of *Irvingia gabonensis* exhibited higher mean \pm standard deviation (22 \pm 1) zone of inhibition against *Shigella dysenteriae* at 400 mg/ml concentration. Methanol and n-hexane crude extracts of *Irvingia gabonensis* exhibited antifungal activities against *Candida albicans* (10.0 \pm 1.0 and 12.0 \pm 1.0 respectively). In Fig 2, N-hexane crude extract of *Irvingia gabonensis* had no effect on *E.coli* and *Salmonella typhi* (0.0 \pm 0.0). In Fig 3, Aqueous crude extract of *Irvingia gabonensis* had no antifungal activity (0.0 \pm 0.0).

Table 1 shows the minimum bactericidal and fungicidal concentration (MBC_s/MFC_s) of different extracts of *Irvingia gabonensis* on test organisms. The Aqueous extract show that the MIC of *E.coli* was 25 mg/ml with MBC of 50 mg/ml, the MIC of *Shigella dysenteriae* was 25 mg/ml with MBC of 50 mg/ml. The Methanol extract of *Irvingia gabonensis* also show that the MIC of *S.aureus* was 12.5 mg/ml with MBC of 25 mg/ml, MIC of *E.coli* was 6.25 mg/ml with MBC of 12.5 mg/ml, MIC_s of *Shigella dysenteriae* and *Salmonella typhi* were 6.25 mg/ml with MBC_s of 12.5 mg/ml. *Candida albicans* had MIC of 25 mg/ml with MFC of 50 mg/ml. The n-hexane extract of *Irvingia gabonensis* also show that the MIC of *Candida albicans* was 25 mg/ml with MFC of 50 mg/ml. The MIC_s of *S.aureus* and *Shigella dysenteriae* were 25 mg/ml with MBC_s of 50 mg/ml.

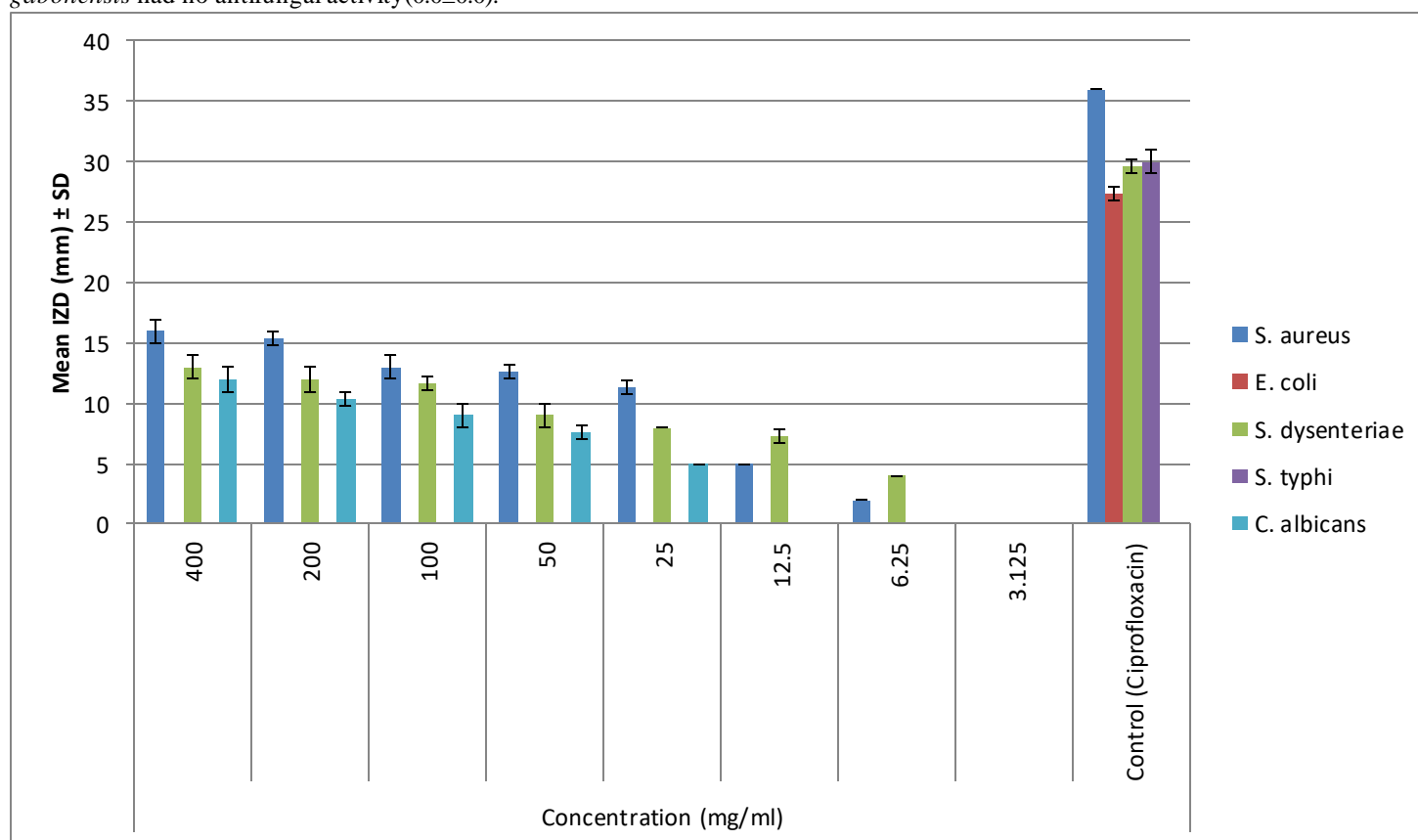


Fig 1: Antimicrobial activity of the crude n-hexane extract of *Irvingia gabonensis* leaves showing the mean inhibition zone diameters and standard deviation produced against test organisms.

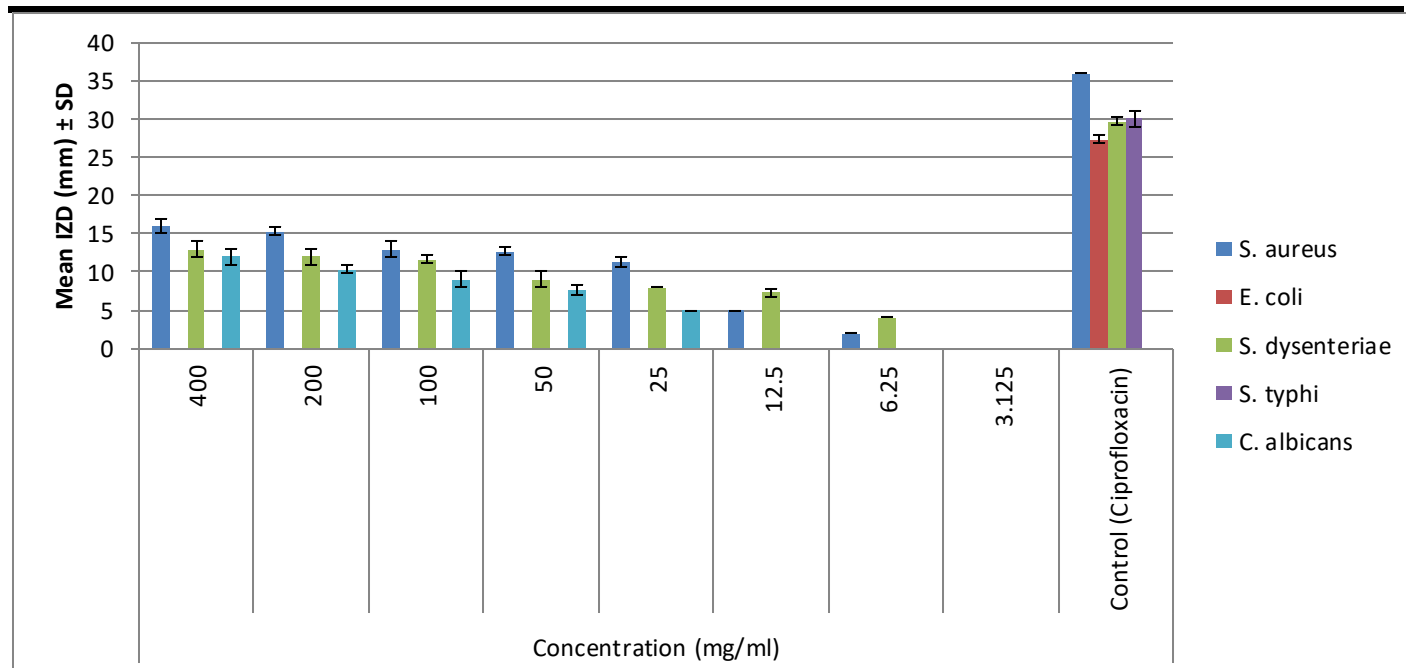


Fig.2: Antimicrobial activity of the crude n-hexane extract of *Irvingia gabonensis* leaves showing the mean inhibition zone diameters and standard deviation produced against test organisms.

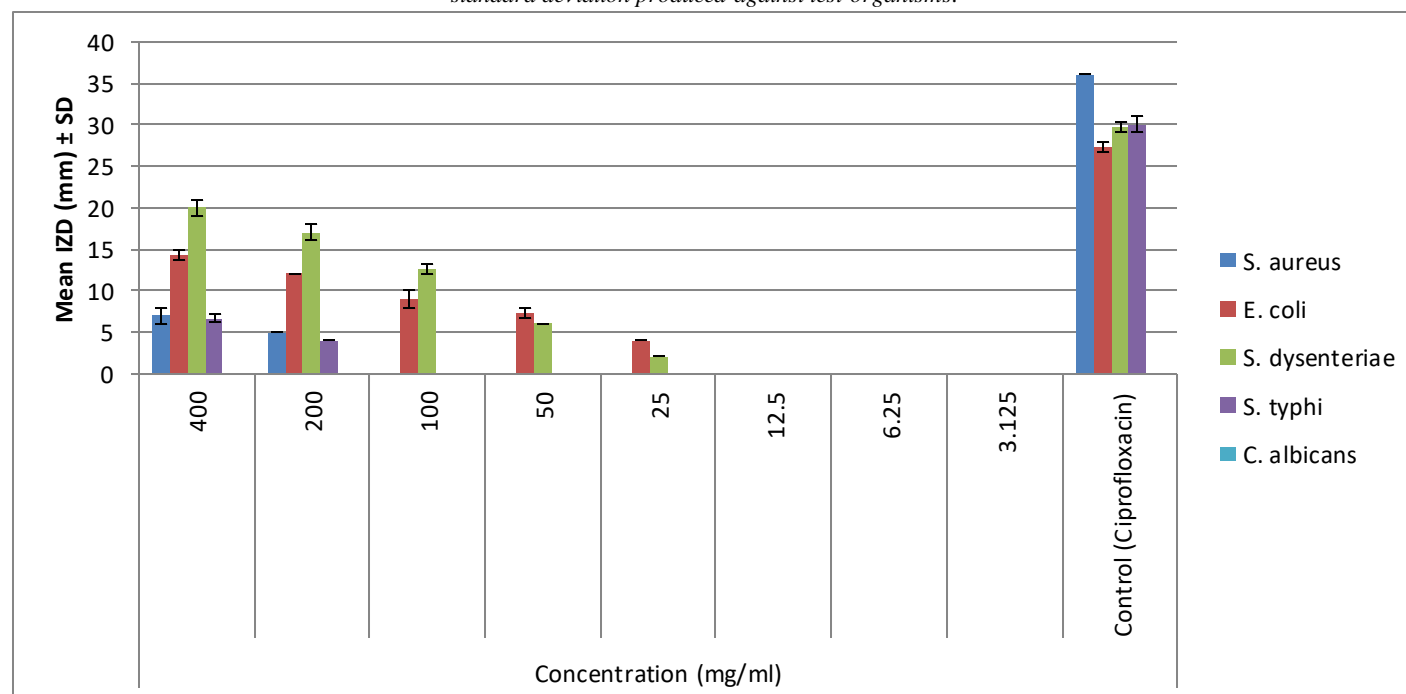


Fig 1: Antimicrobial activity of the crude aqueous extract of *Irvingia gabonensis* leaves showing the mean inhibition zone diameters and standard deviation produced against test organisms.

Table.1: Minimum inhibitory concentrations (MICs) and Minimum Bactericidal/Fungicidal Concentrations (MBCs/MFCs) of extracts of *I. gabonensis* on test organisms.

Test Organisms	Aqueous		Methanol		N-Hexane	
	MICs	MBCs/MFCs	MICs	MBCs/MFCs	MICs	MBCs/MFCs
<i>S. aureus</i>	200	400	12.5	25	25	50
<i>E. coli</i>	25	50	6.25	12.5	50	100
<i>S.dysenteriae</i>	25	50	6.25	12.5	25	50
<i>S. typhi</i>	200	400	6.25	12.5	50	100
<i>C. albicans</i>	-	-	25	50	25	50

IV. DISCUSSION

This study evaluated the antimicrobial effect of n-hexane, methanol and aqueous extracts of *Irvingia gabonensis* (ugiri) leaf against bacterial and fungal agents that causes diarrhoea. The results of the present study showed that the methanol extract of *Irvingia gabonensis* had significant antimicrobial effects.

The antimicrobial effect observed against the test organisms may also be as a result of these bioactive components present in the crude extract as reported by Haslam et al (19). The crude methanol extracts of *Irvingia gabonensis* produced the highest antibacterial effects, where as the n-hexane extract of *Irvingia gabonensis* produced the highest antifungal effects against *Candida albicans*. The crude aqueous extract of *Irvingia gabonensis* had no antifungal activity on *Candida albicans*. The minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC) and minimum fungicidal concentration (MFC) of the plant on the test organisms varied, showing that the effect of the plant extracts differed from one organism to the other. This agrees with the work of Rabe, (20) that also showed good effect with methanol extract of *Irvingia gabonensis*. However, the present study revealed that methanol was the best extracting solvent for *Irvingia gabonensis* and in line with the work of Bipul et al, (21). Kordali et al, (22) had earlier reported that the percentage recovery from plants were dependent on the type of solvent used. These results clearly confirm that *Irvingia gabonensis* leaf is effective alternative therapy against microbial agents that cause diarrhoea disease.

V. CONCLUSION

We conclude that the *Irvingia gabonensis* leaf extract have a significant antimicrobial activity against diarrhoea causing agents. The demonstration of antimicrobial activity of *Irvingia gabonensis* may help to discover new chemical classes of antibiotic substances that could serve as selective agents for infectious disease chemotherapy and control.

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Design of a Visual System to Monitoring Thermal Power in Pool-Type Nuclear Research Reactor

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Abstract— Nuclear research reactors are often found in open pools, allowing visibility of the core and the bluish luminosity of the Cherenkov radiation. In general, the thermal energy released in these reactors is monitored by chambers that measure neutron flux. There are other methods used to measure the power, including: nitrogen formation, measure of the fuel rod central temperature, and the energy balance in the heat exchanger. The brightness of Cherenkov radiation is caused by the emission of visible electromagnetic radiation (in the blue band) by charged particles that pass through an insulating medium (water in research reactors) at a speed greater than that of light in this medium. The objective of this research is to propose, design, and assemble a prototype of an equipment, which uses an innovative and alternative method to monitor the power of nuclear research reactors by measuring the intensity of luminosity generated by the Cherenkov radiation produced within and around the core. An Arduino Uno board was used, with color and luminosity sensors. The work was performed simulating and monitoring experimentally in laboratory, the intensity of luminosity generated by the Cherenkov radiation. The prototype presents potential as an auxiliary methodology for measuring thermal power of research nuclear reactors. It is intended to use this measurement system in the IPR-R1 Triga reactor of the Nuclear Technology Development Center - CDTN (Brazil).

Keywords — Arduino, Cherenkov radiation, Nuclear research reactor, Power, Triga reactor.

I. INTRODUCTION

Two important criteria for power measurement in nuclear reactors are redundancy and diversity. Other criteria such as accuracy, reliability and speed in response are also of major concern. Power monitoring of nuclear reactors is always done by means of nuclear detectors, which are calibrated by thermal methods. The nuclear instrumentation is used to detect neutrons when sub-critical multiplication occurs during the reactor start-up, after achieving the criticality, and during the neutron flux

variation to obtain the automatic control of reactivity maintaining a stable power level.

The IPR-R1 Triga research reactor will be used for the tests proposed in this paper. This reactor is located in the Nuclear Technology Development Center - CDTN (Brazil). In the IPR-R1 four neutron-sensitive chambers are mounted around the reactor core for flux measurement. The type of chamber used and its position with respect to the core determine the range of neutron flux measured [1]. Unfortunately, the ionization chamber neutron detector measures the flux of neutrons thermalized in the vicinity of the detector. This signal is not always proportional to the integral neutron flux in the core and consequently to the core power. Besides the response of a single nuclear detector is sensitive to the changes in the core configuration, particularly to the control rod position. This is important in the Triga reactor, which do not have distributed absorbers for reactivity control and maintaining criticality is by insertion of control rods [2].

The IPR-R1 Triga reactor is an open pool-type reactor and the fuel is cooled by natural convection. The system was updated in the 1970s to reach up 100 kW. Later, it was updated again to its current system, which allows it to reach 250 kW in the steady-state.

Triga reactors are the most popular research reactors in the world. There are more than sixty facilities operating in several countries [3]. Their popularity derives from the fact that they are the only research reactors that can provide true inherent safety, in addition to the usual engineering safety. This is possible due to the properties of the fuel: uranium hydride and zirconium provide unparalleled safety features, allowing flexibility in settings, with minimal environmental effects [4].

In any nuclear installation, the main concern is safety. The IAEA states that the fundamental objective of safety is to protect people and the environment from the harmful effects of ionizing radiation. They suggest ten safety principles that must be followed. The IAEA recommendations focus on the concepts of redundancy, diversity and independence; in other words, there must be

more than one device, with different operating principles, completely independently performing the same function [5].

Safety begins with controlling the parameters and variables in a nuclear reactor; the primary one is the power, which allows the determination of other relevant factors. In power measurements, safety, reliability, accuracy are critical, and very important. For this reason, nuclear reactors use several devices to measure the power of the core [6].

The objective of the project was to develop an innovative and alternative method to monitor the power of nuclear research reactors. This will be done by analyzing and monitoring the intensity of luminescence generated by the Cherenkov radiation in the reactor core.

II. CHERENKOV RADIATION

Electromagnetic radiation known as Cherenkov light is emitted when a charged particle moves in a dielectric medium at a speed greater than the speed of light for that medium. A conspicuous example of that effect is the characteristic blue glow of a pool-type reactor (Fig. 1).

Cherenkov radiation is produced through a number of ways when: (a) beta particles emitted by fission products travel with speeds greater than the speed of light in water and (b) indirect ionization by gamma radiation produces electrons due to photo electric effect, Compton effect and pair production effect. Among these electrons, Compton electrons are the main contributors to Cherenkov radiation [7]. Compton scattering of gamma rays and its intensity is linearly related to reactor fission power, and can be transmitted from the source at the reactor core to a sensing device by means of a highly reflective metallic tube [8].

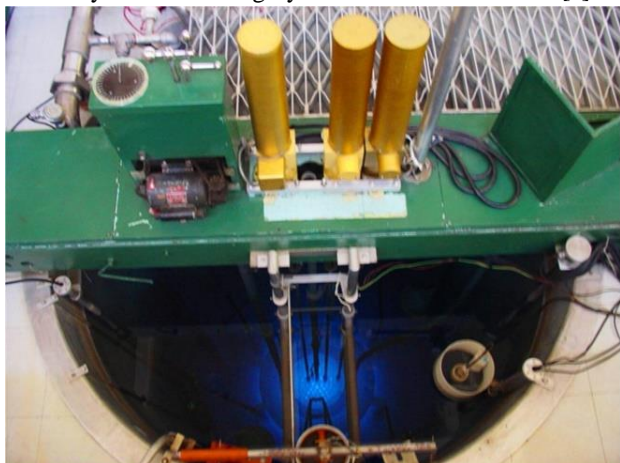


Fig. 1: Cherenkov radiation glowing in the core of the IPR-R1 Triga reactor

According to classical physics, a moving charged particle emits electromagnetic waves. In a quantum mechanical picture, when a charged particle moves inside a polarizable medium with molecules, it excites the molecules to the higher levels and excited states. Upon returning back to

their ground state, the molecules re-emit some photons in the form of electromagnetic radiation. According to the Huygens principle, the emitted waves move out spherically at the phase velocity of the medium. If the particle motion is slow, the radiated waves bunch up slightly in the direction of motion, but they do not cross. However if the particle moves faster than the light speed, the emitted waves add up constructively leading to a coherent radiation at angle θ with respect to the particle direction, known as Cherenkov radiation. The signature of the effect is a cone of emission in the direction of particle motion [9].

III. MATERIALS AND METHODS

The proposed device will use an algorithm developed in the C++ programming language to establish a relationship between the intensity of the Cherenkov luminosity and the power of the nuclear reactor. C++ is a high-level programming language, with slight modifications for the Arduino Uno system (Fig 2), that will be used in this project [10].

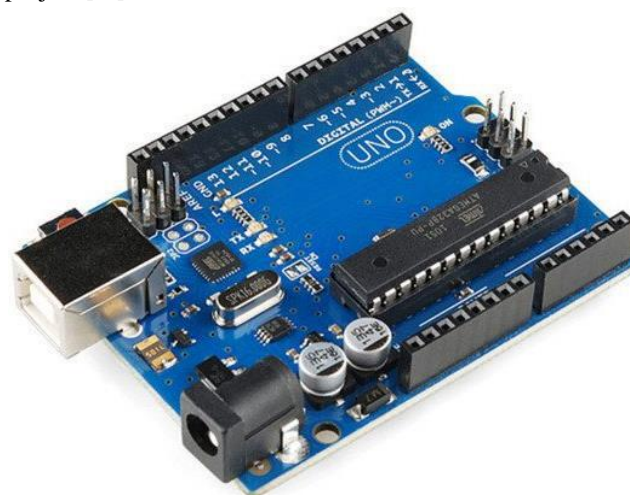


Fig. 2: Arduino Uno System.

In the program the information inputs, the conditions and intervals for the readings, the necessary calculations, and the information output method will be established. The input information will be obtained by the color sensor, and brightness sensor. The output information will be displayed on a Liquid Crystal Display (LCD).

The programming language will be compiled into the Arduino IDE software, and loaded onto the device via USB (Universal Serial Bus) cable.

The main components to be used are described below.

Color sensor:

A color sensor will act to isolate the Cherenkov radiation from other light sources by limiting the luminosity readings for the presence of the blue color characteristic of the Cherenkov radiation.

Luminosity sensor:

A luminosity sensor will be set for the function of determining the intensity of the Cherenkov radiation, giving values in lux.

Output information:

The main device output information is the nuclear reactor power, which will be calculated after processing of input information, and application of the necessary mathematical calculation.

It is intended to perform experiments in the IPR-R1 Triga reactor for the validation of the assembled instrument. Thus, the final adjustments will be made to the luminance to power conversion equations.

The equations will be established after the tests in the Triga reactor, where the luminance values measured by the device will be recorded for each kW varied in the reactor power. The power variation will be observed by the neutron measuring channels of the control console.

IV. RESULTS

The first step in the elaboration of the algorithm was the design of a simplified operating diagram to identify the hierarchical relations, constraints and barriers between the input and output information of the sensors (Fig. 3). The main indicators and conditionals for the algorithm were:

- The system will only operate in the presence of visible electromagnetic radiation in the blue band.
- The sensors will be side by side to ensure homogeneous radiation exposure.

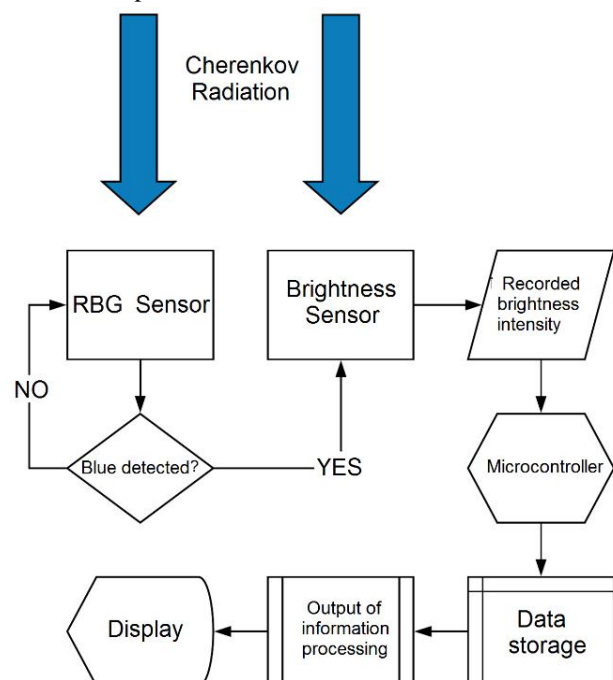


Fig. 3: Block diagram of the system.

The algorithm in high level language was elaborated after the choice of all the components (sensors and display). Due to the need to meet the specificities of each one

regarding the libraries (of codes) and routines. It can be divided into four sections, each with an interdependent function for the full operation of the device, ie: initial settings, subroutines, setup and loop.

Simulated tests were initially performed using Fritzing software (Fig. 4) and AutoCAD software (Fig. 5) to determine the best arrangement of the components for the device assembly. Next, it was used sets of LEDs (Light Emitting Diode) to simulate the Cherenkov luminosity to perform the sensors calibration.

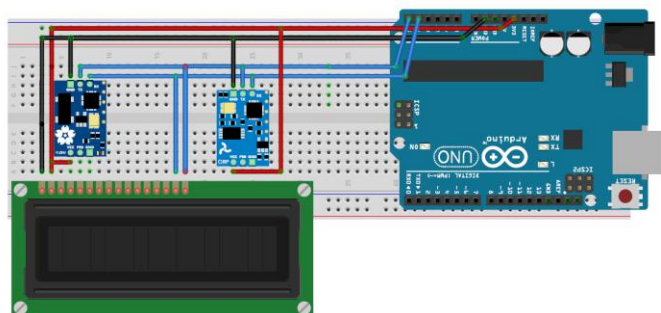


Fig. 4: System modeling in Fritzing software

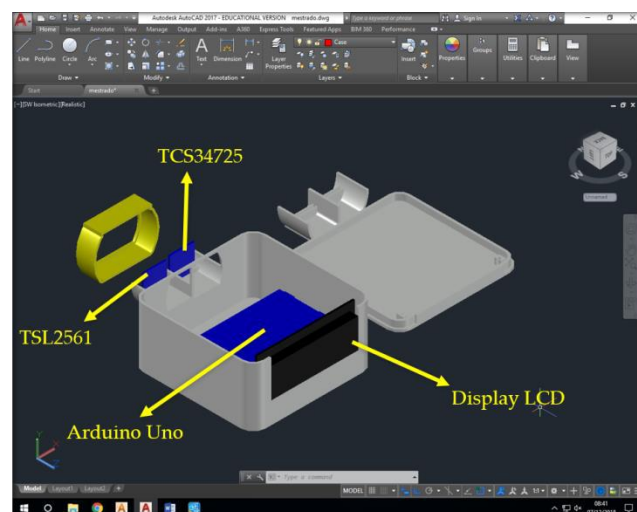


Fig. 5: Three-dimensional model of the device

Tests were performed to verify the device response to the variation of light intensity caused by blue luminosity inserted in the environment. The tests were conducted recording the device response compared to a Thermo-Hybrid-Anemometer Portable Digital Luximeter Model THAL-300 made by Instrutherm. This instrument works in the range of 0 to 20,000 lux, with resolution of 1 lux and accuracy of $\pm 5\%$ of reading ± 8 digits [11].

In the program, the information entries, the conditions and the intervals for the readings, the necessary calculations, information and exit methods will be established. The input information will be obtained from the color and brightness sensors and the output information will be transmitted via Bluetooth. The programming language will be compiled in the Arduino IDE software and will be loaded to the device via a USB cable.

4.1 Color sensor

A color sensor will be used to isolate the Cherenkov radiation from other sources of luminosity by limiting the luminosity readings in the presence of blue coloration, characteristic of Cherenkov radiation. The sensor selected for the device was the TAOS TCS34725 with infrared filter [12]. The reason was because of its RGB logic (Red, Green, Blue), and infrared filter, which guarantee greater precision in the readings with smaller noises.

4.2 Luminosity sensor

A luminosity sensor will be responsible for determining the intensity of the Cherenkov radiation, with values in lux. The TAOS TSL2561 sensor was considered the most suitable for this device, because it is a digital device that accurately captures values between 0.1 and 40,000 lux, and has three precise channels for readings [13].

4.3 Output information

The main output information of the device is the power of the nuclear reactor. It was calculated after processing the input and application information of the required algebra.

The light intensity was displayed on a 16 x 2 LCD display with HD44780U driver model, which has been selected due to its programming base interface, and its reliability [14].

Initially, scale tests will be carried out to assemble and calibrate the device, using LED sets to simulate the Cherenkov luminosity. In Figure 6 is shown photograph of the assembled components prior to being placed in the box.

After the results reach satisfactory levels, the validation in the Triga IPR-R1 reactor will be requested, where the final adjustments in the brightness conversion equations for power will be made.

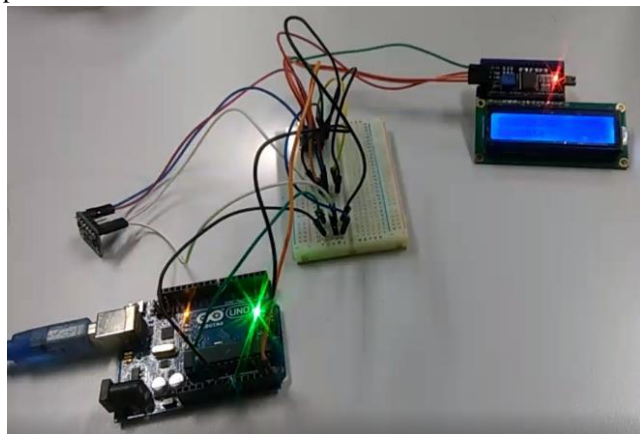


Fig. 6: Assembly of components.

In Figure 7 the system is shown placed inside its housing.

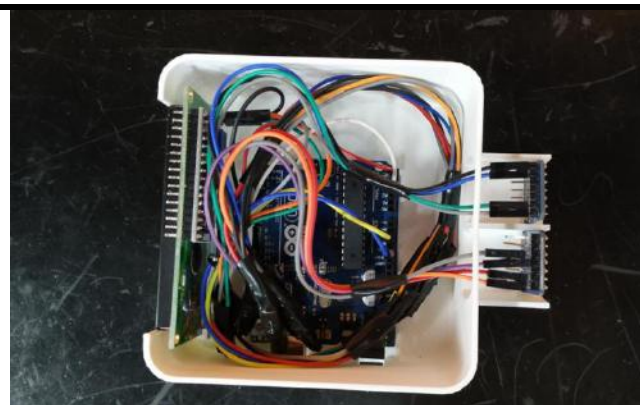


Fig. 7: Internal view of the system

In Figure 8 the system is shown within its housing. In the figure is highlighted the color and light sensors.

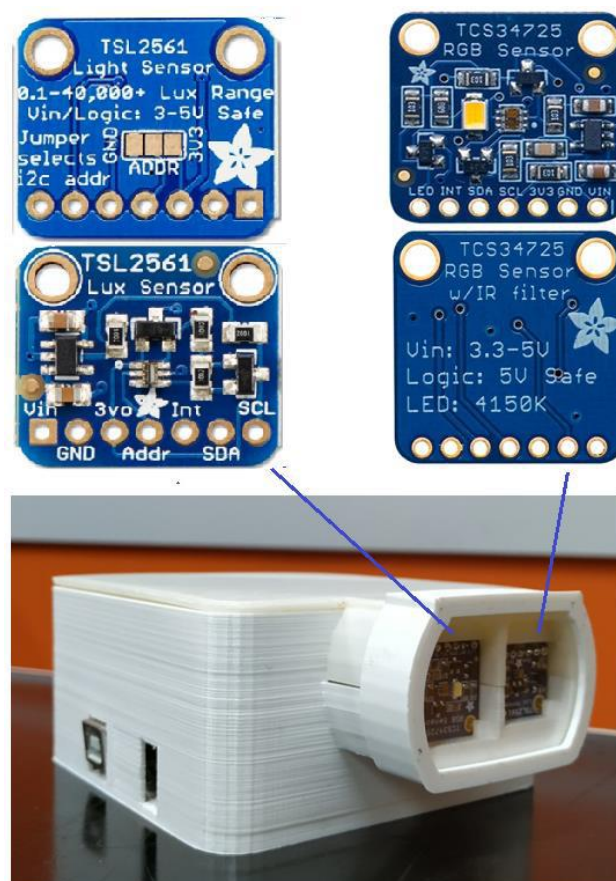


Fig. 8: External view of the device showing highlighted: color and light sensors

The initial tests consisted of attaching an opaque blue acrylic plate near the sensors and focusing light with a flashlight on the other side, varying the beam intensity. The experiments were carried out with natural ambient lighting to simulate the operation of the IPR-R1 Triga reactor, varying the distance between the sensor and the light source, starting one centimeter and increasing one centimeter per step. All tests were performed in triplicate, to validate the values obtained. The mean values of the readings are shown in Table 1. The relationships between

curves obtained with the data of Table 1 are presented in the graphs of Figure 9.

In the tests carried out up to 15 cm away from the sensors, the readings of the device were compatible with those performed by luximeter Model THAL-300. This was calibrated with ambient light, to record only the variations caused by the insertion of the bluish beam. However, above this distance there was much interference from the ambient light, making it impossible to read.

Table.1: Intensity of Light Obtained Experimentally.

Distance (cm)	Prototype			Luximeter		
	Measure (lux)			Measure (lux)		
	Intensity			Intensity		
	Low	Mean	High	Low	Mean	High
1	44	70	97	43	71	96
2	32	51	71	32	52	72
3	27	47	63	28	46	62
4	18	30	42	18	30	41
5	13	22	32	14	22	32
6	11	12	21	10	13	22
7	7	11	14	7	11	15
8	4	7	13	5	8	12
9	5	7	9	4	6	9
10	2	6	6	3	5	7
11	1	5	5	2	4	5
12	3	5	4	2	4	4
13	2	3	2	2	3	3
14	3	3	4	2	2	3
15	0	0	3	1	1	2
16	0	0	0	0	0	1
17	0	0	0	0	0	0

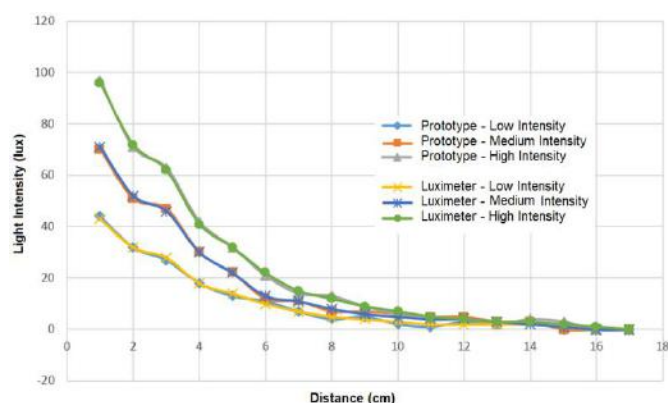


Fig 9: Intensity of light as a function of distance

4.4 Experiment in the IPR-R1 Triga reactor

Due to the large distance (about 6 m) between the sensors and the core of the IPR-R1 Triga reactor, it was not possible to adjust the system to monitor the power released by the core of this reactor. It was identified that the best option to connect the system to the edge of the reactor pool, with the display accessible to the operator and the sensors directed to the core (Fig. 10). Studies are being

done on how best to bring the sensors closer to the light source, ie the core. Another possibility is to transmit the luminosity more efficiently to the reactor surface.



Fig. 10: Device fixed in the IPR-R1 Triga reactor

V. CONCLUSION

Cherenkov radiation is a process that could be used as an extra channel for power measurement to enhance redundancy and diversity of a reactor. This is especially easy to establish in a pool type research reactor. Light produced by charged particles when they pass through an optically transparent medium at speeds greater than the speed of light in that medium. In research nuclear reactor the electrons from the core travel through shielding water, they do so at a speed greater than that of light through water and they displace some electrons from the atoms in their path. This causes emission of electromagnetic radiation that appears as a weak bluish-white glow. Cherenkov radiation is used to detect high-energy charged particles. In pool-type nuclear reactors, the intensity of Cherenkov radiation is related to the frequency of the fission events that produce high-energy electrons, and hence is a measure of the intensity of the reaction. Cherenkov radiation is also used to characterize the remaining radioactivity of spent fuel rods.

As noted by the IAEA, a greater number of channels to measure power provides a more reliable and safe operation of the reactor [15]. The advantages of the proposed device are that it will be installed far from the core, making maintenance and adjustment easier than with conventional methods of power measurement. Furthermore, it is a low-cost device, without consumables, easily allowing modifications to improve accuracy and reliability.

The prototype presents potential for monitor thermal power of pool-type nuclear reactor, increasing redundancy and diversity. It will provide stable and reliable readings for power generated in medium-power reactors. It will improve the operation of the reactor by adding one more measurement channel. The system was able to isolate the bluish luminosity, which simulated the blue glow of Cherenkov radiation, from ambient light, and measured its variation. However, it will be necessary to change the way of light capture to enable the operation in the IPR-R1 Triga reactor. This will be the next step in this research.

ACKNOWLEDGEMENTS

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Correlation of Weighting Coefficient at Weighted Total Acceleration with Rayleigh Distribution and with Pierson-Moskowitz Spectrum

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Abstract— This paper describes the research on the correlation between weighting coefficient in weighted total acceleration equation with wave height distribution from Rayleigh and with Pierson-Moskowitz spectrum. The research is done using dispersion equation for deep water wave where there is wave amplitude as its variable and a limitation of wave height maximum for a wave period. From that dispersion equation, a maximum wave height equation is formulated for a wave period.

Keywords— weighting coefficient, Rayleigh distribution coefficient.

I. INTRODUCTION

Hutahaean (2019) obtained weighted total acceleration equation for a function $F(x, t)$ in the form of $\frac{DF}{dt} = \gamma \frac{dF}{dt} + u \frac{dF}{dx}$, where γ is weighting coefficient with a value around 2.784-3.160 which is obtained analytically using surface water equation and particle velocity equation of the linear wave theory. Using the weighted total acceleration, Hutahaean (2019) formulated dispersion equation for deep water wave where there is wave amplitude as its variable and also maximum wave amplitude for a wave period. From that dispersion equation, wave height maximum equation is formulated for a wave period value resulted in different wave height maximum for different γ value.

There are various waves heights, the most commonly used being the significant wave height H_s or is often also called $H_{1/3}$. Therefore, a hypothesis can be made that there is a value of weighting coefficient that correlates with $H_{1/3}$.

Wiegel (1949 and 1964) and Silvester (1974) produced a relation between wave period and deep water wave height, where with an input of a wave height, its wave period can be calculated. Using wave period from the two

equations, wave height maximum is calculated using wave amplitude maximum equation, by changing the value of weighting coefficient until the wave height that is similar to the wave height that becomes the input for Wiegel equation and Silvester equation is obtained. The obtained weighting coefficient is different for the two equations. From the two weighting coefficient values, the characteristics of the closeness with the Rayleigh distribution coefficient are obtained.

Furthermore, studying the Rayleigh distribution coefficient produced weighting coefficient values that correspond to Rayleigh coefficient. Silvester equation (1974), formulated using Pierson-Moskowitz spectrum, obtained that wave height at the equation is for a certain weighting coefficient value that is correlated with $H_{1/10}$.

II. DISPERSION EQUATION AT DEEP WATER

Dispersion equation at deep water (Hutahaean, 2019) is a function of wave amplitude A , by ignoring bottom slope is

$$\gamma^2 \sigma^2 = gk \left(1 - \left(\frac{kA_0}{2} \right) \right) \quad \dots\dots\dots(1)$$

γ is a weighting coefficient at the weighted total acceleration or total derivative equation, where the result of Hutahaean research (2019) analytically using water surface equation and particle velocity of linear wave theory obtained γ value of 2.784-3.160. σ is angular frequency $\sigma = \frac{2\pi}{T}$, T is wave period, g is gravity velocity, k is wave number and A_0 is deep water wave amplitude.

Equation (1) has a solution if the value of determinant $D \geq 0$, where

$$D = g^2 - 4 \left(\frac{gA_0}{2} \right) (\gamma^2 \sigma^2) \quad \text{for } D = 0$$

$$A_{0-max} = \frac{g}{2\gamma^2 \sigma^2} \quad \dots\dots\dots(2)$$

Using (2), wave amplitude A_0 at the deep water can be calculated, which is A_0 maximum at the concerned wave period, where with the assumption that at the deep water the wave profile is still sinusoidal, then H_0 maximum is twice A_0 maximum. In addition, in (2) there is also a relation that wave height maximum is also determined by the value of γ .

2.1. Comparative Study with Wiegel Equation (1949 and 1964)

Wiegel (1949 and 1964) produced a relation between wave period with H_{0-max} , i.e.

$$T_{Wieg} = 15.6 \left(\frac{H_{0-max}}{g} \right)^{0.5} \quad \text{.....(3)}$$

Study at Wiegel equation is done by providing an input of wave height at (3) and is assumed as H_{0-max} and T_{Wieg} is calculated. Then, using the T_{Wieg} , $H_{0-max,m}$ is calculated with (2), by experimenting the value of γ . Table (1) shows the result of the calculation with $\gamma = 2.483$, where produced $H_{0-max,m} = H_{0-max}$. Therefore (2) provides a result that corresponds to Wiegel equation at the value of $\gamma = 2.483$. Using wave period T_{Wieg} and with $A_{0-max} = \frac{H_{0-max}}{2}$, wave length L is calculated with (1) and $\frac{H_{0-max}}{L}$ where constant value of 0.32 is obtained which is a critical wave steepness from Hatahaean (2019), i.e. $\frac{H_b}{L_b} = \frac{1}{\pi}$. H_b is breaker height and L_b is breaker length. At the wave length L calculation, the value of T_{Wieg} is multiplied with coefficient 1.0001, to prevent determinant $D < 0$ from happening.

Table.1: Comparison of (2) with Wiegelequation

H_{0-max} (m)	T_{Wieg} (sec)	$\frac{H_{0-max}}{L}$	$H_{0-max,m}$ (m)
1	4,98	0,32	1
1,5	6,1	0,32	1,5
2	7,04	0,32	2
2,5	7,88	0,32	2,5
3	8,63	0,32	3
3,5	9,32	0,32	3,5
4	9,96	0,32	4
4,5	10,57	0,32	4,5
5	11,14	0,32	5

2.2. Comparative Study with Silvester Equation (1974)

Silvester (1974), formulated a relation between wave period and $H_{1/3}$ using Pierson-Moskowitz spectrum, i.e.

$$T_{Sil} = \sqrt{19.68 H_{1/3}} \quad \text{.....(4)}$$

As with the comparative study with Wiegel equation, the study is done by providing an input of a wave height that is assumed as $H_{1/3}$ and the wave period is calculated with (4). Then, using T_{Sil} , $H_{1/3-m}$ is calculated with (2). By experimenting the value of γ , the value of $\gamma = 2.211$ is produced. The value of $\frac{H_{1/3}}{L}$ is obtained as 0.31, although it is close to $\frac{1}{\pi} = 0.318$ it is still somewhat smaller. Thus shows that with wave period (4) the wave is only in critical condition, not breaking yet. Wave length L calculation with (1) is done using wave period $1.0001 T_{Sil}$.

Table.2: Comparison of (2) with Silvester equation

$H_{1/3}$ (m)	T_{Sil} (sec)	$\frac{H_{1/3}}{L}$	$H_{1/3-m}$ (m)
1	4,44	0,31	1
1,5	5,43	0,31	1,5
2	6,27	0,31	2
2,5	7,01	0,31	2,5
3	7,68	0,31	3
3,5	8,3	0,31	3,5
4	8,87	0,31	4
4,5	9,41	0,31	4,5
5	9,92	0,31	5

2.3. The Correlation between Weighting Coefficient and Rayleigh Distribution

Comparative study between Wiegel equation and Silvester equation produced different γ value. At (2) it can be seen that the bigger the value of γ the smaller the H_{0-max} . If wave amplitude calculation is done with (2),

$$\text{Wiegel, } \gamma = 2.483 : A_{Wieg} = \frac{g}{2 \times 2.483^2 \sigma^2}$$

$$\text{Silvester, } \gamma = 2.211 : A_{Sil} = \frac{g}{2 \times 2.211^2 \sigma^2}$$

$$\frac{H_{Sil}}{H_{Wieg}} = \frac{A_{Sil}}{A_{Wieg}} = \frac{2.483^2}{2.211^2} = 1.261$$

The comparative number is close enough with the value of $\frac{H_{1/10}}{H_{1/3}} = 1.271$, where it can be estimated that there is

γ value where $\frac{2.483^2}{\gamma^2} = 1.271$, and other relation. To learn that, coefficient distribution from Rayleigh will be used.

The relation between H_p and $H_{1/3}$ for $0 < p \leq 1$ is obtained

from Rayleigh coefficient (Forristall (1978)), i.e

$$H_p = \alpha_p H_{rms} \quad \text{.....(5)}$$

$$\alpha_p = \ln \sqrt{\frac{1}{p}} + \frac{\sqrt{\pi}}{2p} \operatorname{erfc} \left(\sqrt{\ln \frac{1}{p}} \right) \quad \text{.....(6)}$$

From (4) relation between H_p and $H_{1/3}$ can be made

$$H_p = c_p H_{1/3} \quad \dots\dots\dots(7)$$

$$c_p = \frac{\alpha_p}{\alpha_{1/3}} \quad \dots\dots\dots(8)$$

Table.3: Rayleigh distribution coefficient

p	$c_p = \frac{H_p}{H_{1/3}}$
$1/10$	1,271
$1/9$	1,25
$1/8$	1,226
$1/7$	1,198
$1/6$	1,165
$1/5$	1,124
$1/4$	1,072
$1/3$	1
$1/2$	0,887
1	0,626

Table (3) shows that $\frac{H_{Sil}}{H_{Wieg}}$ is quite close with the value of $\frac{H_{1/10}}{H_{1/3}}$. Furthermore, through an experiment, γ values are obtained where $\frac{\gamma^2}{2.483^2} = \frac{H_p}{H_{1/3}}$. The result of the calculation can be seen on Table (4).

Table.4: Correlation between the value of γ and Rayleigh distribution

p	$\frac{H_p}{H_{1/3}}$	$\frac{\gamma^2}{2.483^2}$	γ
$1/10$	1,271	1,272	2,202
$1/9$	1,25	1,25	2,221
$1/8$	1,226	1,225	2,243
$1/7$	1,198	1,198	2,269
$1/6$	1,165	1,164	2,301
$1/5$	1,124	1,124	2,342
$1/4$	1,072	1,072	2,398
$1/3$	1	1	2,483
$1/2$	0,887	0,887	2,636
1	0,626	0,626	3,138

Table (4) shows that if the value of $\gamma = 2.483$ is assumed to correspond to $H_{1/3}$, then $\gamma = 2.202$ corresponds to $H_{1/10}$, $\gamma = 2.342$ corresponds to $H_{1/5}$, etc. This proves that there is a correlation between weighting coefficient

value and Rayleigh distribution coefficient and this shows the existence of weighted total acceleration equation with weighting coefficient in the nature.

Therefore, the study at this section shows that the value of $\gamma = 2.483$, correlates with $H_{1/3}$ so that Wiegel equation (3) is an equation for $H_{1/3}$, whereas the value of $\gamma = 2.202$ is in accordance with Silvester equation (4) and correlates with $H_{1/10}$, therefore Silvester equation is the equation for $H_{1/10}$.

2.4. The Correlation of Weighting Coefficient with Pierson- Moskowitz spectrum

In addition to producing a relation between wave period and wave height, Silvester (1974), also produces a relation between wind velocity $U_{19.5}$ and wave period for FAS (Fully Arisen Sea) condition, where $U_{19.5}$ is wind velocity measured at an elevation of 19.5 m from the surface. The relation is also formulated using Pierson-Moskowitz spectrum. The form of the relation is.

$$T = \frac{2\pi}{g} U_{19.5} \text{ sec.} \quad \dots\dots\dots(9)$$

where $g(m/sec^2)$ is gravity acceleration and $U_{19.5}(m/sec)$ is wind velocity.

Table.5: The calculation of $H_{1/10}$ and $T_{1/10}$ at FAS condition

$U_{19.5}$ (m/sec)	$T_{1/10}$ (sec)	$H_{1/10}$ (m)	$T_{1/10-Sil}$ (sec)
5	3,2	0,53	3,22
10	6,4	2,1	6,43
15	9,61	4,73	9,65
20	12,81	8,41	12,86
25	16,01	13,14	16,08

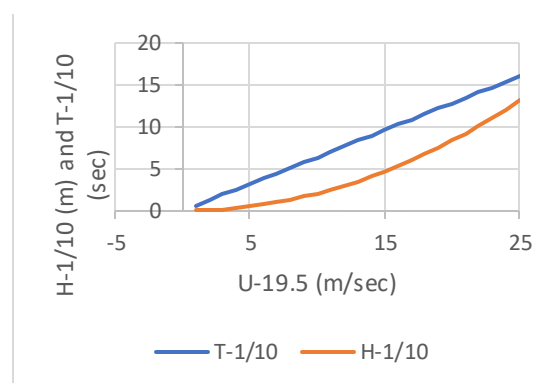


Fig.1: Relation between $U_{19.5}$ with $T_{1/10}$ (wave period for $H_{1/10}$) and $H_{1/10}$

$T_{1/10}$ (wave period for $H_{1/10}$), is calculated with (9), $H_{1/10}$ is calculated with (2) using wave period $T_{1/10}$ and

$\gamma = 2.202$, whereas $T_{1/10-sil}$ at column 4 is calculated with (4), where the wave height is $H_{1/10}$ at column 3. Wave period in column 2 does not differ much with wave period at column 4 and can be said it is the same. It can be concluded that the calculation of $H_{1/10}$ with (2) using $\gamma = 2.202$ produces a wave height that is in accordance with wave height at the Silvester equation. Therefore, from the result, it can be said that wave height (4) is $H_{1/10}$. It is estimated that this is because (4) and (9) are formulated at the peak of spectrum.

Then to obtain $H_{1/3}$ and $T_{1/3}$ (wave period for $H_{1/3}$) at FAS condition, $H_{1/10}$ at column 2 in Table (5) is divided with 1.271, followed $T_{1/3}$ calculation using Wiegel equation (3). With the $T_{1/3}$, $H_{1/3-(2)}$ is calculated using (2) and $\gamma = 2.483$. The result of the calculation is presented in Table (6), which shows that $H_{1/3} = H_{1/3-(2)}$ which can be interpreted that $\gamma = 2.483$ correlates with $H_{1/3}$ from Pierson-Moskowitz spectrum, whereas wave height in Wiegel equation (3) is an equation for $H_{1/3}$.

Table.6: The Calculation of $H_{1/3}$ and $T_{1/3}$ at FAS condition

$U_{19.5}$ (m/sec)	$H_{1/10}$ (m)	$H_{1/3}$ (m)	$T_{1/3}$ (sec)	$H_{1/3-(2)}$ (m)
5	0,41	0,41	3,2	0,41
10	1,65	1,65	6,41	1,65
15	3,72	3,72	9,61	3,72
20	6,62	6,62	12,81	6,62
25	10,34	10,34	16,01	10,34

The result of the study in this section is that the value of weighting coefficient $\gamma = 2.202$ correlates with $H_{1/10}$ whereas $\gamma = 2.483$ correlates with $H_{1/3}$ at Pierson-Moskowitz spectrum.

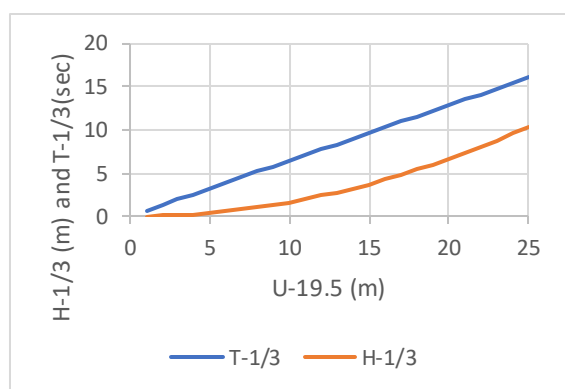


Fig.2: Relation between $U_{19.5}$ and $T_{1/3}$ (wave period for $H_{1/3}$) and $H_{1/3}$

III. CONCLUSION

The result of the study that has been done, obtained that weighting coefficient at the weighted total acceleration equation correlates with Rayleigh distribution and Pierson-Moskowitz spectrum. Considering that Rayleigh distribution and Pierson-Moskowitz spectrum were formulated based on data in the nature, then this proves the existence of weighting coefficient in the nature.

The calculation of significant wave height can be done using maximum wave amplitude equation using $\gamma = 2.483$. Wave dynamics modeling can be done using weighted total acceleration equation with weighting coefficient $\gamma = 2.483$.

Analytically, using sinusoidal water surface equation and particle velocity equation of the linear wave theory the value of γ is obtained between 2.784-3.160, whereas in this research the obtained value of γ is smaller, i.e. 2.483 for $H_{1/3}$ and 2.202 for $H_{1/10}$. This can be concluded that there is another sinusoidal water surface equation that will produce weighting coefficient value of 2.483 and 2.202. Therefore, further research that should be done is to conduct a research on the sinusoidal water surface equation, where the equation will have an influence on another wave parameter, i.e. wave length.

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Regional Development in the Amazonian Border Area from the Installation of Areas of Free Trade

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Abstract— *The concept of development goes back to the classical theory of economics and has many other aspects over the years. In Brazil, many public policies instituted by the Federal Government sought to promote the country's development, such as the creation of the Manaus Free Zone, which aimed to promote the development of the North region in a sustainable way. Likewise, Free Trade Areas were created - decentralized FTAs, as in the case of Guajará-Mirim, as territorial and developmental strategies. The objective of this article is to analyze the regional development of Guajará-Mirim and verify its relation with the institutionalization of the Free Trade Area, having as research variables the Municipal Human Development Indexes - MHDI, Education Index, Income Index and Work Index. The following question is answered: did the installation of the Free Trade Area in Guajará-Mirim contribute to regional development? To answer the research problem, the main theoretical approaches to regional development and related public policies are used, with emphasis on the studies provided by MYRDAL (1957), BALDWIN (1979), BARQUERO (1995), AMARAL FILHO (1999), SOUZA, (1999, 2005, 2009), CABUGUEIRA (2007), FREY (1997), among others..*

Keywords— *Regional development, public policy, free zone.*

I. INTRODUCTION

When it seeks to understand public policies of frontier development, the main focus is given to the responsibility of the federal sphere in presenting solutions, even by its constitutional competence. The concept of development, according to classical theories, can be measured by the increase in economic indicators, improvement in infrastructure, better distribution of income and increase in the population's welfare indices.

It is a fact that in Brazil, certain regions have advanced more to the detriment of others, as is the case in the northern region. The theoretical analysis of unequal development provides a basis for understanding this phenomenon and analyzing its variables, even with the contribution of public policies that favor development. Often endogenous factors are taken as the essential elements for which a particular region evolves.

In the north of the country, one of the strategies to enhance sustainable development was the creation of the Manaus Free Zone and then its decentralization for some strategic regions. In this context, the Federal Government created the decentralized Free Trade Areas to promote the development of international frontiers in the Western Amazon, in order to seek integration with the rest of the country through fiscal incentives similar to those applied in the Free Zone of Manaus. One of the FTAs created was established in the municipality of Guajará-Mirim, state of Rondônia.

In this bias, this article aims to analyze the regional development of Guajará-Mirim and verify its relation with the institutionalization of the Free Trade Area, having as research variables the Municipal Human Development Indexes - MHDI, Education Index, Index of Income and Index of Work. The following question is answered: did the installation of the Free Trade Area in Guajará-Mirim contribute to regional development?

In the quest to respond to the research problem, the main theoretical approaches to regional development and public policies related to the subject are used, mostly constituted by legislation, plans and government programs. In the theoretical field, the understanding provided by MYRDAL (1957), BALDWIN (1979), BARQUERO (1995), AMARAL FILHO (1999), SOUZA, (1999, 2005, 2009), CABUGUEIRA (2007), and others.

The study is characterized in a qualitative research with data analysis by means of a case study, seeking to establish relation with the data found in the variables with the development from the Free Zone installation. For this purpose, data collection was based on the consolidated database of the Human Development Atlas of Brazil, which uses data from the Brazilian Institute of Geography and Statistics (IBGE) for the years 1991, 2000 and 2010. For the presentation of the studies carried out, the article was divided into three stages: initial introduction, the second part discusses the theoretical reference on the theories involving the concept of regional development, the third stage discusses the concepts and typologies of public policy, in the fourth step is the presentation and discussion of the data found and finally the final considerations.

II. CONCEPTS OF REGIONAL DEVELOPMENT

The **headings** and **subheadings**, starting with "**1. Introduction**", appear in upper and lower case letters and should be **set in bold and aligned flush left**. All headings from the Introduction to Acknowledgements are numbered sequentially using 1, 2, 3, etc. Subheadings are numbered 1.1, 1.2, etc. If the search for reducing existing inequalities in Brazil and promoting regional development permeates the country's decentralization history promulgated in the 1988 constitution. As a provider of public policies, the State has undergone social and economic reformulations, but it has not been successful in process of reducing regional inequalities, a fact that leads the federal government to give more autonomy to the states in the conduct of these public development policies. Financial and political cooperation between federation and state becomes more and more constant. (SOUZA, 1999)

In this sense, it is the theoretical construction that Vladimir Lenin considers as unequal geographical development, reflecting on development, which can easily be applied to the process of decentralization and development of the Brazil.

From an economic perspective, growth points to the conceptualization of development. In the book "The Wealth of Nations," Adam Smith (1776) identifies the causes of growth with the high rate of positive profit, with market growth and worker productivity (SOUZA, 2005). Thus, development is characterized by the increase of economic indicators, improvement in infrastructure, better distribution of income and increase in the population's well-being indexes.

Allied to the economic thought of Adam Smith (1776), Baldwin (1979) considers as economic development the process in which, over a period of time there is an increase in the real national income.

Souza (2005) points out that although there is a certain consensus in most nations to perceive development from the economic bias, the existence of public policies related to the social objectives and well-being of the population, also favored economic development. According to the author, in Brazil economic thinking involves neoliberal, developmentalist, socialist currents and even eclectic thinking.

With regard to regional development, Isard apud Souza (2009) points out that the concept of the region cannot be thought only in the economic context, but must incorporate demographic, social and technological concepts, observing the multidisciplinary character and the peculiar features.

Starting from the administrative political context, Cabugueira (2007) reiterates that regional demarcation is established by territorial boundaries. In this way, it is consistent with the studies on regional development aspects related to spatial economic theory, economic growth theory and legislations that establish and determine the paths of growth.

The spatial economic theory is based on Johann Heinrich Von Thünen (1826), followed by Walter Christaller (1933), Francois Perroux (1955), among others, and seeks to explain concepts related to the geographic space of organizations, agglomerative and general spatial organization. Similarly, regional economic theory also based on Von Thünen (1826) relates the territorial location of production with its commercialization and consequent economic growth. That is, growth or development is intertwined with the strategies of location and territorial occupation of markets (SOUZA, 2009).

Such theories reflect the territorial reality of the nations, especially those more extensive, with distant internal territorial distances, that the access to new markets and new technologies occur late. The difficulties of access is presented as an inhibiting factor of development, triggering the expansion of regional inequalities. From the same point of view, Souza (2009) reports that regional development policy aims at the distribution of urban and industrial poles within the regions as a means of containing a demographic concentration at one particular location over another. The fact is that not always such policies are effective.

In relation to the existing uneven development, Gunnar Myrdal (1957) presents one of the most important studies on the developments of development theory, called "Theory of Cumulative circular causality". Myrdal (1957) preached that the social system was not capable of modifying itself in order to provide a balance of forces. The development would then depend on other forces institutions to move forward.

Another important theoretical current on regional development is the conception of endogenous

local/regional development in the 1980, in which herein that the success of the growth of certain regions is due to internal performance. Paul Romer and Robert Lucas (1986) were the forerunners of this theory that considers factors such as "human capital, knowledge, information, research and development, which added to the creative and innovative capacity would function as competitive advantages Regional". (AMARAL FILHO, 1996, p. 41). The theory of endogenous development arises from rupture with traditional theory of development. In the definition of Amaral Filho (1999, p. 2), endogenous development is:

(...) a process of economic growth implying in a continuous increase of the capacity of aggregation of value on the production as well as of the capacity of absorption of the region, whose unfolding is the retention of the economic surplus generated in the local economy and / or the attraction of surpluses from other regions. This process results in the expansion of employment, output and income of the local or more or less defined region within a specific model of regional development.

Such a definition is incorporated into new organizational concepts and ways of organizing, enhancing the capacities of a region or community so that it can be sustainable over time. In addition to the studies, Amaral Filho (1996) affirms that the proposed development model extends the bases of autonomous decisions on the part of the social actors, who have the power to interact directly in the way of regional or local development. However, it is not a closed and static model, but a model capable of establishing and fomenting a society capable of providing for itself as models and means of production, in order to fulfill its basic needs and to widen the integration between the people (SERRA AND FERNANDEZ, 2004).

In this perspective, Barquero (1995) presents endogenous regional development in two dimensions, the first in an economic perspective, in which the local business society uses its capacity to organize the productive factors of the region and the second a socio-cultural dimension, where the values and local institutions serve as the basis for the development of the region. In this thought, the implementation of public policies becomes as a driving force of development, without being the main factor, but the necessary strategic variable.

Under this prism of economic development emerges in the 1970s studies on sustainable development as a response of the United Nations - UN climate change occurred. The concept combines economic development with social and environmental development, in a perspective called triple bottom line (Elkington, 1994).

Although there is no single definition, in an overview, Klink (2001) Apud Santos (2005), reiterates that the term sustainability encompasses economic growth and

development with environmental conservation. Therefore, the concept encompasses three main objectives: economic efficiency, social equity and environmental integrity.

Sustainable development is a systemic concept under an understanding of global development. The term was used for the first time in the Brundtland report (1987) prepared by the World Commission on Environment and Development. In line with the Sustainable Development Report, "it seeks to meet the needs of the current generation without compromising the ability of future generations to meet their own needs" (OUR COMMON FUTURE, 1988)

As a sustainable development strategy in Brazil, there is Agenda 21 that encourages the country to develop and harmonize development policies for the various sectors, adding governmental, civil society and private sector capacities for a sustainable future vision. According to Arnt (2010) for the attainment of sustainable development it is necessary to overcome deadlocks and build consensus. The aggregation of forces regains the idea of endogenous development, with unbiased and consensual discussions.

Faced with the various theoretical currents and the scientific ambiguities in relation to the role of each instrument to promote regional development, Cavalcante (2008) infers the need to have development strategies in a way Individualised, there is a view that there is no single guideline applicable to all regions.

After this brief review of the concepts and reflections on regional development, there is a reflection on public policies focused on promoting regional development in Brazil.

III. PUBLIC POLICIES FOR DEVELOPMENT

Studies on public policy do not have a uniform theory, but part of the modern combination of methods and a new and peculiar focus, moving through economic, political, administrative, and other conceptions. According to Souza (2006) the public policy area considers the researchers H. Laswell, H. Simon, C. Lindblom and D. Easton as the founding fathers of the area.

In the 1930s, Laswell (1936) introduced the term policy analysis relating scientific knowledge to the empirical production of governments. Simon (1957) applied the concept of limited rationality of policymakers in view that this rationality could be minimized by rational knowledge. Lindblom (1959, 1979) considered the concepts of rationalism of Laswell and Simon proposing the integration of other variables as relations of power and joining of different phases of the decision process. In turn, Easton (1965) defined public policy as a system, that is, a relation between formulation, outcome, and environment. Public policy can be seen in a broad sense, under a holistic vision covering diverse disciplines, theories and

methodologies. The design and formulations of public policies are deployed in plans, programs, projects and information and research systems. In Frey's (1997, 243) conception, the study of the material dimension of public policies presupposes "a general knowledge of problem solving processes", because a satisfactory knowledge is necessary both in relation to institutions and in order to create a frame of reference for the analysis of each policy field (FREY, 1997).

In a Brazilian context, public policy meets different forms of support and rejection, and the disputes over which it passes its decisions operate through differentiated arenas (FREY, 1997). Theodor Lowi (1972) presented the concept of policy arena that assumes that "people's reactions and expectations are affected by political measures" whose effect anticipates the political decision-making process and implementation, in this context, public policy makes policy. The discussions raised by Lowi (1972 apud FREY, 1997) distinguish four types of public policies according to their character, being: distributive, redistributive, regulatory or constitutive.

Distributive policies, as the name suggests, are government decisions that aim to distribute advantages by privileging certain social groups to the detriment of the whole. Redistributive policies are those universal calls because they cover more people and they are also a policy pervaded by conflicts. Regulatory policies involve bureaucracy (orders, prohibitions, decrees and ordinances), politicians, and interest groups. Public policies are more visible to the public because the costs and benefits are distributed in a balanced way to society, just as certain policies may serve particular interests. Finally, constitutive policies are those structures that deal with procedures. Each type of policy signaled the types of programs, plans and projects that will be planned and / or implemented as public policies.

In Brazil, such policy typologies directly reflect how public policies are shaped in order to develop the country. Many government plans or programs are geared toward one region over another. The 1980s are marked by a new way of thinking about public policies, moving from centralized planning to political-administrative decentralization, generating administrative regionalization. More than a division of territories, planning is conceived with a view to interregional equity and opening space for the participation of regional and local actors.

Regional development can occur in many ways and be conceived under various theoretical bias, as discussed in the previous section. The administrative regionalization plan of the federal government was one of the impetus for

the promotion of regional development, mainly for the territories that were farther away from the central regions. The institutionalization of regions, governance and budgetary distribution, besides the articulation of social, political and economic actors also contributed. Governance occurs when regional and local actors, together, perform actions to assess problems relevant to their regions or locations, aiming to observe problems better compared to national or supra-national actors.

IV. SCENARIO OF THE FREE TRADE AREAS ON THE AMAZON BORDER

In order to build a model of sustainable regional development in the north of the country, in 1967 the Federal Government created the Superintendence of the Manaus Free Trade Zone (SMFTZ), an agency linked to the Ministry of Development, Industry and Foreign Trade. Based in the city of Manaus in the state of Amazonas, SMFTZ seeks economic alternatives to attract enterprises to the Amazon region, aiming at generating income, employment and sustainable development.

Following the strategy of promoting development, Free Trade Areas were created - FTA decentralized of the city of Manaus, with the objective of promoting the development of the cities of international borders located in the Western Amazon.

The institutionalization of these areas aimed to integrate them to the rest of the country, offering tax benefits similar to those of the Manaus Free Trade Zone, with incentives from the Industrialized Products Tax (IPT) and the Tax on Goods Circulation and Provision of Services (TGCPs).

The main objectives of the FTAs are to improve the supervision of entry and exit of goods, the strengthening of the commercial sector, the opening of new companies and the generation of jobs. In these areas, good business options are obtained from investments in local raw materials using fiscal incentives or even the establishment of wholesale trades of imported products to meet the needs of local and adjacent populations.

Currently, the Free Trade Areas included in the perimeter of the Free Zone of Manaus model are: Boa Vista and Bonfim in the State of Roraima; Tabatinga, in the State of Amazonas; Macapá and Santana, in the State of Amapá; Guajará-Mirim in the State of Rondônia; Brasília with extension to Eptaciolândia and Cruzeiro do Sul in the State of Acre.

To ensure a high-quality product, diagrams and lettering MUST be either computer-drafted or drawn using India ink.



Fig. 1: Map of Free Trade Areas in the Amazon

With the purpose of analyzing the regional development from the establishment of the free trade area, the FTA of Guajará-Mirim, located in the state of Rondônia, in the border area with the city of Guayaramirim in Bolivia, was delimited as a research locus.

Established by Law no. 8,210 of 07/19/1991 and regulated by Decree no. 843 of 06/23/1993, the creation provided for free trade of import and export under special tax regime with the purpose of promoting the development of the region of the extreme northwest of the State, besides increasing the bilateral relations with the neighboring countries according to the policy of Latin American integration.

Considering the mission of the Superintendence of the Manaus Free Trade Zone - SMFTZ to *"promote regional economic development, through generation, attraction and consolidation of investments, supported by education, science, technology and innovation, aiming at national integration and competitive international insertion"* the study intends to evaluate the development of the Guajará-Mirim region based on the variables income, employment, education and human development index from the establishment of the free zone.

ANALYSIS OF REGIONAL DEVELOPMENT: THE CASE OF GUAJARÁ-MIRIM

The history of Guajará-Mirim is inherent in the history of Rondônia, its settlement and the clearing of the north of the country. Its location was already known since the 18th century as a point of reference for the river route. At the beginning of the twentieth century was chosen as the end point of the railroad Madeira-Mamoré at the height of the exploitation of rubber. In 1928, the Legislative Power approves the request for installation of the municipality and district of Guajará-Mirim, which is approved by the then governor through the law 991 of 07/12/1928. Already on April 10, 1929 is actually installed the county

and municipality of Guajará-Mirim. In 1943 the Federal Territory of Guaporé was constituted by Decree-Law 5812, maintaining the same denomination. According to data from the IBGE (2016), the municipality located in the II microregion of the State of Rondônia occupies an area 24,855,724 km² and a population of 47,048 inhabitants.

The history of the municipality is marked by advances and setbacks. Although the Manaus Free Zone was installed in 1967, public development policies for the Amazon were still centralized. As a way to maximize development and expand it to other territories, it was promoted to the decentralized Unit of SMFTZ in 1991 through Law n. 8210.

The Human Development Atlas of Brazil is a platform for consulting the municipal human development index (MHDI) of 5,565 Brazilian municipalities of 27 units of the federation (UF). The data presented by the Atlas Brazil were extracted from the Demographic Censuses of 1991, 2000 and 2010 and gathers more than 200 indicators of demography. According to the analysis proposal, the following indices of the municipality of Guajará-Mirim were observed.

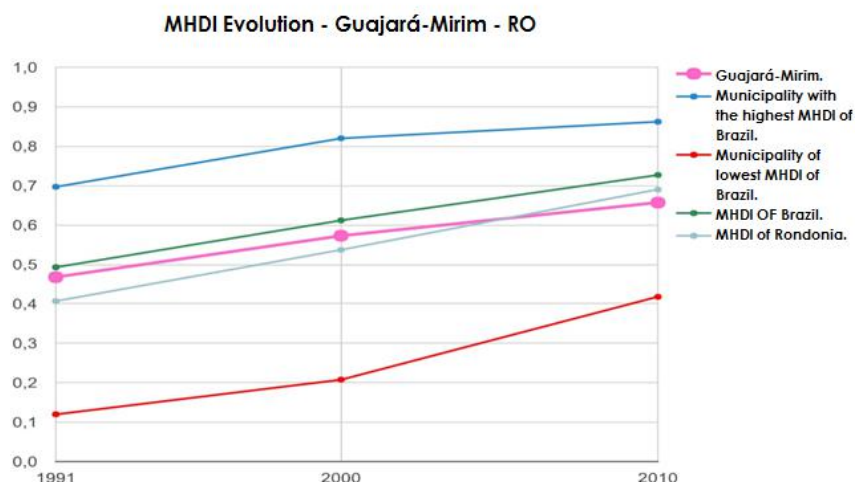
Table 1 Indices of the Municipality in the years according to the Census of the years 1991, 2000, 2010

Index	Year 1991	Year 2000	Year 2010
MHDI	0,468	0,573	0,657
Education	0,247	0,398	0,519
Income	0,625	0,638	0,663
Job	-	67,24 %	62,55 %

The ideal index for each variable would be the equivalent of 1. In this sense, it is noticed that none of the variables is in the situation considered as optimal, or full development. Considering that the installation of the Free

Zone took place in 1991, it can be seen that there were no significant advances, as shown in figure 1. In 2010, the Guajará-Mirim Human Development Index (MHDI) was 0.657, which places the municipality in the Medium

Human Development (MHDI range between 0.600 and 0.699). Contributing to this dimension is the growth of the Income Index with an average of 0.663, and Education, with an index of 0.519.

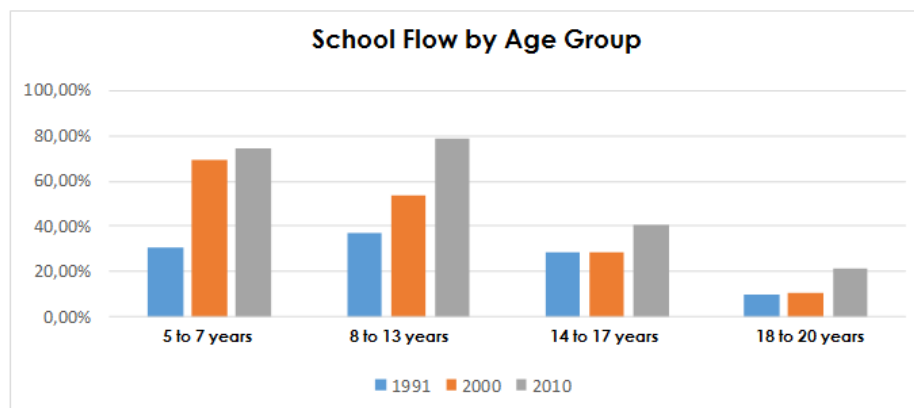


Graph. 1: Municipal Human Development Index

What is verified by means of the graph is that the proportion of growth of the municipality followed the growth of the country, the one can not attribute such factor to the installation of the Free Zone. The MHDI increased from 0,468 in 1991 to 0.573 in 2000, which is equivalent to a growth rate of 22.44%. Already in the

period from 1991 to 2010 the growth of the MHDI of the municipality was 40.38% while the state of Rondônia grew by 47% in the same period.

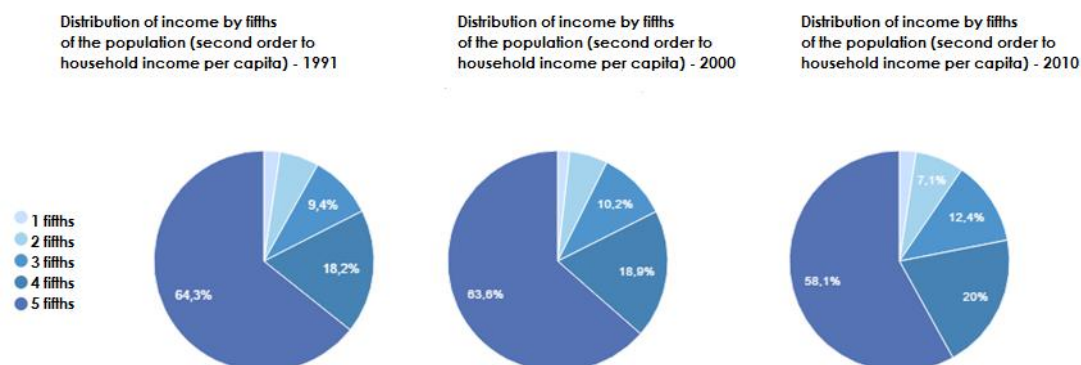
The rates of education were the ones that grew the most, leaving from 0.247 in 1991 to 0.519 in 2010.



Graph. 2: Education Index in the years 1991, 2000, 2010

The gradual growth of education occurred in all age groups and in all years of evaluation. However, growth is still less than the average state and the national average. According to information from the Atlas Brazil, the average per capita income of Guajará-Mirim increased by 26.40% in the last two decades, from R \$ 391.37 in 1991 to R\$ 422.65 in 2000, and for R\$ 494.69 in 2010.

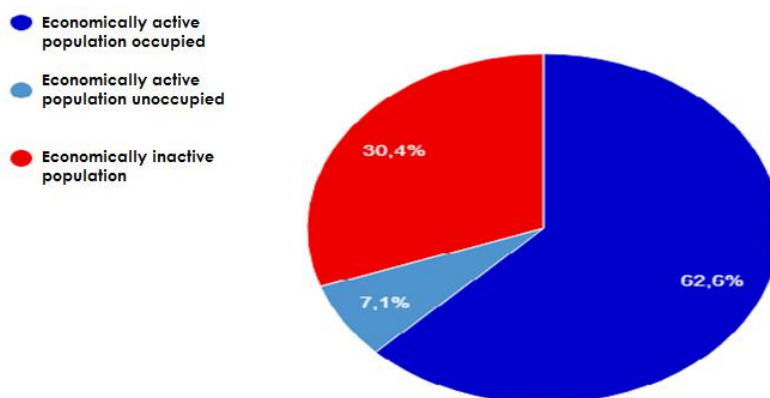
To describe the evolution of income inequality in the periods of analysis the Atlas Brazil uses the Gini, which is an instrument used to measure the degree of concentration of income and points out the difference between the income of the richest and the poorest, being represented on a scale of 0 to 1. Using the Gini index, the evolution of income inequality rose from 0.60 in 1991 to 0.60 in 2000 and to 0.54 in 2010.



Graph. 3: Distribution of Income in the years 1991, 2000, 2010

The income scenario of the municipality did not undergo major changes between the periods analyzed, which

means that there was no factor that could influence the increase in per capita income.



Graph. 4: Composition of the population aged 18 years and over - 2010

The labor scenario presented by the Atlas Brazil, shows that the percentage of the population that was economically active (18 years or more) went from 67.24% in 2000 to 62.55% in 2010. The unemployment rate also decreased from 14.18% to 7.07% in 2010. The services sector is the one with the highest occupancy rate with 51.64%, followed by the commercial sector with 18.26% and by the agricultural sector with 11.33%.

V. CONCLUSION

The data raised in the research does not allow to relate the implantation of the area of free trade in Guajará-Mirin with the growth or development of the municipality, there is a view that in the same period the state of Rondônia grew higher than those presented in Research.

Some public policies such as implantation educational centres favor the development of the region, can be evaluated as a possibility for the increase of educational indexes.

Between 1991 to 2000 the municipality had an increase in population at an average annual rate of 1.74% while the state had a 2.22% increase. In the following decade the population increase of Guajará-Mirin was 0.91%, below the state average. What reveals a migration to the north of

the country, not representing however relationship with free zone of Guajará-Mirin.

To better define the factors contributing to the development of the region, other studies are needed with the detailing of other variables and interviews. It is a fact that public policies favored the region or were the basis for the migration of people to the municipality, seeing that the territoriality of the state of Rondônia is related to the emergence and emancipation of the municipality of Guajará-Mirin.

It is not possible to report whether endogenous factors contributed to the increase in the index of Municipal Human development – IDHM, even in a not so significant way. Territorial factors such as the international border and proximity to the Bolivian city can be pointed to as conditions for growth. It is possible to relate the growth of the municipality with the theoretical construction of Vladimir Lenin on unequal geographical development, because despite being a territory already known since the 18th century, its evolution did not accompany the rest of the country or even the same State.

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Physicochemical Characteristics of Groundwater Quality of Dumne Area NE Nigeria

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Abstract— The aim of this study is to assess the shallow groundwater quality of Dumne Area of northeastern Nigeria for drinking and domestic purposes. The study area is underlain by the alluvium, basalt, gneisses and granitic rocks of northeastern Nigeria. Twenty water samples collected from hand-dug wells and boreholes tapping shallow aquifer were analyzed. Chemical analyses were performed in the laboratory employing standard methods viz Atomic Adsorption Spectrophotometer for cations and conventional titration for anions. In addition ions in milligram per litre were converted to milliequivalent per litre and anion balanced against cations as a control check of the reliability of the analyzed results. The analyzed chemical parameters was interpreted and the result revealed that all other parameters with the exception of pH, potassium, total hardness and zinc falls below the guidelines established by local and international standards. The Gibbs diagrams show that all the groundwater and surface water samples fall within the rock dominance portion indicating that the water quality is largely controlled by water-rock interactions. A plot of the Trilinear diagrams of the water samples indicate $\text{Na}^+ + \text{K}^+$ as the major cations and SO_4^{2-} as the major anions with $\text{Na}^+ + \text{K}^+$ facies as the hydrogeochemical facies. This suggests significant groundwater mixing, water-rock interaction and a common source for both surface water and groundwater samples. Finally it is suggested that all the water samples with high values of pH, Mn^{2+} , phosphate, Fe^{2+} potassium, total hardness and zinc that falls above the guidelines established by local and international standards for drinking and domestic purposes should be treated before use.

Keywords— Groundwater quality, Gibbs diagram, Piper trilinear diagram, Dumne Area, Northeastern Nigeria.

I. INTRODUCTION

Groundwater is a very important natural resource and plays a significant role in the economy of any country. It is

globally important for human consumption irrigation and industrial purposes. It is also important for the support of habitat and for maintaining the quality of base flow to rivers. The chemical composition of groundwater is a measure of its suitability as a source of water for human consumption and for other purposes and also influences ecosystem, health and function (Appelo and Postma 1993). It is thus important to detect change and early warnings of change both in natural systems and resulting from pollution. The chemistry (quality) of groundwater reflects input from the atmosphere, soil and water-rock interactions as well as pollutant sources such as mining, land subsidence, agriculture and precipitation and domestic and industrial waters (Appelo and Postma 1993). Increased understanding of the chemical processes affecting groundwater chemistry of the study area will give an insight into the hydrogeology. Currently groundwater in the study area is intensively used for irrigation processes and other human activities such as industrial and domestic activities. Despite its importance little is known about the natural processes that govern the chemical composition of groundwater or the anthropogenic factors that presently affect them (Garcia et al 2001). This work therefore intends to assess the water quality of the study area.

II. STUDY AREA

The study area lies within longitude 12° 18' E and 12° 30' E and latitude 09° 44' N and 09° 51' N and located in Song Local Government area of Adamawa State. It has an area extent of about 104 km². (Figure 1). It is bounded to the north by Gombi and Hong Local Government Areas, to the east by Maiha Local Government Area, to the south by Fufore and Girei Local Government and to the West by Shelleng and Demsa Local Government Area. It is located about 70 Km north of Yola the capital of Adamawa State. The area is accessible by Yola-Dumne- Song-Gombi highway as well as Dotubi-Dumne and Dumne-Humtoi minor roads. It is traversed by several footpaths and tracks

that provide access to remote villages and mountains and drained by numerous rivers and streams that take their source from hills in the southwestern part and flows towards the low lands in the northeastern parts.

The study area is characterized by hilly topography with structural ridges and inselbergs surrounding the alluvial plains. The hills surrounding the study area include the Bongo three sisters' rocks, Mujaran, Sawim, Murkumchi, Mudungo, Mbal Yebbe and Kiccei-dada hills. The area is drained mainly by streams with Kuade stream as the major one. The streams take their source from the hilly northwestern and southwestern parts and drains through the plains of northeastern and southeastern parts. Denudational processes such as weathering and erosion affected the study area. Physical weathering due to temperature fluctuations lead to the exfoliation of the granitic rocks in parts of the study area. Plants growth also caused the mechanical disintegration of rocks throughout the study area. Chemical weathering resulting from acid rain affected the volcanic rocks of the basement rocks. Sheet and gully erosion are observable in parts of the study area which resulted from the fast flowing surface water runoffs from higher elevation to lower elevation.

The soil types in the study area are products of insitu weathering and erosion of the underlying basement complex rocks. The soil types consist of both lateritic and vegetative soils. They can be classified into Litho soils and Luvi soils (Ray, 1999). The litho soils are shallow soils of less than 10 cm deep and are found around hills, mountain ranges and rock terrains as well as rocky terrains in inselbergs and intervening plains and valleys. The organic content, exchangeable cation and base saturation levels are low to moderate and thus strongly acidic to neutral (Ray 1999). The soils are ferruginized with high iron oxide concentration as well as lateritic and hydromorphic with colours ranging from red to deep brown at B-horizons level. The texture is gravely to loamy-sand surface horizons with relatively low pH (5.1 to 6.1) and moderate to high organic matter. The vegetation is intertropical northern guinea savannah which is characterized by savannah plants/trees such as *Azizella Africana*, *Vitellia paradoxa*, *Terminalia coxiplora* whereas grass species include *peniselum*, *andropogan*, *bracharia*, *hyparrheria* and *aristida*.

The climate of the study area is typically tropical which is variable and dominated by two main seasons the dry season and the rainy season. The rainy season runs between April and October whereas the dry season lasts from November to March. These seasonal climatic conditions are influenced by the North-South fluctuation of the zone of discontinuity called the inter-tropical convergence zone (ITCZ) which

lies between the dry continental Saharan air mass and the humid maritime Atlantic air mass. At the surface it forms a boundary called a surface of discontinuity. Thus during the dry season the surface of discontinuity lies further south showing a southwards movement of wind and pressure from high pressure zone of the Sahara whereas during the rainy season the surface of discontinuity moves up north. The dry continental Saharan air mass causes the dry season which is accompanied by low humidity and intense aridity that makes the atmosphere very dusty whereas the moisture laden humid Atlantic air mass bring about the rainy season. The climate of the study area is often described in terms of the mean values of meteorological variables such as rainfall, temperature, wind, humidity and cloud cover (Hartmann, 1997). Rainfall is the most variable element of the tropical climate. All its characteristics such as amount, intensity and frequency vary with space and time and the variation has influence on the water resources (Adebayo 1999). In the study area, the rainy season begins in April and ends in October. The heaviest rains and the highest number of rainy days were recorded in the months of August and September whereas in some cases rainy season may extend up to the first week of November. The mean monthly rainfall range from 1.40 mm in November to 208 mm in August and from the year 1990 to 2000 the mean annual rainfall was 846 mm (Adebayo 1999). Temperature in the study area is typically of the West African Savannah Climate and is relatively high throughout the year due to high radiation. Temperatures are relatively high in the months of March, April, May and June when the daily maximum temperature may reach 45°C whereas it is low in the months of December and January with temperature value of 20°C. The relative humidity varies seasonally with values of about 90 % during the rainy season (Months of August and September) with values of 45 % to 59 % during the dry season (Months of January to March). This is largely due to the influence of tropical maritime air mass which covers the area (Adebayo 1999). The relative humidity starts to decline as from October following the cessation of rains and becomes extremely low during the harmattan sub-season. Hence, the mean relative humidity ranges from 32 % in December to 77 % in August (Adebayo 1999). The study area is dominated by two trade winds such as the northeast and the southwest trade winds. The northeast trade winds originate from the Sahara desert and occurs from November to April and characterized by thick haze of diatomaceous dust which obscures sun rays and make visibility poor. The southwest trade winds originate from the Atlantic Ocean and occurs from May to September and characterized by high moisture content. The northeast trade winds are associated with the dry season

whereas the southwest trade wind are associated with the rainy season.

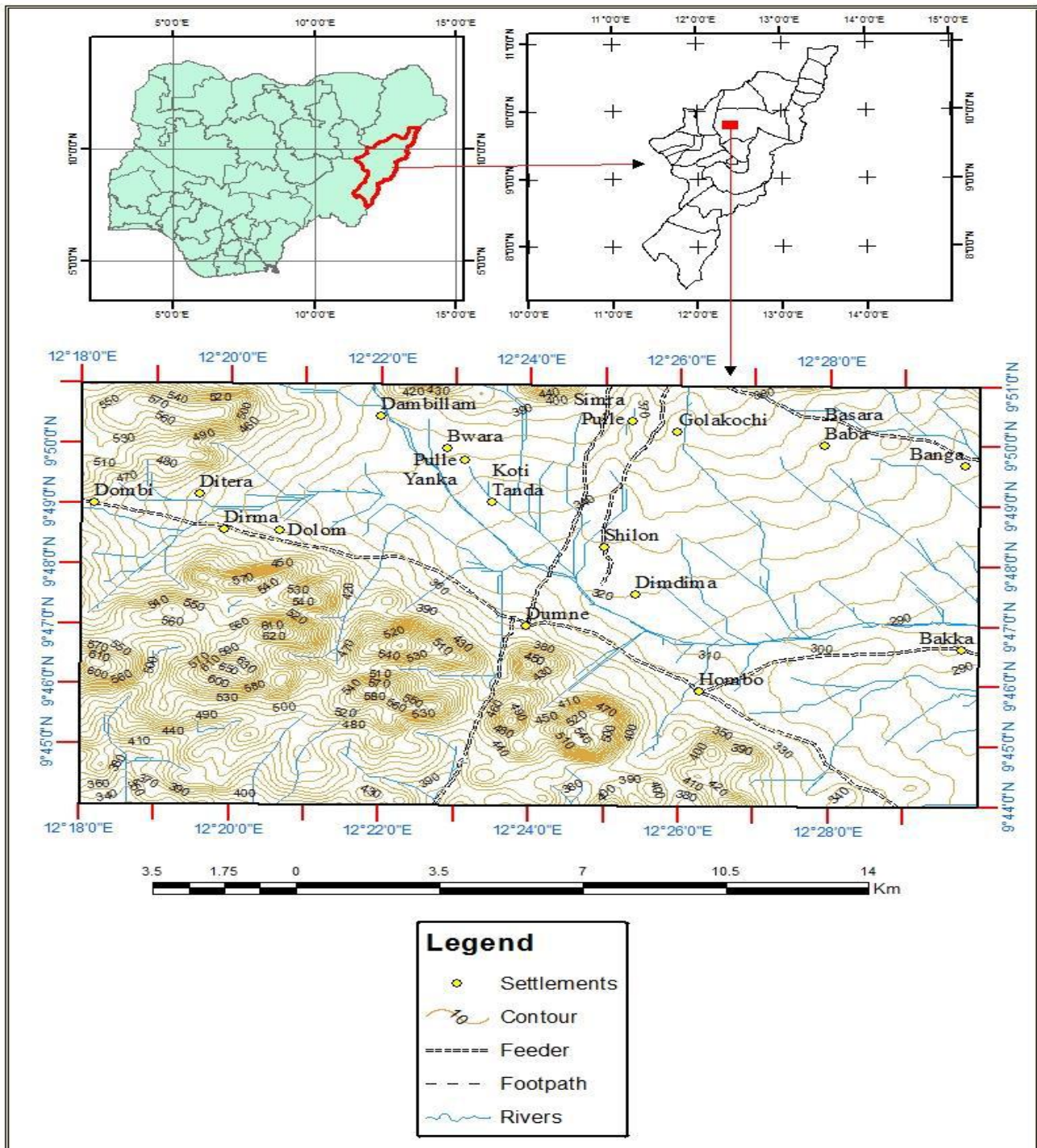


Fig.1: Topographic Map of the Study Area Showing Access Routes

III. LITERATURE REVIEW

Most of the previous works in the study area are mainly regional studies (Falconer, 1911; Dupreeze and Barber,

1965; Kiser, 1968) and discussed the geology and ground water Chemistry of the old northeastern Nigeria. These studies which were more or less outside the study area was

only speculative of groundwater conditions in the study. Subsequently, Carter et al (1963) and Reymont (1965) published some details about the geology, stratigraphy, hydrology and water quality of most parts of the northern Nigeria and classified the water of northeastern Nigeria into Calcium and Sodium Bicarbonate types. Ekwueme (1993) gave details of the basement rocks of northeastern Nigeria in which he classified the rocks as consisting of migmatites, gneisses, diorites, porphyritic granites, volcanic rocks and young alluvial deposits. Ntekim (2001) in his work on groundwater characterization in Adamawa State classified groundwater into Ca-Mg-HCO₃ facies in the sedimentary areas and Ca-Mg-Na-Cl-SO₄ in the basement areas.

Recent works elsewhere (Nwaichi and James 2012, Hadian et al 2015, Khan and Jhariya 2017, Hazi et al 2018) gave a detailed account of the assessment of groundwater quality of parts Niger Delta Nigeria, Java Indonesia and Yazd Iran.

Geology of the Study Area

The study area consist essentially of alluvium, basalt, porphyritic granite and coarse grained granite and gneisses and (Figure 2).

Alluvium

The alluvial deposits are mechanically weathered materials derived from bedrocks and surrounding hills which are found along stream and river channels. They consist essentially of sands, gravels, pebbles and cobbles and are exposed on the plains of the northeastern parts of the study area where intense farming activities takes place.

Basalts

Two types of basalts were encountered in the study area and consist essentially of the vesicular and non-vesicular basalts. They are fine grained with grain sizes ranging from 4 cm to about 8 cm and occur as boulders of different sizes. They are dark coloured and porphyritic with phenocrysts of olivine in a groundmass of calcic plagioclase feldspar and pyroxene with accessory minerals such as iron oxides, magnetite and ilmenite. The vesicular basalt occurs at the base of gneisses south of Dumne and ranges in size from 30 cm to about 60 cm. The vesicle ranges in size between 2 mm to 4 mm in diameter and are randomly distributed within the rock.

The non-vesicular basalts occur as ridges south of Dumne and Gban whereas relics of basaltic flows, represented by boulders and black soils are found in almost all the drainage channels and low-lying plains (Plates 1 and 2).

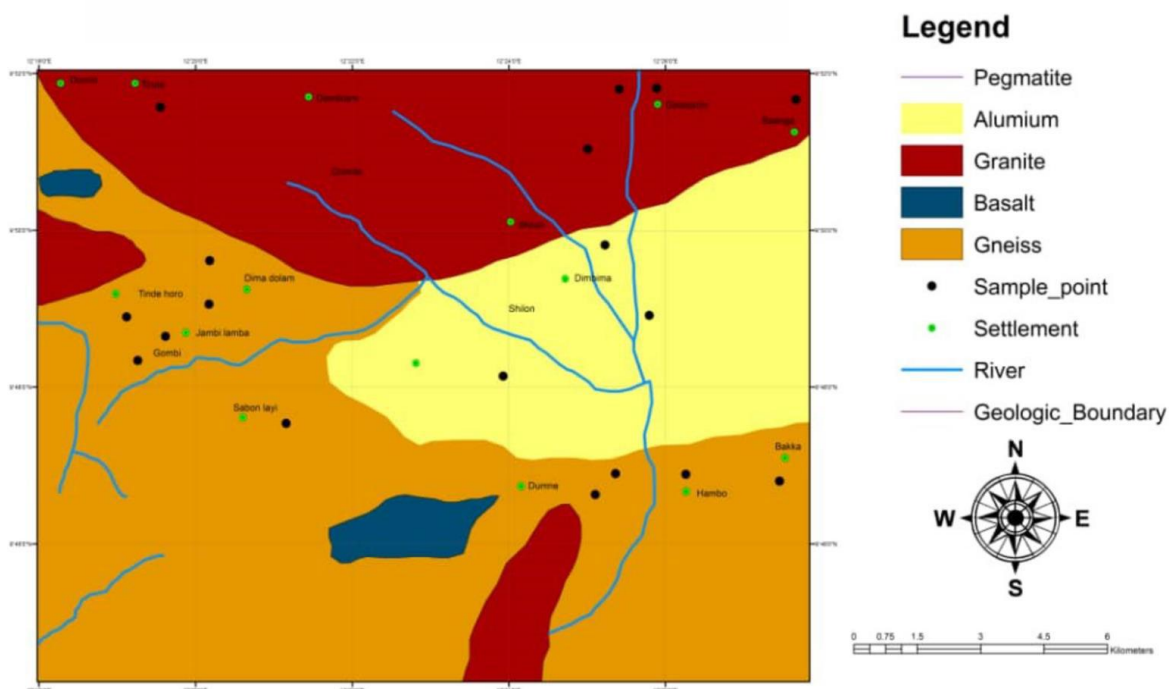


Figure 2: Geological Map of the Study Area

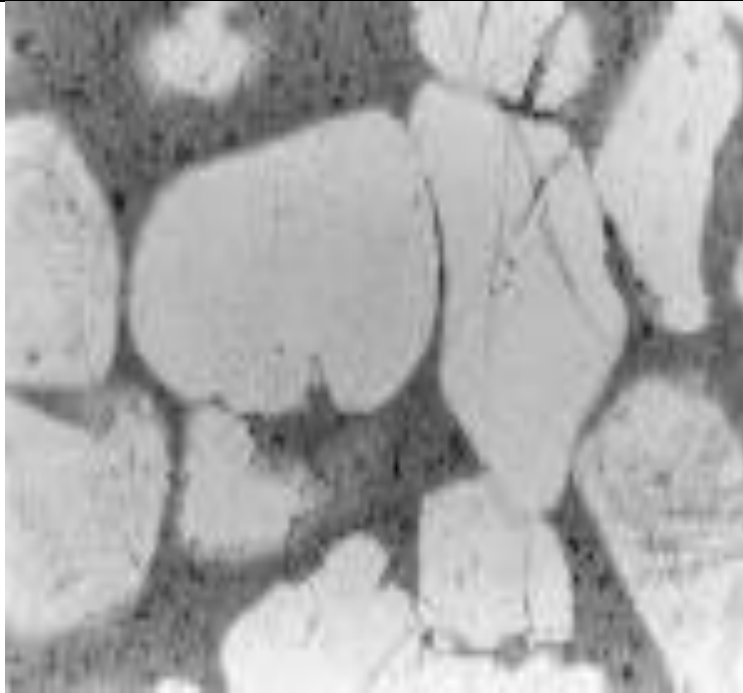


Plate 1 Photomicrograph showing Basalt under plain polarized light

(Magnification x 100)



Plate 2 Photomicrograph showing Basalt under cross polarized light (Magnification x 100)

Granites

Two types of granites namely porphyritic granites and the coarse grained granites occur in the study area. The porphyritic granites outcrop conspicuously at the base of slopes of small isolated hills of Laro, Biri Pintara, Old Prambe, Zamba, Dirma and east of Waltandi. Most of them occur as in-situ boulders of different sizes ranging from 50

cm to 20 m with gradational to sharp contact with the gneisses. The porphyritic granites are sometimes medium to coarse grained and are affected by extensive spheroidal weathered as seen at Dumne, Koti, Biri and Gbengere hills and occur as high reliefs in Gban areas (Plates 3 and 4). They consist of phenocrysts of biotite and hornblende set in a groundmass of quartz and plagioclase.

The coarse grained granites occur in various locations closely associated with the migmatites and gneisses in low reliefs. They occur as plutons and show lithological variations with aplites with exposures of both types

distinctly observed at Shure, Poma, Kubta, Bwara and north of Mopa areas. The rock is crystalline, coarse grained and compact with few distinct fractures of aplitic and pegmatitic composition crisscrossing the rock surface (Plates 5 and 6).



Plate 3 Photomicrograph showing porphyritic granite under cross polarized light (Magnification x 100)

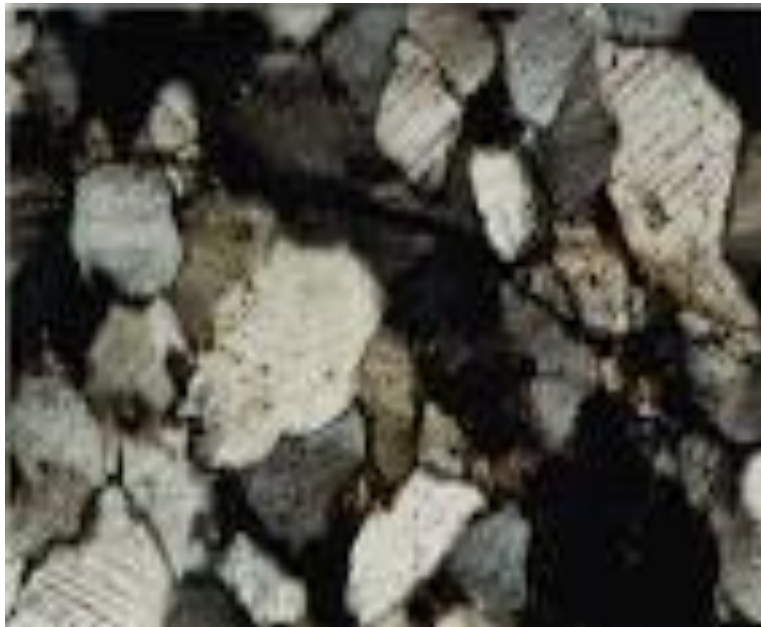


Plate 4 Photomicrograph showing porphyritic granite under cross polarized light (Magnification x 100)

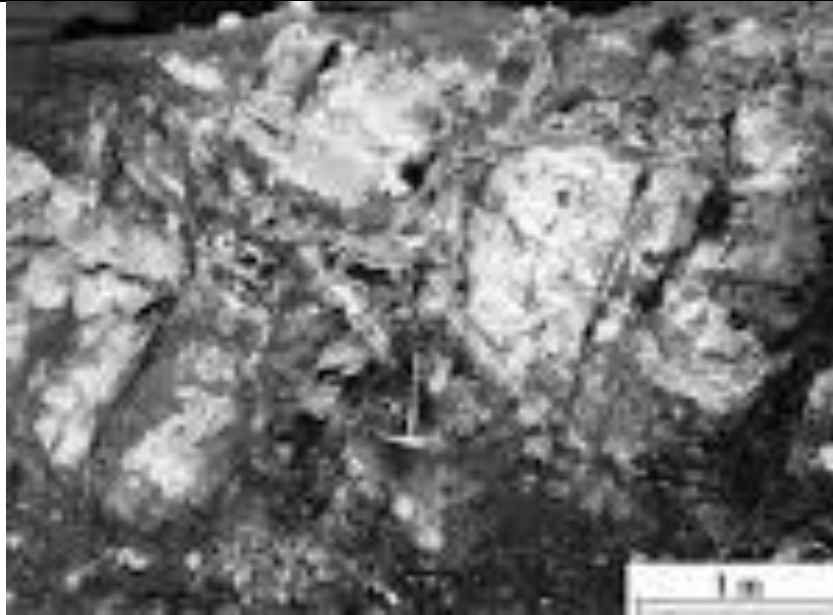


Plate 5 Photomicrograph showing coarse grained granite under cross polarized light (Magnification x 100)



Plate 6 Photomicrograph showing coarse grained granite under cross polarized light (Magnification x 100)

Gneisses

The rocks generally the most dominant gneissic rocks and outcrop sandwiched between migmatites and granites in Dumne, Koti, Waltandi, Biri, Wuro Kitaku, Dombi and Dirma areas. Granite gneisses are the dominant gneissic rocks and were observed. They are granitic in nature which sometimes grade into dioritic composition with increasing mafic minerals especially biotite and hornblende as seen west and south of Dirma and Dombi-Simba and are called biotite-hornblende gneisses. They grade into migmatitic

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gneisses in some places especially towards the base of the hills. They also exhibit weak foliations marked by varied sizes, amounts and orientation of feldspar porphyroblasts. The porphyroblasts are sometimes numerous and moderately large (between 4 mm and 1 cm in width and 1 to 1.5 cm long), lineated, augen-shaped or may show small equidimensional rhombic grains with less pronounced lineation as observed in Dirma, Laro and Old Prambe. In some areas (Koti, Dirma and Waltandi), the rocks are banded and in others especially those with increased biotite

content no distinctive banding is observed. They exhibit variable colours due largely to the nature and proportion of the feldspar and mafic minerals such as biotite and hornblende. They are coarse grained and consist of alternating bands of mafic and felsic minerals with abundant quartz and orthoclase feldspars. They are fractured and intruded by pegmatite dykes which are evidence of recrystallization especially around Gban areas. They are characterized by spheroidal weathering as observed south of Dumne, Zamba, Laro and Woro.

Geological Structure

Joints and Faults

The joints of the study are found in all the rock units with most of them trending WNW-ESE and ENE-WSW and are largely initiated by tectonic activities. This is consistent with the general trend of the Nigerian Basement Complex (Figures 3 and 4).

Faults are cracks in rocks caused by forces that compress or stretch a section of earth's crust. The earth's crust is divided up into several tectonic plates that essentially float on a mantle of plastic, partially mantled rocks. These plates slide under or slide past one another, stressing the rock along the edges of each plate. A new fault forms when the stress on the rock is great enough to cause a fracture, and one wall in the fracture moves relative to the other. Faults can also appear far from the boundaries between tectonic plates when stress caused by rising magma from the mantle overcomes the strength of rocks in the overlying crusts.

Faults in the study area are recognized based on the occurrence of mylonitess, slickensides, shear zones and rock breccia and occur mainly in Tinde, Dumne and Gwaraguda

Quartz Veins

The quartz veins and lenses occur by crisscrosses the granitic basement rocks of the study area. They vary from 10 cm to 40 cm in width and more than 100 m in length and are irregular in shape. They are found in Dumne, Mopa, Shure, Zamba and Dirma.

Pegmatite Veins

Pegmatite veins composed of microcline and quartz minerals were observed in all the rock units. They vary in size from lenses and vein lets of 20 cm to bodies up to 2 m wide and over 100 m long. They are widespread in the western part of the study area around Waltandi, southeast of Gban and Dombi.

Dolerite Dykes

They are the youngest member of the basement complex and occur as tabular and jointed unmetamorphosed bodies crosscutting the Gneisses and Older Granites in Waltandi, Gban, Shure and Dumne. They are generally dark in colour

with some pale green spots of olivine when observed in hand specimen.. They range from 6 cm to 1.5 m wide and over 50 m long.

Mylonite

The mylonites are found in Gban and Dumne within the Gneisses and Older Granites. They are brecciated and sheared containing angular fragments produced by the fracturing, crushing and differential movement of the component grains of pre-existing rocks. They are fine to medium grained, creamy white in colour and trends ENE-WSW coinciding with the trend of the Benue Trough as found in Gban area. They exhibit some streaky or banded structure which have been pulverized indicating faulting and accordingly large mylonitic zones or shear belts as observed in the study area are usually associated with faulting and fault zones.

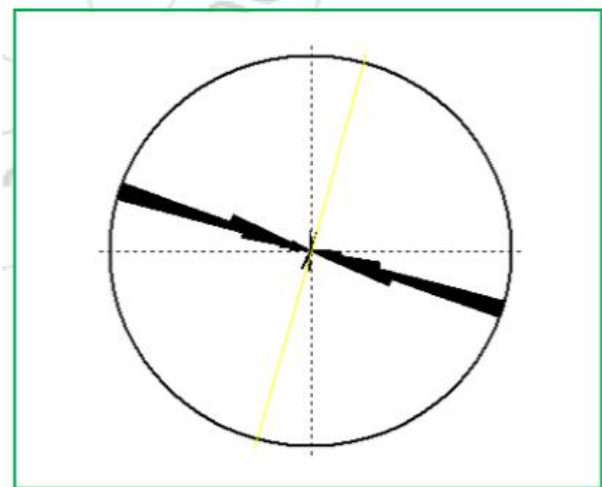


Fig.3: Rose Diagram of Lineaments in Granitic Rocks in Dumne Area (Total number of points = 25)

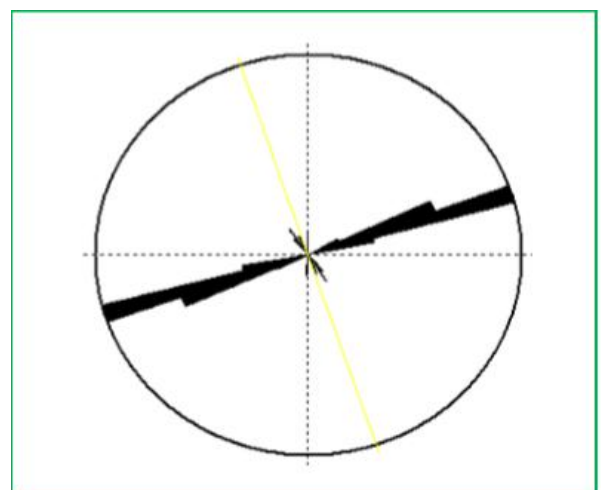


Fig.4: Rose Diagram of Lineaments in Granitic Rocks in Tinde Area (Total number of points = 20)

Hydrogeology of the Study Area

The study area is underlain by the Precambrian Basement rocks consisting essentially of alluvial deposits, basalt, porphyritic granites, coarse grained granites, gneisses and migmatites. These rocks have been subjected to tectonism leading to fracturing and as a result the occurrence of joints, faults, dykes and veins as well as intrusion of basaltic rocks. Furthermore these rocks have subsequently undergone complete weathering and lateritization resulting in the occurrence of unconsolidated weathered overburden materials such as gravels, clays, laterites and sands. Subsequently, two aquifer units have been identified in the study area based on geological reconnaissance namely; the unconsolidated weathered overburden and the fractured basement aquifer units (Obiefuna et al 1997).

This study is confined to shallow groundwater hosted within the unconsolidated weathered overburden aquifer unit that are tapped mainly by hand-dug wells and shallow boreholes. These wells are considered to be vulnerable to pollution by largely anthropogenic activities that is tapping place regularly in the study area.

IV. MATERIALS AND METHODS

The first step involve the use of topographic map of the study area in the identification of the rock formations as well as their structural and stratigraphic relationships. Geological field mapping was undertaken in order to collect, identify and study the field occurrences and structural relationship of all the rock types present in the study area. Fresh and unweathered rock samples were broken for hand specimen examination. Preliminary observation and identification of each constituent mineral were carried out using magnifying lens. Other structural imprints like joints trends, dimensions of xenoliths, veins dykes were also recorded, Sources and causes of groundwater pollution were located and plotted on a map. This was followed by detailed surface and subsurface geologic and hydrogeological studies during which geological boundaries were demarcated and hydraulic parameters measured. An inventory of wells in the area were performed which included location with Global Positioning System (GPS) and documentation of each well site, including land-use, soil type, geology,

Chemical Analyses of water samples

Analytical Techniques/ Procedures

For water analyses and assessment regarding the suitability of water for human consumption and other domestic purposes, specialized sampling and sampling procedures are required. The site of sampling was selected randomly taking cognizance of the geology and soil characteristics,

geographical distribution of wells as well as density, method and place of storage of samples prior to analyses, effects of human activities and environmental constituents such as surface scums and leachate contaminations.

A total of twenty shallow ground water samples consisting of hand-dug wells and shallow boreholes were collected from different locations between the months of August and September 2017.

The samples were filtered through a thin polycarbonate membrane with 0.45µm pore size and collected in polyethylene bottles of four litre capacity with stopper. Each bottle was washed with 2% Nitric acid and then rinsed several times with distilled water and preserved in a cool, clean place prior to analysis.

The water samples were analyzed for various parameters in the chemical laboratory of the Adamawa State Water Board Yola, Nigeria. Various physicochemical parameters like Temperature, pH, Turbidity, Total Dissolved Solids (TDS), Total Hardness, Dissolved Oxygen (DO), Electrical Conductivity (EC), Chloride, Sulphate, Total Alkalinity, Fluoride, Iron, Calcium, Magnesium, Nitrate-Nitrogen have been measured.

In general, the standard methods recommended by APHA, AWWA, WPCF (1998), USEPA (2003) were adopted for determination of various physico-chemical parameters. A brief description is given as follows;

Physicochemical parameters such as Temperature, pH, Turbidity, Dissolved Oxygen (DO), Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were measured using water analysis kit model (Merk, DR Spectrophotometer 2400). All multi-probes of the kit were calibrated together using the same standards and procedures.

Electrical Conductivity was calibrated against 0.005, 0.05 and 0.5 M standard potassium Chloride solutions. pH was calibrated with standard buffer solution at pH-4 and pH-9.2. Dissolved Oxygen was calibrated against zero solution (Sodium Sulphite) and an air saturated beaker of water checked with a Winklers's titration. Temperature is factory set and cannot be adjusted but was checked against a standard Mercury Thermometer for consistency between multi-probes. Turbidity was calibrated with standard solution of 400 NTU using Hydrazine Sulphate and Hexamethylenetetramine. Dissolved Oxygen was also measured by modified Winkler's method at the site.

For the determination of Hardness, 50 ml of sample was buffered at pH 8-10 (NH₄Cl and NH₄OH) and titrated against standard EDTA using Erichrome Black T indicator. Calcium was measured by titrating the water sample against standard EDTA using murexide indicator. Magnesium was

determined by calculation method using the formular (APHA, AWWA, WPCF 1998).

$$Mg(Mg/l) = (Total\ Hardness - Calcium\ Hardness) \times 0.243 \quad (1)$$

The Total Alkalinity was measured by titrating the sample against N/50 solution of sulphuric acid using methyl orange and phenolphthalein indicator respectively. Chloride content was measured by titrating against N/50 solution of silver nitrate using potassium chromate as indicator. Fluoride, Sulphate, Nitrate-Nitrogen and Iron were determined spectrophotometrically following the standard procedure recommended by APHA, AWWA, WPCF (1998). All the samples were assessed for charge balance and most of them fall within the acceptable range of ± 5 .

V. RESULTS AND DISCUSSION

Assessment of physicochemical qualities of groundwater

The summary of the groundwater parameters and composition with the World Health Organization standards (WHO 2013) and Nigerian Standard for Drinking Water Quality (NSDWQ 2007) for drinking suitability is indicated in Tables 1. The table revealed that all other parameters with the exception of pH, Mn^{2+} phosphate, Fe^{2+} , potassium, total hardness and Zinc falls below the guidelines established by the world Health Organization (WHO 2013) and (NSDWQ 2007) for potable water.

The pH values in more than 78% of the groundwater samples fall above the (WHO 2013) and (NSDWQ 2007) recommended limit of 6.5 to 8.5 whereas that of surface water samples falls within the recommended limit with a value of 7.11. This indicate largely alkaline groundwater but nearly neutral surface water which could be attributed to the precipitation and dissolution of carbonate or calcite minerals within the underlying basaltic rocks. The generally high alkaline groundwater however does not impact human health but can alter and affect the taste of the groundwater.

The groundwater samples of the study area revealed elevated Mn^{2+} values ranging from 5.00 mg/l to 7.10 mg/l with a mean value of 6.00 mg/l whereas those of Fe^{2+} values varies from 0.17 mg/l to 8.57 mg/l with a mean value of 0.85 mg/l. These values are largely above the WHO (2013) and NSDWQ (2007) limits of 0.50 mg/l for Mn^{2+} and 0.30 mg/l for Fe^{2+} . The elevated values of manganese and iron in groundwater samples could be attributed to the weathering of manganese and iron bearing minerals that make up the underlying igneous rocks in the study area. Other possible sources include leakages from poorly constructed sewage facilities and/or organic rich soil materials.

The values of phosphate ranges from 0.10 mg/l 0.92 mg/l with a mean value of 0.69 mg/l whereas those of potassium

varies from 458 mg/l to 522 mg/l with a mean value of 493.22 mg/l. These are largely above the WHO (2013) and (NSDWQ 2007) recommended limit of 0.30 mg/l for phosphate and 50 mg/l for potassium respectively. The relatively high values could be attributed to anthropogenic activities such as application of fertilizer and animal wastes in farming as well as leaching and dissolution of phosphate and potassium from minerals that make up the underlying igneous rocks in the study area. Phosphates and potassium as important fertilizers are strongly held by clay particles in soils and is also soluble in water and increases in concentration with time. Therefore leaching of phosphate and potassium through the soil profile and into groundwater is important particularly in coarse-textured soils (Groundwater Monitoring and Assessment Programme (1999).

The zinc concentration in the sampled water varies from 33.44 mg/l to 41 mg/l with a mean value of 38.17 mg/l is by far above the WHO (2013) and (NSDWQ 2007) recommended limit of 3 mg/l. The primary source of zinc are the underlying igneous rocks where they can occur in significant quantities whereas the anthropogenic sources include industrial wastes and sewage sludges. They however do not represent drinking water concerns in ambient groundwater but proper disposal of industrial wastes remains the best management strategy for reducing the potential impacts of this metal on groundwater quality.

The dataset of groundwater samples in the study area revealed total hardness values ranging from 85 mg/l to 93.42 mg/l with a mean value of 88.16 mg/l whereas surface water displayed a value of 63.98 mg/l. Thus while the total hardness values of both groundwater and surface water samples fall below the WHO (2013) and (NSDWQ 2007) permissible limit of 500 mg/l the Sawyer and McCarty (1967) classification indicate that they are largely moderately hard water. Water hardness in most groundwater naturally occur from weathering of limestone, as well as from calcium bearing minerals in the underlying rocks. They can also occur locally in groundwater from chemical and mining industrial effluent or from excessive application of lime to the soils in agricultural areas. The relatively high hardness values recorded in the groundwater samples are largely due to anthropogenic activities such as the excessive application of lime to the soils in farming activities in the study area.

Table 1 Summary of Physicochemical parameters of the shallow groundwater in the Study Area.

PARAMETER	RANGE	MEAN	WHO (2013)	NSDWQ (2007)
<i>pH (unit)</i>	8.10-9.00	8.66	6-5 – 8.5	6.5-8.5
<i>Temperature (°C)</i>	27-29	27.98	-	
<i>EC (μS/cm)</i>	400-473	445.11	1400	1400
<i>TDS (mg/l)</i>	278.10-346	304.43	500	500
<i>Turbidity (NTU)</i>	0.002-1.101	0.301	5	5
<i>Calcium (mg/l)</i>	41.66-57.12	48.53	75	75
<i>Magnesium (mg/l)</i>	7.00-9.10	7.97	50	50
<i>Sodium (mg/l)</i>	0-1.20	0.23	200	200
<i>Potassium (mg/l)</i>	458-522	493.22	50	50
<i>Zinc (mg/l)</i>	33.44-41.00	38.17	3.0	3.0
<i>Manganese (mg/l)</i>	5.00-7.10	6.00	0.50	0.50
<i>Total Hardness (mg/l)</i>	84.99-93.42	88.16	500	500
<i>Bicarbonate (mg/l)</i>	35.92-47.81	39.91	1000	1000
<i>Carbonate (mg/l)</i>	0.001-0.550	0.38	500	500
<i>Sulphate (mg/l)</i>	39.82-69.98	62.55	400	400
<i>Chloride (mg/l)</i>	0.001-0.004	0.002	250	250
<i>Fluoride (mg/l)</i>	0.001-0.012	0.008	1.50	1.50
<i>Phosphate (mg/l)</i>	0.100-0.918	0.69	0.30	0.30
<i>Nitrate-N</i>	0.937-2.100	1.24	10	10
<i>Iron (mg/l)</i>	0.167-8.568	0.85	0.30	0.30

Hydrogeochemical Facies

The Piper trilinear diagram is used to categorize the water facies on the basis of dominant ions (Piper 1944). In Piper diagram, major ions are plotted in two base triangles as major cations and major anions. It shows the relatively concentrations of the different ions from the individual samples based on average values for each location. The Piper trilinear Diagrams are plotted to illustrate chemical differences between water samples collected from different boreholes and hand-dug wells (Figures 5 and 6).

The results revealed that both the hand-well and borehole samples indicate $\text{Na}^+ + \text{K}^+$ as the major cations and SO_4^{2-} as

the major anions with the $\text{Na}^+ + \text{K}^+$ facies as the major hydrogeochemical facies. The similarity in major cation and major anion types as well as hydrogeochemical facies indicate significant groundwater mixing, water-rock interaction and a common source for both water sources. It further reveals relatively old groundwater samples and the preponderance of alkali metals ($\text{Na}^+ + \text{K}^+$) over the alkaline earth metals ($\text{Ca}^{2+} + \text{Mg}^{2+}$) as well as strong acids ($\text{SO}_4^{2-} + \text{Cl}^-$) over weak acids ($\text{CO}_3^{2-} + \text{HCO}_3^-$) in both hand-well and borehole samples in the study area.

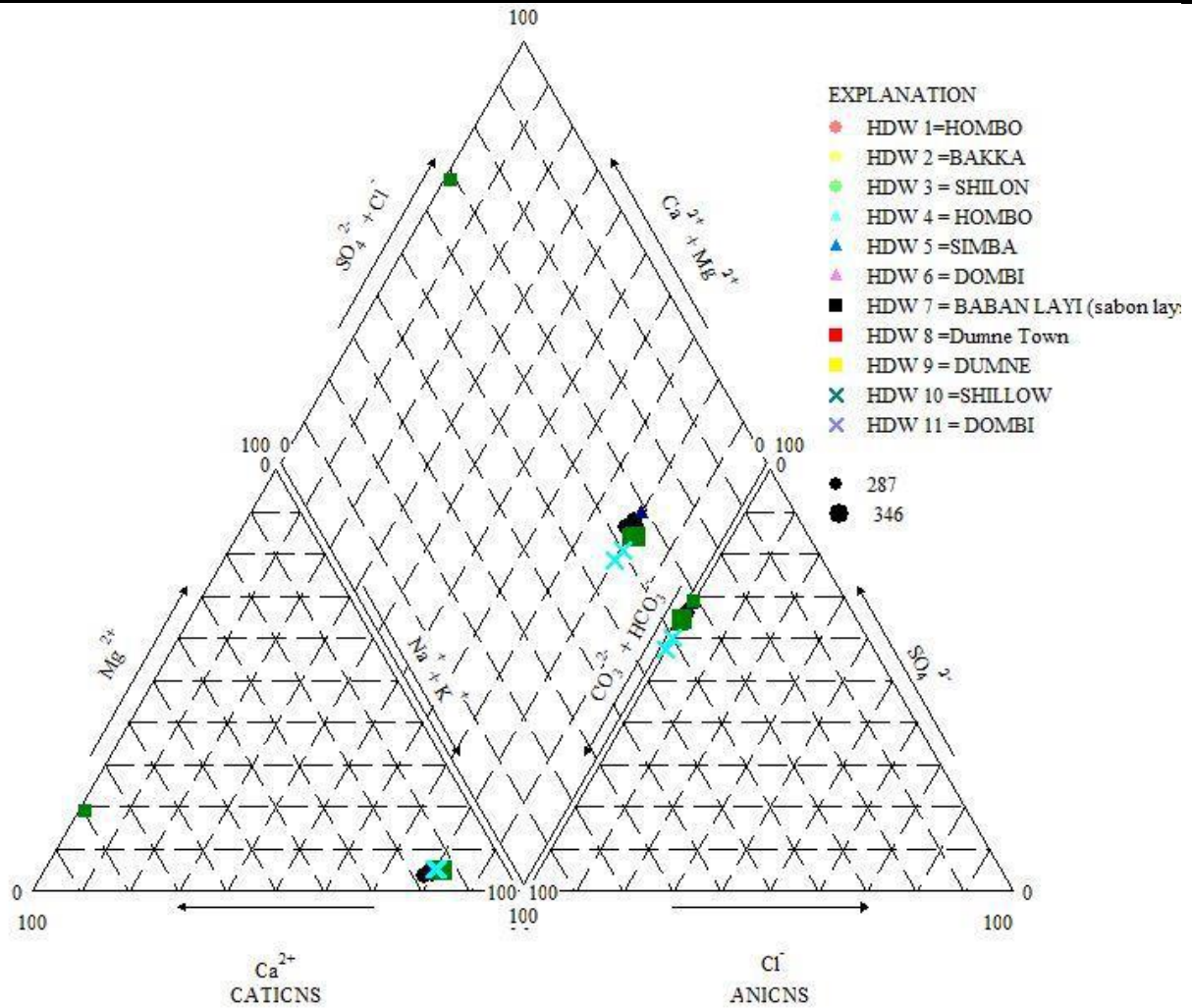


Fig.5: Piper Trilinear Diagrams for Hand-dug Wells in the Study Area

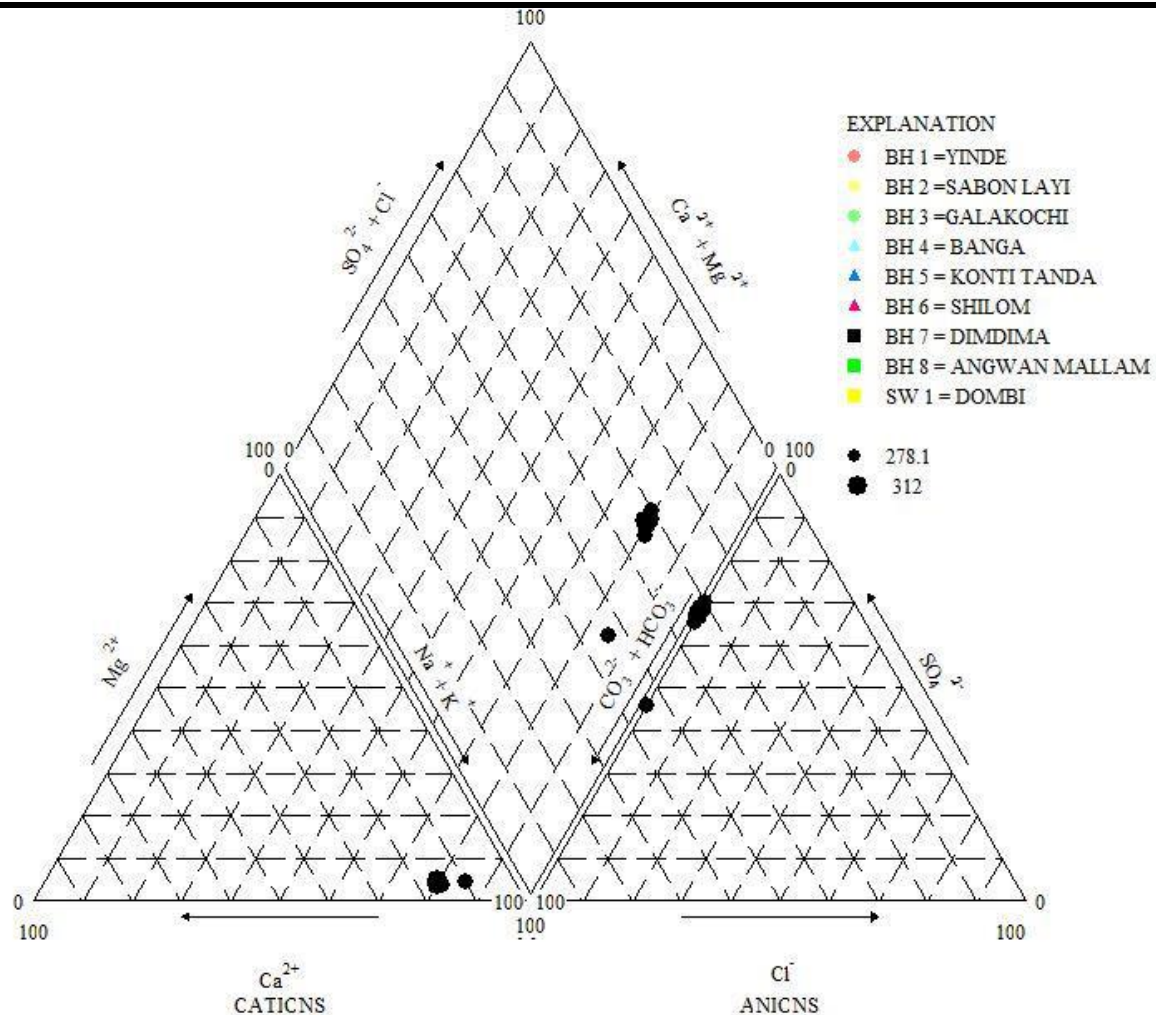


Fig.6: Piper Trilinear Diagrams for Boreholes and Surface Water in the Study Area

Gibbs (1970) proposed two diagrams to understand the hydrogeochemical factors that control the groundwater chemistry by plotting a graph of the ratio of cations ($\text{Na}+\text{K}/\text{Na}+\text{K}+\text{Ca}$) in milliequivalent/litre against TDS in mg/litre as well as the ratio of anions ($\text{Cl}/\text{Cl}+\text{HCO}_3$) in milliequivalent/litre against TDS in mg/litre. The Gibbs plot of both the groundwater and surface water samples revealed

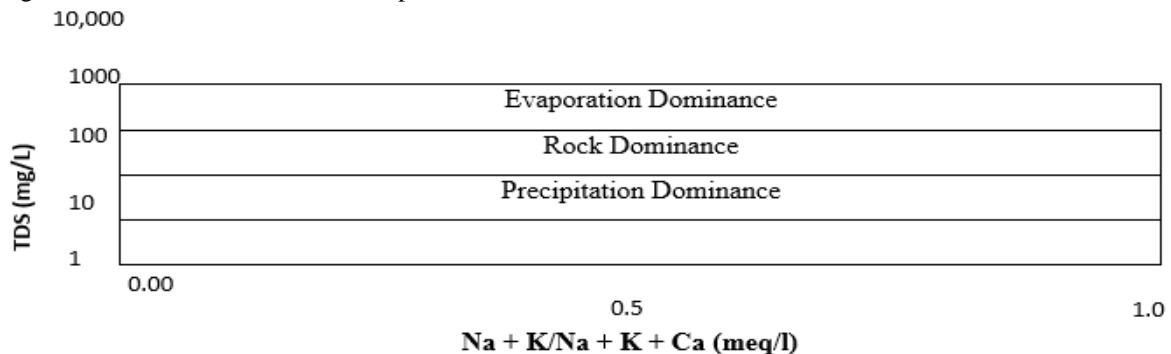


Fig.7: Mechanism controlling groundwater chemistry (Gibbs I).

that the datasets plot within the rock dominance portion indicating that the groundwater and surface water chemistry are strongly controlled by the water-rock interactions (Figures 7 and 8). Thus rock-water interaction is the key factor that controls the chemistry of groundwater in the study area (Alam 2013; Raju et al 2011).

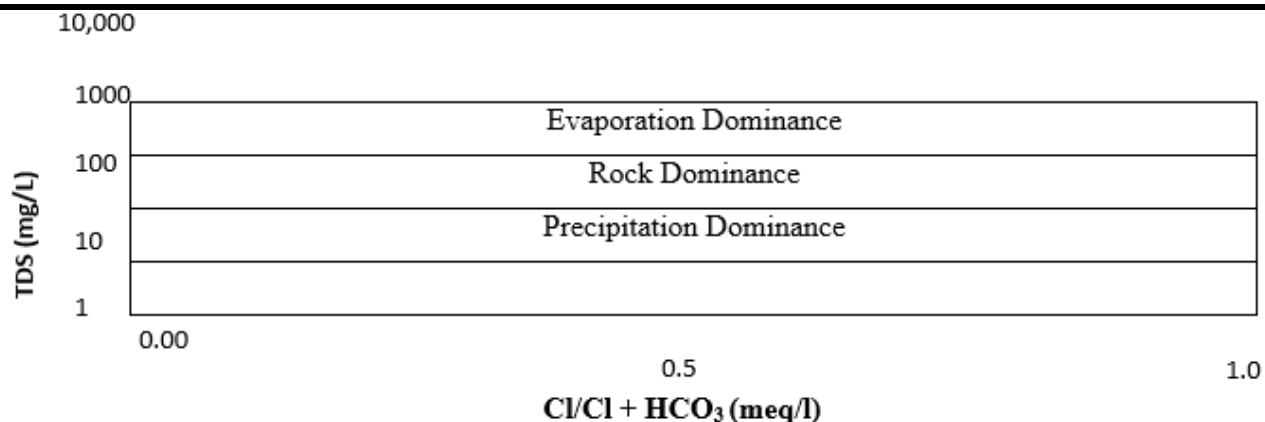


Fig.8: Mechanism controlling groundwater chemistry (Gibbs II).

VI CONCLUSIONS

This study revealed that all other parameters with the exception of pH, potassium, total hardness and Zinc exceeded the guidelines established by the world Health Organization (WHO 2013) for potable water.

The pH values in more than 78% of the groundwater samples fall above the (WHO 2013) recommended limit of 6.5 to 8.5 whereas that of surface water samples falls within the recommended limit with a value of 7.11. This indicate largely alkaline groundwater but nearly neutral surface water which could be attributed to the precipitation and dissolution of carbonate or calcite minerals within the underlying basaltic rocks. The generally high alkaline groundwater however does not impact human health but can alter and affect the taste of the groundwater.

All the groundwater and surface water samples in the study area display potassium values above the WHO (2013) recommended limit of 250 mg/l with values ranging from 458 mg/l to 522 mg/l and a mean value of 4.87 mg/l. The relatively high values could be attributed to anthropogenic activities such as application of fertilizer and animal wastes in farming as well as leaching and dissolution of potassium from minerals that make up the underlying igneous rocks in the study area. Potassium as an important fertilizer is strongly held by clay particles in soils and is also soluble in water and increases in concentration with time. Therefore leaching of potassium through the soil profile and into groundwater is important particularly in coarse-textured soils (Groundwater Monitoring and Assessment Programme 1999).

The zinc concentration in the sampled water varies from 33.44 mg/l to 41 mg/l with a mean value of 38.17 mg/l is by far above the WHO (2013) recommended limit of 3 mg/l. The primary source of zinc are the underlying igneous rocks where they can occur in significant quantities whereas the

anthropogenic sources include industrial wastes and sewage sludges. They however do not represent drinking water concerns in ambient groundwater but proper disposal of industrial wastes remains the best management strategy for reducing the potential impacts of this metal on groundwater quality.

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Propensity to Patent Brazilian Companies: importance of Economic and Financial Performance

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Abstract— *The innovation process is a global phenomenon that affects the economic sectors, especially the companies. Patents help in the process of business competitiveness and serve as a business strategy. The objective of this paper was to investigate how the economic and financial factors affect the decision to deposit patents of publicly traded companies listed on the stock exchange Brasil, Bolsa, Balcão (B3). The data used are a fusion of the information provided by two sources: patent data provided by the National Institute of Industrial Property (INPI) and company data of the financial information system of the B3 Stock Exchange, in the period from 2010 to 2017. The data were analyzed using descriptive statistics and the logit econometric model. The results indicate that the companies with greater propensity to patent are characterized as being large, with lower general and short term indebtedness and with lower overall liquidity, together with a higher potential of the asset add value. They are also more likely to be assignor and assignees of technology transfer contracts, in addition to being generally in sectors of high or low technological intensity. The results also show that financial performance indicators have a significant negative impact on the probability of a company filing a patent application.*

Keywords— *industrial property, innovation, stock exchange.*

I. INTRODUCTION

Analyzing the indexes of innovation and protection of intellectual property, Brazil has inferior positions when compared to international ones. In 2018, according to the ranking of the Global Innovation Index (GII), developed in partnership between Cornell University, INSEAD and the World Intellectual Property Organization (WIPO), Brazil ranked 64th [1]. Regarding the Intellectual Property Protection Index (IPPI), according to the World

Economic Forum, the country was in the 77th position among the 140 countries analyzed [2].

Brazilian companies have reduced participation among the leading patent filing organizations in the country. In a survey of the Foundation for Research Support of the State of São Paulo (FAPESP), 9 of the 15 leading organizations in the period 2000-2005 were companies, a figure that reduced to three in the 2013-2017 list [3]. Considering only 2017, the INPI report, which refers to the ranking of the ten main patent depositors resident in the country, only one company was included in the group, ranking 7th [4].

Brazil has low performance in the world rankings of innovation and presents a reduction of the participation of the companies among the main patent applicants in the country, in spite of the growth of the deposits. In this sense, it is necessary to understand how the economic and financial factors alter the propensity to patent the companies, that is, how these factors influence the probability of the company to patent. The patent is an industrial title of invention or utility model. The basic function of a patent, originally established by the intellectual property system, is to provide an effective instrument to prevent imitation by competitors. This can guarantee gains of innovative technologies for the inventor and cover their expenses [5].

The decisive factors in deciding whether or not firms have patents has been the subject of several studies, however, little attention has been given to economic and financial performance indicators. Data obtained from companies in the Netherlands from 1988 to 1992 allowed the identification of propensity to patent and how it varies between companies of different sizes and sectors, concluding that small firms are less likely to deposit patents and the sectors pharmaceuticals, chemicals and precision instruments is more likely to patent [6]. It has also been identified that the innovative effort and the degree of innovation codification affect the probability of

the company depositing patents through analyzes carried out in industrial companies in Spain [7].

Studies carried out with primary data in Belgium for the year 2001 indicate that the propensity to patent is affected by company characteristics (age, size, foreign subsidiary and degree of internationalization), sector characteristics (sector concentration, high-tech sector, service sector) and innovation strategy (new product or processes development, basic and applied research, collaboration partners). It was found that firms that have innovation strategies through partnerships are the ones that are most likely to patent [8].

Analyzing the food and beverage industry in the United States between 2000 and 2014, with variables of company characteristics (age and size) and financial characteristics (lagged income and debt ratio), it was concluded that the size, age and lagged income has a positive effect on the propensity to patent [9].

In general, the factors that influence a company's decision to patent an innovation vary among firms, industries and countries. The firms' propensity to patent is influenced by internal factors such as size, knowledge codified, internal R&D, firm's age, type of patent, and productivity output, and by external factors, such as international market, high price competition, collaboration with other entity and clustering area [10].

This article contributes the state of the art to determinants of propensity to patent in at least three different aspects. This article contributes the state of the art on patent application determinants in at least three different aspects. First, it reduced the lack of research on the relationship between economic and financial performance and the probability filing corporate patents. A second aspect is the construction of a new database that aggregates patent information with the companies' accounting statements. This allows the calculation of economic and financial performance indicators of companies in the Brazilian stock market. Finally, it complements the literature with data from Brazil, since previous studies are based mainly on data from North American or European companies. In this context, the objective of this study was to investigate how economic and financial factors affect the decision of companies to deposit patents.

In the econometric results the financial performance indicators had a significant impact on the probability of a company filing a patent, indicating that this factor should be better studied by studies in which the determinants of the propensity to patent the firms are investigated. Among the indicators of economic performance, measured productivity was the only one that had a positive and significant effect.

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1.1 Hypotheses

The variables of economic and financial performance are accounting indicators that make it possible to analyze the company's situation in five aspects: liquidity, indebtedness, profitability, intangibility and productivity. To answer the problem question of how economic and financial performance indicators influence the propensity to patent companies, the following hypotheses have been constructed.

H1: Liquidity negatively influences the propensity to patent.

Liquidity refers to the ease with which a company can meet its financial obligations with available assets. Current Liquidity and General Liquidity index are used to measure liquidity. There are few empirical studies that investigate how liquidity relates to patent filing. However, it is noted that the increase in the liquidity of a company's shares causes a reduction in future innovation [11]. Thus, it is expected that the higher the accounting liquidity indices the lower the likelihood of filing patents. H2: Indebtedness negatively influences the propensity to patent.

The General Debt Ratio and Short-term Debt Ratio indexes are used to capture corporate indebtedness. Companies that face high levels of indebtedness will find it more difficult to obtain financing and resources to apply for innovation and patent deposit because of the risky investment type [12], [13]. In this way, the indebtedness indexes are expected to have a negative relation to patent application.

H3: Profitability positively influences the propensity to patent.

The profitability of companies is measured by the Return on Asset (ROA) and Return on Equity (ROE) indexes. The relationship between profitability and corporate patent application is still not well established. While studies point out that firms' innovation activities, such as patent applications, are not necessarily associated with higher profitability [14], other studies indicate that profitability positively influences patent citation, and presents a mechanism that also explains the influence profitability on the patent application [15].

H4: Intangibility positively influences propensity to patent

Intangibility refers to the share of intangible assets in the company's investment structure. In Brazil, the Accounting Pronouncements Committee, based on the International Accounting Standard (IAS) 38 [16], establishes the accounting standard regarding the recognition and

measurement of intangible assets. According to this standard, the intangible asset is defined as a non-monetary, identifiable and non-physical asset. For an asset to be identifiable, it must be separable, and can be negotiated on an individual basis, and be the result of contractual rights. The concept of identifiable assets is mainly necessary to distinguish intangible assets from goodwill, which represent advantages that are not specifically identifiable [17].

There are many possibilities of investing in intangible assets by companies, such as softwares, patents, copyrights, trademarks, customer lists, licenses, franchises, among others. In all possibilities, knowledge is always linked to assets. However, to qualify for intangible assets, they should be identifiable, controlled and generate future economic benefits [16].

The Asset Intangibility (AI) and Equity Intangibility (EI) indexes measure the share of intangible assets in the company's capital. The intangible assets represent the stock of immaterial resources that characterize the process of production of new products or processes, and are therefore directly related to the innovation capacity of companies [18]. In this way, intangibility is expected to positively influence the probability of patent applications. H5: Productivity positively influences the propensity to patent.

Firm productivity is expected to be positively related to patent filing [19]. More productive companies usually have more specific internal knowledge that can be protected by patent deposits. The Equity's Potential to Add Value and the Asset's Potential to Add Value indexes are used to measure corporate productivity. Figure 1 presents a research framework related to the aforementioned hypotheses.

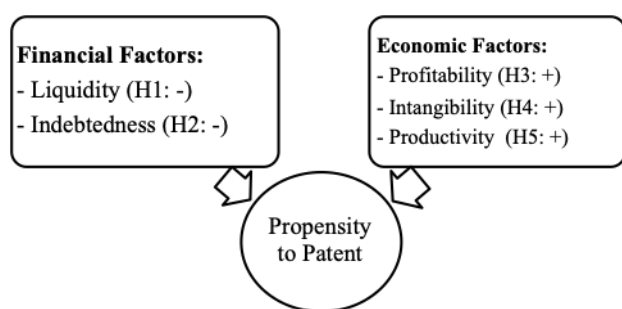


Fig1: Research framework of financial and economic factors in the propensity to patent companies.

1.2 Control Variables

Other variables are likely to influence the propensity to patent. The control variables used in this study are whether companies have a technology transfer contract as assignor or assignee and technology intensity sector, as well as their age and size.

Two main reasons are usually presented to explain why patent registration is positively related to company's size.

The first is that large companies have greater ability to manage information, maintain large R&D departments, and attract the best technicians and scientists. Thus, large companies introduce more often than smaller companies, original innovations that make it possible to register a patent [20], [21]. The second reason concerns the financial constraints faced by smaller firms, since the cost of patent protection - including the costs of obtaining and maintaining a record, monitoring whether a violation occurs and litigation - is relatively high for smaller firms [22].

The company's age represents the time in years of the constitution until the observed year and can be considered a factor favorable to the deposit of patents. One explanation is that the technological processes are cumulative and the time of experience favors the obtaining of innovative results that can be translated into patents [23]. Another factor is that the protection and appropriation of the value of innovation is a long-term process associated with organizational learning [24].

Technology transfer is the relationship between assignor - that transfers technology that develops or owns - and assignee - the one that gets a technology to use. Thus, assignor companies are those that assign or license intellectual property rights to other individuals, while assignee companies are those who buy or obtain a license to use the intellectual property of a third party.

It is expected that companies that have a technology transfer contracts registered with INPI, either as assignor or assignee, are more likely to hold a patent than other companies. The technological diffusion established by contracts between companies increases the competitiveness and the technological experience of both, because an innovation is being transferred and exploited. This encourages assignor and assignee firms to register their innovations through patent applications [25], [26].

The technological classification proposed by the Organization for Economic Co-operation and Development (OECD) groups the sectors of the processing industry according to their technological intensity in four categories (high, medium-high, medium-low and low). For this, the level of technology specific to the sector and the technology incorporated in the purchases of intermediate goods and capital are considered [27], [28].

II. MATERIALS AND METHODS

2.1 Sample

The analysis was based on administrative data from companies listed on the Brazil Stock Exchange B3, formerly *BM&FBovespa*, which are combined with National Institute of Industrial Property (INPI) data covering patent applications from 2010 to 2017.

The period chosen was due to the lack of financial information on intangible assets that were not mandatory before 2010 and by 2017 being the last available year. Data source providing economic and financial information collected from balance sheets and income statements.

The sample consisted of 337 companies operating in the Brazilian stock market. Financial institutions were not included in the sample due to their own regulations and specific patrimonial characteristics, which are not comparable to other types of companies [29], [7].

2.2 Variables

To measure the variables, we used secondary sources from the B3 stock exchange and from the INPI government agency. Specifically, the variables corresponding to the company's patent deposits and technology transfer contracts were measured based on the INPI's official information. The variables related to economic and financial performance and company demographics were measured based on the accounting and administrative reports of the B3 stock exchange. The corresponding definition for each of the variables is described in Table 1.

Table.1: Variables used to evaluate firms' propensity to patent

Variable	Description
Patent Application (dependent)	Binary variable coded as "1" for the companies that deposited one or more patents in the year and "0" otherwise.
Current Liquidity	It measures the company's ability to honor its short-term obligations.
General Liquidity	It indicates the broad relationship of the company's ability to pay all of its obligations.
General Debt Ratio	It measures the degree of participation of creditors in the company's total assets.
Short-term Debt Ratio	It indicates the percentage of the debts that are short-term.
Return on Assets (ROA)	It measures the company's ability to generate profits by considering available assets.
Return on Equity (ROE)	It informs the return that the company obtained in relation to the capital invested in it.
Equity Intangibility	Represents the percentage of intangible assets in equity
Asset Intangibility	Represents the percentage of intangible assets in total assets

Equity's potential to add value	It measures value added attributable to total equity.
Asset's potential to add value	It measures value added attributable to total assets.
Size	\ln (total asset)
Age	Number of years from the company's incorporation to the sampled year.
Technology assignor	Binary variable coded as "1" for the companies who transfers one or more technology in the year and "0" otherwise.
Technology assignee	Binary variable coded as "1" for the companies that granted the transfer one or more technology in the year and "0" otherwise.
High technological intensity	Binary variable coded as "1" if company belongs to an industry of high or medium-high technology industries and "0" otherwise.
Low technological intensity	Binary variable coded as "1" if company belongs to an industry of medium-low or low technology industries and "0" otherwise.

Financial performance represents the repayment capacity that companies present in relation to their creditors and is formed by the groups of liquidity and indebtedness. In turn, economic performance refers to equity variations and wealth generation over time and is composed of profitability, intangibility and productivity groups [30], [31].

Based on the OECD's technological classification, this study groups the four categories into two only to identify the technology sector of companies (it uses the term "high intensity" for high and medium-high intensity, and "low intensity" for medium- low and low intensity). Thus, companies that are in the high or medium-high sectors were classified as high technological intensity. And companies in the mid-low and low sectors were classified as low technological intensity.

2.3 Model

In order to investigate how the economic-financial variables influence the decision of a company to deposit or not patents, a discrete-choice econometric modeling was presented for variables of a binary nature. This modeling is generally applied to firms' patent applications [9], [8], [6]. The logistic regression model (logit model) is used to estimate the probability of a patent application occurring given the values of the explanatory variables of the company:

$$P(y_{it}=1|x_{it}) = F(\beta'x_{it}) \quad (1)$$

where:

$P(y_{it}=1/x_{it})$ is the probability of firm i having one or more patent filing requests in year t ;

y_{it} is the binary variable that is equal to 1 if there is one or more patent filing application and 0 otherwise;

x_{it} is the vector of explanatory variables for firm i in year t ;

β is the parameter vector to be estimated;

F denotes the logistic function which ensures that the estimated probabilities are strictly between zero and one.

The model assumes that the expected return y_{it}^* of depositing at least one patent for firm i in year t is influenced by a set of explanatory variables x_{it} :

$$y_{it}^* = \beta'x_{it} + \varepsilon_{it} \quad (2)$$

where:

y_{it}^* is the latent variable that represents the expected return;

ε_{it} is the stochastic error term.

Although the return y_{it}^* is not observed, the variation in the company's patent deposit is observed and is related to the expected return as follows:

$$y_{it} = \begin{cases} 1 & \text{se } y_{it}^* > 0 \\ 0 & \text{se } y_{it}^* \leq 0 \end{cases} \quad (3)$$

In this way, it is assumed that when the expected return of depositing a patent is positive, the company decides on the deposit. Although the data structure is in panel, the model is estimated with grouped data and maximum likelihood. The pooled model was chosen for analysis in the present study because the data are extremely unbalanced, e.g., some companies exist only one observation.

III. RESULTS AND DISCUSSION

The descriptive statistics for the variables are shown in Table 1. It can be noted that of the total number of publicly traded companies analyzed, an average of 11% deposited one or more patent applications per year.

In the United Kingdom during the period 1998-2006 only 1.6% of all registered companies had at least one patent. Even in high-tech industrial sectors, the share of firms that deposit patents in the UK does not exceed 10% [32].

An explanation for why the percentage of companies with patents on the Brazilian stock exchange (11%) is greater than that found for the United Kingdom occurs because of the samples used. Whereas, in the last mentioned country the sample represents all the companies of the United Kingdom, in this study the sample represents only companies of Brazil that have shares traded in the stock exchange.

When comparing the use of formal contracts for transfer of technology registered at INPI, it should be noted that B3 companies classified as assignor, that is, that licensed some intellectual property, accounted for 8% of the sample.

For the assignee companies, those who bought the right or the license to exploit some intellectual property registry with the INPI, have a representation of 37% in the sample, a higher percentage when compared to the assignor companies. This discrepancy between the percentage of companies assignee (37%) and assignor (8%) indicates that most companies in the Brazilian stock exchange prefer to buy the right or license to use a registered technology, rather than to develop innovation. Comparing the economic-financial variables, it can be seen that for the Equity Intangibility, Current Liquidity, ROA, ROE, Short-term Debt Ratio and Equity's Potential to Add Value indexes, the standard deviation is three times or more the mean value, indicating that there is a large discrepancy between the companies that found in the sample. Although the average age of companies is 35.71 years, which refers to the period of incorporation of the company up to the present, there are newly incorporated companies, such as Movida SA, to 126-year-old companies such as CIA Tecidos Santanense.

Table 1: Summary of the variables studied of Brazilian publicly traded companies, regarding the propensity to patent.

Variable	Mean	S.Dev.	Min.	Max.
Patent Application	0.11	0.31	0	1
Current Liquidity	37.14	1146.9	0.005	39077
General Liquidity	2.09	2.26	0.01	31.29
General Debt Ratio	0.45	0.22	1.3e-07	1
Short-term Debt Ratio	0.86	2.52	0.03	70.37
Return on Assets (ROA)	-0.01	0.49	-11.19	11.89
Return on Equity (ROE)	0.14	2.19	-15.17	75
Equity Intangibility	0.62	2.08	-25.4	44.56
Asset Intangibility	0.17	0.23	0	0.97
Equity's Potential to Add Value	0.86	2.52	0.03	70.37
Asset's Potential to Add Value	0.31	0.48	-7.18	15.68
Size	14.38	2.09	3.25	20.62
Age	35.71	25.84	0	126
Technology Assignor	0.08	0.28	0	1

Technology Assignee	0.37	0.48	0	1
High Technological Intensity	0.11	0.31	0	1
Low Technological Intensity	0.21	0.41	0	1

Table 1 also shows the proportion of firms in the high and low technology sectors according to the OECD (Organization for Economic Co-operation and Development) classification. It is observed that 32% of the companies are in sectors of high or low technological intensity, while the other companies, which represent 78% of the sample, do not fall into either category. This is expected given that the OECD classification groups only the sectors of the manufacturing industry as can be seen in [33] e [28].

Table 2: Distribution of Brazilian publicly traded companies and the propensity to patent by sectors - period 2010 to 2017

Sector	Num. of companies (% of total)	Num. of companies with one or more patents (% of total)	Propensity to patent
	A	B	C= B/A
Capital Goods and Services	71 (21.6)	15 (20.3)	0.21
Consumer Cyclical	80 (24.4)	5 (6.8)	0.06
Consumer non-Cyclical	25 (7.6)	7 (9.5)	0.28
Basic Materials	31 (9.5)	12 (16.2)	0.39
Others	16 (4.9)	0 (0)	0.00
Oil, Gas and Biofuels	11 (3.4)	1 (1.4)	0.09
Health	19 (5.8)	3 (4.1)	0.16
Information Technology	7 (2.1)	3 (4.1)	0.43
Telecommunications	5 (1.5)	0 (0)	0.00
Utilities	63 (19.2)	28 (37.8)	0.44
Total	328 (100)	74 (100)	0.22

Note: B3's industry classification structure.

Table 2 shows the distribution of firms and the propensity to patent by sectors for the period 2010-2017. The first finding is that most publicly traded companies listed on

B3 are not involved in official patent registration. Of the 328 companies in the sample, only 74 filed one or more patents during the period 2010-2017, which creates a propensity to patent of 0.22, i.e. out of every 100 companies in B3, it is expected that only 22 of these companies patent.

Analyzing the distribution, it stands out that the Cyclical Consumption sector concentrates the majority of the companies, with almost 25%. However, considering only the companies with one or more patent deposited, the same sector concentrates less than 7%. Consequently, the data suggest that manufacturers of cyclical consumer goods do not necessarily depend on official patent registration for creation, protection or value appropriation, which is indicative of price-versus-quality competition [34].

It should also be noted that the Public Utility, Information Technology and Basic Materials sectors are the ones that present the highest estimates for the probability of filing patents, with 0.44, 0.43 and 0.39. The Public Utilities sector is comprised of the Water and Sanitation, Electric Energy and Gas subsectors. Following this, the Basic Materials sector is composed of the Sub-sectors of Packaging, Wood and Paper, Chemicals, Mining and Steel and Metallurgy.

3.1 Econometric Modeling

The propensity to patent is studied in terms of patents filed and aims to identify how the specific characteristics of companies influence the decision to deposit or not patent with the official body of registration of intellectual property INPI. Thus, the logit regression clustered model was chosen since the dependent variable deposited patent consists of a binary variable with value 1 for companies that have one or more patent filing in the year and the value 0 for corporations without filing in the year.

Table 3 presents the results of the logistic model estimation. Because the model is nonlinear, the estimated coefficients only indicate whether an explanatory variable has a positive or negative impact on the probability of filing a patent. The mean marginal effect measures the change in probability when the explanatory variable increases by one unit, thus providing an interpretation similar to that used in linear models.

According to the results of the logit model, the firms with the highest propensity to patent are characterized by their large size and lower general and short-term indebtedness and lower overall liquidity, together with a greater potential to generate wealth through assets. They are also more likely to be transferors and assignees of technology transfer contracts, in addition to being generally in sectors of high or low technological intensity.

Analyzing the marginal effect of the variables, we can observe that the economic-financial indicators were statistically significant and presented the following

variables: (a) greater marginal effects when compared to the other variables of the model. This shows the importance of the company's capital structure in the decision to file a patent.

Table 3: Results of the logit model estimation with clustered data for Brazilian companies in the stock exchange regarding the propensity to patent

Explanatory Variables	Coefficients	Marginal effects
Constant	-5.532*** (1.886)	-
Current Liquidity	-0.079 (0.111)	-0.006
General Liquidity	-1.181*** (0.418)	-0.086***
General Debt Ratio	-2.982*** (0.601)	-0.217***
Short-term Debt Ratio	-4.863*** (1.375)	-0.353***
Return on Assets (ROA)	1.170 (1.146)	0.085
Return on Equity (ROE)	-0.004 (0.148)	0.000
Asset Intangibility	0.435 (0.498)	0.032
Equity Intangibility	-0.094 (0.101)	-0.007
Asset's Potential to Add Value	1.886*** (0.410)	0.137***
Equity's Potential to Add Value	-0.003 (0.022)	0.000
Age	-0.002 (0.004)	0.000
Size	0.540*** (0.059)	0.039***
Technology assignor	0.408* (0.231)	0.030*
Technology assignee	0.911*** (0.173)	0.066***
High technological intensity	2.465*** (0.262)	0.179***
Low technological intensity	0.689*** (0.218)	0.050***
Number of observations	2269	
McFadden's Pseudo R ²	0.341	
Nagelkerke's Pseudo R ²	0.419	
Percent correctly predicted:		
for file patent application (y = 1)	58.333	
for non-file patent application (y=0)	91.767	
for all observations	90.176	

It should be noted that profitability (ROA and ROE) and intangibility indicators (Asset's Potential to Add Value and Equity's Potential to Add Value) presented insignificant marginal effects, indicating that the level of profitability and intangibility of the company has no influence on the process of registration of intellectual property by means of a patent.

An explanation for intangibility has no impact on the probability of filing patents may be the fact that the companies listed on the Brazilian stock exchange are reporting in the financial statements amounts of intangible assets that do not conform to the official standard of the Accounting Pronouncements Committee [25], [35].

The size of the firm, measured by the logarithm of total assets, showed a positive relation with the propensity to patent, that is, everything else constant, the probability of filing a patent increases with the size of the company. This corroborates the hypothesis that, for smaller companies, high costs may discourage the use of the official INPI patent register..

One way to evaluate the performance of logit model is to allow the prediction of which companies must deposit patents in a given year and comparing this prediction with the actual patent applications. The last lines of Table 3 denoted as "hit percentage" shows the percentage of firms in the sample that were correctly classified by the logit regression as possessing or not patent filing. In spite of only 50.6% accuracy for companies with patent deposits, the model had more than 92% in relation to companies that did not file a patent.

IV. CONCLUSION

This paper provides an analysis of the determinants of a company's patenting decision and assesses the implications for the official intellectual property protection system. The analysis is based on a new integrated dataset that combines a variety of sources by forming a dashboard with information at the firm level.

The descriptive analysis shows that, on average, only 10% of the non-financial companies listed in Brazil's Bolsa Balcão (B3) filed at least one patent application per year. In particular, considering all the period from 2010 to 2017, companies that have one or more patents in the period represent only 22% of the sample, indicating that they are generally the same companies that are depositing patents with the INPI, with low annual turnover between depositors.

When analyzing the characteristics of the companies that influence the decision to deposit or not patent, it is found that the companies with greater propensity to patent are characterized by being large and have lower general and short term indebtedness and lower liquidity general, along with a greater potential to generate wealth through the

asset. They are also more likely to be transferors and assignees of technology transfer contracts, in addition to being generally in sectors of high or low technological intensity.

One explanation for the fact that so few companies patent, even if it restricts only listed non-financial corporations listed in B3, is that companies may consider the use of the official IP system to be very expensive, since the use of any mechanism of intellectual property protection costs companies time and money, and in the case of patents, the expected benefits may not exceed the patent filing costs with the INPI.

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Analysis and Design of Box Culvert: A Manual Approach

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Abstract— Box culverts are the monolithic structure made to pass across a roadway, railway lines etc. Embankments are used to balance the flood water on both sides. Box takes various types of loads generated by water, traffic, cushion, soil etc. This work deals with complete design of box culvert manually and study the design parameters such as effect of earth pressure, depth of cushion at the top slab of culvert, factor such as braking force, Impact load, Live load, Dispersal of load through tracked or wheeled vehicle, effective width etc. In this work, study of culvert with and without cushion analyzed for different classes of IRC loadings and conclusions made on the basis of bending moments and shear forces with and without cushioning cases. This paper provides full discussion of provisions provided by Indian Standards, their justifications and considerations are taken into the account for design purpose.

Keywords— Box culvert, Cushioning, Loading class, Moment calculations, Percent reinforcement, Pressure cases, Side walls, Top slab.

I. INTRODUCTION

Box culverts are low rise bridge or structure which is used to discharge water in the proper channel in crossing of railway, flyover, roads etc. and is used where the bearing capacity of soil is low. Culverts are always economical than bridge where the discharge in the opening is 18 m² it depends on the number of cells which is generally used where roadway crosses the high embankment. Box culverts are generally cast in situ in India, but in other countries the box culverts are preferred due to low cost and economically with having fast workmanship. The box is just name given for its shape, can be found in various types of shapes and also it can be act as minor bridge when the number of cells increases and span greater than 6m in length. Its height depends on span. It can control all water coming from irrigation, surface water, river and canals they control all the storm water and flood water during rainy season.

Box culverts which have four corners are monolithically jointed. In other cases the box will be of three sides means which has bottom slab (Raft) and vertical walls. Top slab needed to be made otherwise precast slab also available in market we cannot joint it monolithically. Cushioning is very important in every box culvert which decided by road profile and bearing capacity of soil available at site.

II. TYPES OF BOX CULVERTS

1) According to the Classification by Materials

- 1.1) Concrete
- 1.2) Steel
- 1.3) Aluminum
- 1.4) Plastic
- 1.5) High density Polyethylene
- 1.6) Timber

2) According to the Classification by Shape

- 2.1) Box culvert
- 2.2) Pipe culvert
- 2.3) Pipe arch culvert
- 2.4) Bridge culvert
- 2.5) Arch culvert

3) According to the Classification by Loading as per IRC

- 3.1) IRC-CLASS-70 R
- 3.2) IRC-CLASS-A
- 3.3) IRC-CLASS-B

3.1) **IRC-CLASS-70 R**: -It is a loading which used by the municipality which includes industrial areas along with major highways, bridges culverts etc. For military heavy loads vehicles, the bridge, culverts designed for Class-A and also for Class-B. It should be checked for Class-A loading because there will be heavy stresses created under Class-A loadings. As per IRC 6, the value for Class 70 R provided is 350 KN for tracked vehicle.

3.2) **IRC-CLASS-A**: - This loading is preferred on each and every roads on which permanent structures are made

such as bridges, culverts etc. As per IRC 6, the value for Class A provided is 114 KN for wheeled vehicle.

3.3) **IRC-CLASS-B:** - This loading is preferred on each and every road on which temporary structures are made and for bridges the different materials are used respect to situations. As per IRC 6, the value for Class B provided is 68 KN for wheeled vehicle.

III. CASES TO BE SOLVED & PARAMETERS USED

For this work, total six cases are taken for analysis and design. For that each case is numbered as Case A, Case B, etc. Description for Without Cushion and With Cushion cases are mentioned in table 1.

Table.1:- Types of cases used with description as per loading class

Cushion Type	Cases	Description
Without Cushion	CASE A	350 KN of Tracked vehicle using Class-70(R)
	CASE B	114 KN of Wheeled vehicle is using Class-A
	CASE C	68 KN of Wheeled vehicle is using Class-B
With Cushion	CASE D	350 KN of Tracked vehicle using Class-70(R)
	CASE E	114 KN of Wheeled vehicle is using Class-A
	CASE F	68 KN of Wheeled vehicle is using Class-B

For this work, parametric values taken for analysis and designing of box culvert. Description for both Without Cushion and With Cushion cases are mentioned in table 2.

Table.2:- Parameters used for designing

Parameters	Values
Clear span	3m
Clear height	3m
Top slab thickness	0.3m
Bottom slab thickness	0.35m
Side wall thickness	0.35m
Unit weight of concrete	25 KN/m ³
Unit weight of earth	18kN/m ³
Unit weight of water	10kN/m ³
Coefficient of earth pressure at rest	0.5
Types of cushioning	With/Without
Thickness of wearing coat	0.070m
Carriageway	8 lane divided
Concrete grade	M 25

Steel grade	Fe 500
Esc(concrete)	8.33Mpa
Esc(steel)	200 Mpa
Cushion depth	3.5m
Modular ratio	10
n (for depth of neutral axis)	0.294
j (for effective depth)	0.902
k (for moment of resistance)	1.105

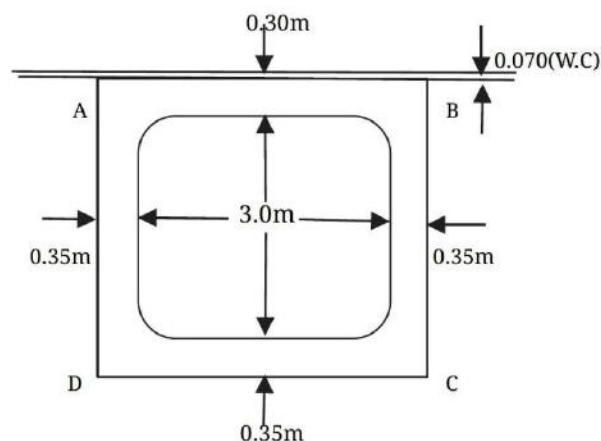


Fig.1: Box culvert without cushion

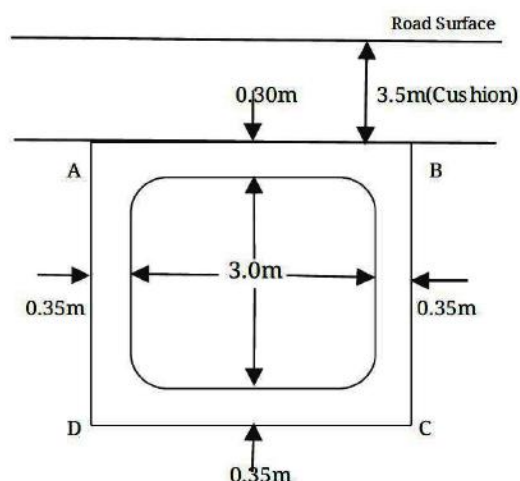


Fig.2: Box culvert with cushion

IV. METHODOLOGY AND PROBLEM SOLVING APPROACH STEPS

1) Design steps without cushion:-

1.1) Silent Features

1.2) Load Calculations

1.2.1) Top slab

1.2.2) Bottom slab

1.2.3) Total load

1.3) Moment Calculations

1.3.1) Top Slab

1.3.2) Bottom Slab

1.3.3) Side Walls

1.4) Distribution Factors

1.5) Moment Distribution

1.5.1) Fixed end moment due to dead load

1.5.2) Fixed end moment due to live load

1.5.3) Fixed end moment due to total load

1.6) Braking Force

1.6.1) Load: 70 R (T)

1.6.2) Moment due to Braking Force

1.7) Design of Section

1.7.1) Top Slab

1.7.2) Bottom slab

1.7.3) Side Walls

2) Design steps with cushion:-

2.1) Silent Features

2.2) Load Calculations

2.2.1) Top slab

2.2.2) Bottom slab

2.2.3) Total load

2.3) Moment Calculations

2.3.1) Top Slab

2.3.2) Bottom Slab

2.3.3) Side Walls

2.4) Distribution Factors

2.5) Moment Distribution

2.5.1) Fixed end moment due to dead load

2.5.2) Fixed end moment due to live load

2.5.3) Fixed end moment due to total load

2.6) Design of Section

2.6.1) Top Slab

2.6.2) Bottom slab

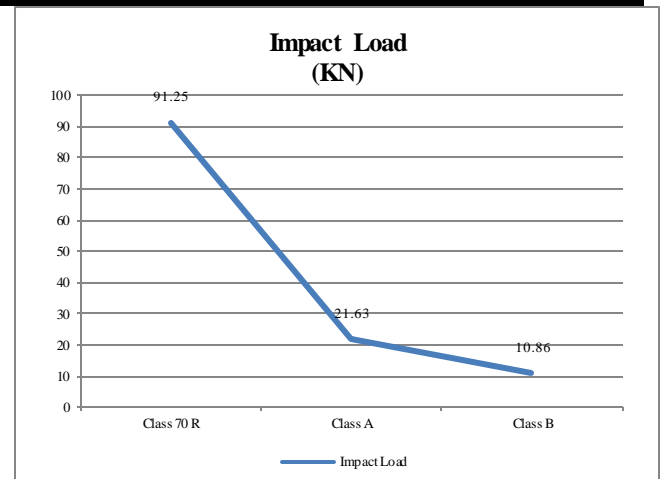
2.6.3) Side Walls

V. RESULT AND DISCUSSIONS

1) Impact load

Table 3:- Values of Impact Loads

Non Cushion	Class 70-(R) Loading	Class A Loading	Class B Loading
	91.25kN	21.63kN	10.86kN

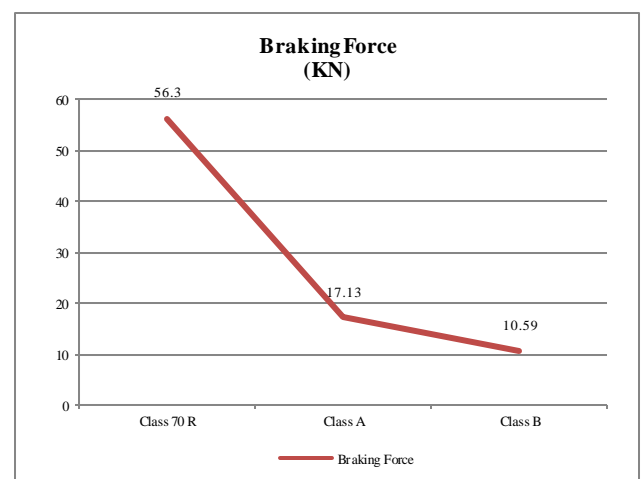


Graph 1:- Graphical representation of values of Impact Load

2) Braking force

Table 4:-Values of Braking Forces

Non Cushion	Class 70-(R) Loading	Class A Loading	Class B Loading
	54.52kN	17.13kN	10.59kN



Graph 2:- Graphical representation of values of Braking Forces

3) Bending moment of structure

Without-Cushioning:

Table 5:-Values of Bending Moments (Without-Cushion)

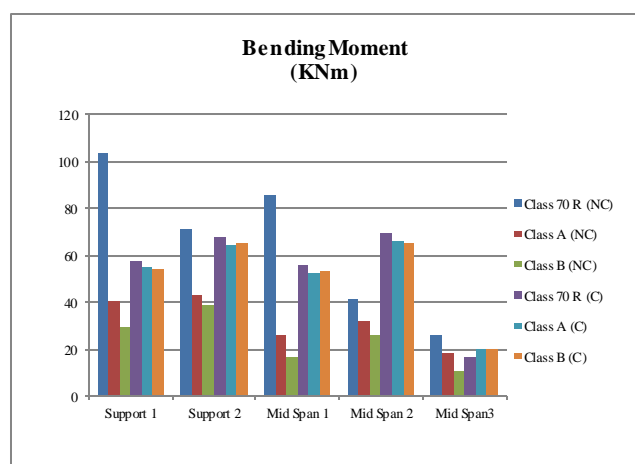
Item	Location	Members	Classes		
			70-(R)	A	B
Bending Moments (kN.m)	Support	$M_{AB}, M_{BA}, M_{AD}, M_{DC}$	103.74	41.04	29.69
		$M_{DC}, M_{CD}, M_{DA}, M_{CB}$	70.94	43.26	38.58
	Mid	M_{AB}, M_{BA}	85.54	25.9	16.91

	Span	A		2	
		M _{DC} ,M _C D	41.75	32.2 1	26.38
		M _{AD} ,M _D A	26.12	18.2 6	10.54

With Cushioning:

Table 6:-Values of Bending Moments (With-Cushion)

Item	Location	Members	Classes		
			70-(R)	A	B
Bending Moments (kN.m)	Support	M _{AB} ,M _{BA} , M _{AD} ,M _D C	57.67	55.03	54.56
		M _{DC} ,M _{CD} , M _{DA} ,M _C B	67.54	64.63	65.22
	Mid Span	M _{AB} ,M _{BA}	56.15	52.78	53.50
		M _{DC} ,M _{CD}	69.43	66.40	64.90
		M _{AD} ,M _D A	17.23	20.01	19.95



Graph 3:- Graphical representation of values of Bending Moments (Without and With Cushion)

4) Shear force of structure

Without Cushioning:

Table 7:-Values of Shear Forces (Without-Cushion)

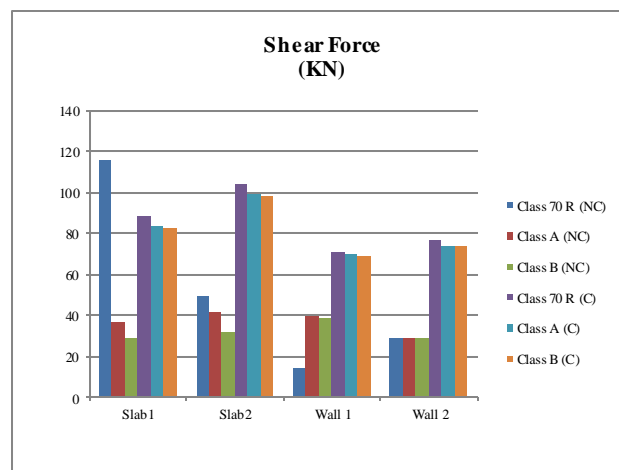
Item	Location	Members	Classes		
			70-(R)	A	B
Shear Force (kN)	At d _{eff} from support for slab	A&B	115.8	37.35	24.43
		D&C	49.45	42.14	37.51
	At d _{eff}	A&B	40.18	39.89	39.31

	from top slab for wall				
	At d _{eff} from bottom slab for wall	D&C	29.61	29.69	28.69

With Cushioning:

Table 8:-Values of Shear Force (With Cushion)

Item	Location	Members	Classes		
			70-(R)	A	B
Shear Force (kN)	At d _{eff} from support for slab	A&B	88.26	83.49	82.61
		D&C	104.36	99.46	98.52
	At d _{eff} from top slab for wall	A&B	71.74	70.16	69.26
	At d _{eff} from bottom slab for wall	D&C	77.21	74.23	73.54



Graph 4:- Graphical representation of values of Shear Force (Without and With Cushion)

5) Steel percentage

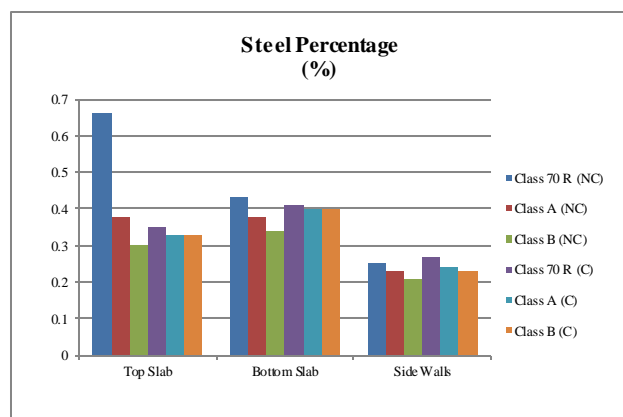
Without -Cushioning load:

Table 9:-Values of Steel Percent (Without-Cushion)

Classes	Top slab	Bottom slab	Side wall
70-(R) loading	0.63	0.43	0.25
A-loading	0.38	0.38	0.23
B-loading	0.30	0.34	0.21

With Cushioning load:*Table 10:-Values of Steel Percent (With Cushion)*

Classes	Top Slab	Bottom Slab	Side Wall
70-(R) loading	0.35	0.41	0.27
A-loading	0.33	0.40	0.24
B-loading	0.33	0.40	0.23

*Graph 5:- Graphical representation of values of Steel Percent (Without and With Cushion)***VI. CONCLUSIONS AND RECOMMENDATIONS**

1. By using manual calculations as per IRC rules, the design and analysis of box has thoroughly done. By using the manual calculation, we can easily find out the data which is beneficial.
2. Small variations in coefficient of earth pressure observed have very small influence on design of box culverts without cushioning. It is easy to judge the variations observed in percent as per different classes of loading.
3. When Cushioning is not used, Impact Values are observed as 91.25 KN, 21.63 KN & 10.86 KN for Class 70 R, Class A & for Class B respectively. Values of Braking Forces seem to be 56.30 KN, 17.13 KN & 10.59 KN for Class 70 R, Class A & for Class B respectively.
4. For box culvert which is without cushion braking force is required to consider for small spans. It is easy to widen the box length when required.
5. Comparing different loading cases, class 70 R loading gives maximum B. M. at support with and without cushioning cases. Least values are observed in Class B for the same. Again, mid span moment values are greater in 70 R class loading comparing to least values observed in Class B loading.
6. At upstream and downstream there will be apron floor that should be provided with level to be maintained and also haunches should be provided at edge of box.

7. The total deformations of box full without cushion condition are more than box full with cushion conditions. The normal stress, maximum principle stress and equivalent stress are without cushion is more than with cushion.
8. For Shear force values, class 70 R loading gives maximum values for top slab, bottom slab and side walls for non cushion cases. Comparing shear force values for cushion cases, again Class 70 R shows maximum values. Class B shows minimum shear force values for both cushion and non cushion cases in top slab, bottom slab and side walls.

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Technological Development and Policies in the Scenario of Irrigated Agriculture in Brazilⁱ

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Abstract—The need for the conservation of natural resources is of paramount importance with regard to irrigated agriculture, since it is the main consumer and user of water resources in Brazil and in the world. Thus, technologies are being used to increase the efficiency of water use in irrigation and to conserve water resources. Patent data on technological developments of irrigation systems were collected from the National Institute of Industrial Property database, as well as legislation and public policies regarding irrigated agriculture in Brazil. A total of 732 patent registrations were registered in the period between 1974 and 2016. The number of patent registrations on the development of technological processes for irrigation has been increasing, as well as the implementation of policies aimed at irrigated agriculture.

Keywords—Irrigation. Efficiency in water use. INPI. Technology.

I. INTRODUCTION

For a long time, world agricultural production has been built under the guise of the productivist logic, established by the Green Revolution as a result of the population increase and increasing demand for food, aiming at maximizing productivity gains through technological advances; as well as the mechanization of the field and the use of chemical products, as well as the cultivation of monocultures, driving the development of commodity chains [5] [7] [14].

These factors are the consequences of the Industrial Revolution of the eighteenth and nineteenth centuries, which was dominated by the mechanization of mining and fossil fuel-producing factories, expanding the means of maritime and land transport, which resulted in

population growth and urbanization of the cities, thus increasing the demand for food, as opposed to the reduced number of rural workers moved by the rural exodus [10][18].

In spite of the productive advances for the agricultural sector by the Green Revolution, losses were generated to the environment, for example, deforestation of large areas for agricultural activities and formation of latifundios; planting of monocultures, which facilitated the dissemination of the application of chemical products for pest control and crop invaders; soil depletion caused by its intensive use concurrently with chemical fertilizer applications [2] [12].

At the same time, in order to conserve natural resources and promote sustainability with economic, social and environmental aspects, we find Conservation Agriculture (CA), aiming at high agricultural productivity [6], and that due to the increase in productivity in recent years, the use and exploitation of natural resources in order to supply the world food demand has become significant [8], the CA being based on the principles: (i) minimum soil rotation combined with no-tillage system; (ii) maintenance of soil cover by residues from other crops, acting as a fertilizer medium for successor crop, and (iii) adoption of crop rotation [17].

In this sense, it is deprived of the need to conserve available natural resources, highlighting the use of water resources, which has been associated with agriculture as the main consuming and user unit of these resources for purposes and irrigation using approximately 85% of the amount of water consumed globally [19].

It is aggravated by the fact that the small amount available for consumption is only 1.2%, which is fresh water contained in rivers, lakes and streams, since 97% of

all water on the planet is salted, and only 3 % is considered fresh water, readily available for human consumption. However, it is known that two-thirds of these fresh waters are present in the polar and glacial ice caps, and the other one third are groundwater [15].

In this sense, Brazil registered an average annual growth of 4% per year in the area irrigated since 1960, from 462 thousand hectares to 6.95 million hectares in 2015, which made the country one of the ten largest in an area equipped for irrigation, allocating about 70% of the total freshwater for irrigation [1] [11].

Thus, new technologies are being used in agriculture to increase the efficiency of water use in irrigation in line with the creation of legislation and public policies in irrigated agriculture, promoting productivity increase by conserving water resources [13].

The objective of this work is to verify the relations of public policies and legislation on technological development with a view to the efficient use of water.

II. MATERIALS AND METHOD

The methodology used for research is similar to that developed by [16], together with the database of the National Institute of Industrial Property [9] on patent registrations concerning the technological development of irrigation systems in the period between 1974 and 2016. Regression analysis was performed using Excel and Minitab® software, as well as Pearson's correlation coefficient, in order to determine the relationship between the variables studied, above the increase in the number of patents during the course years.

The search was carried out according to the International Patent Classification (IPC), respecting the hierarchical levels of the records in the INPI database. The patents referring to the technological development of irrigation systems classified in Section A (Human Needs), inserted in Subsection A01 (Agriculture) and allocated to class A01G (horticulture, cultivation of vegetables, flowers, rice, fruit, vines, hops or algae, silviculture, irrigation), these being divided into four subclasses: A01G 25 /, A01G 27 / A01G 29/ and A01G 31/, and distributed into 15 groups: A01G 25/00, A01G 25/02, A01G 25/06, A01G 25/09, A01G 25/14, A01G 25/16, A01G 27/00, A01G 27/02, A01G 27/04, A01G 27/06, A01G 29/00, A01G 31/00, A01G 31/02, A01G 31/04 and A01G 31/06. The methodological focus was to quantify the number of patent registrations referring to the technological process of irrigation in Brazil.

On the other hand, the records related to the Public Policies were obtained by means of a search in the Federal Government Legislations database through keywords, such as: "Irrigation", "Irrigated Agriculture" and "Water Resources", in addition to consulting the

Atlas of Irrigation of the National Water Agency (ANA) of the Ministry of the Environment [1].

III. RESULTS AND DISCUSSION

A total of 733 patent registrations were recorded in the INPI database, between 1974 and 2016, over 15 classifications according to the International Patent Classification (IPC), as can be seen in Table 1.

Table 1. Classification of patents according to INPI (2018) and number of registrations in the period between 1974 and 2016.

Code	Description	Quantity
A01G 25/00	Irrigation of gardens, meadows, sports grounds or similar	87
A01G 25/02	Arrangements, for irrigation, under the soil of the piping medium. ex. for drip irrigation	138
A01G 25/06	Arrangements for irrigation by piping. Realized in not only	35
A01G 25/09	Splits for irrigation by means of escalators or similar	93
A01G 25/14	Handheld irrigation systems, p. ex. watering cans	14
A01G 25/16	Irrigation Control (Spray Control Devices)	100
A01G 27/00	Automatic irrigation devices, p. ex. for flower pots	84
A01G 27/02	You must have a water reservoir, one of the main risk factors for growth and the growth substrate	21
A01G 27/04	Using muslin or similar	4
A01G 27/06	with a water reservoir, a main part is being completely around or next to the growth substrate	4
A01G 29/00	Root feeding devices; Injection of fertilizers into the roots	20
A01G 31/00	Cultivation without use of soil, p. ex. hydroponics	68
A01G 31/02	Special apparatus for this purpose (apparatus for growing in receptacles or greenhouses in general)	51
A01G 31/04	Hydroponic culture in transporters	5
A01G 31/06	Hydroponic shelf culture or in stacked containers	9

The highest number of patent registrations in classification A01G 25/02, on provisions for irrigation under the ground by pipes with a total of 138 registers,

concentrating 18.8% of the records; with a percentage of 13.6%, are patents registered in the classification A01G 25/16 with 100 patents, which are technologies aimed at the control of irrigation. Following are the A01G 25/09 (93), A01G 25/00 (87) and A01G 27/00 (84) classifications, with the respective percentages of 12.7%, 11.9% and 11.5% of the concentration of patents.

On the other hand, the behavior on the evolution of the number of patent registrations regarding the technological development of irrigated agriculture is observed in Image 1

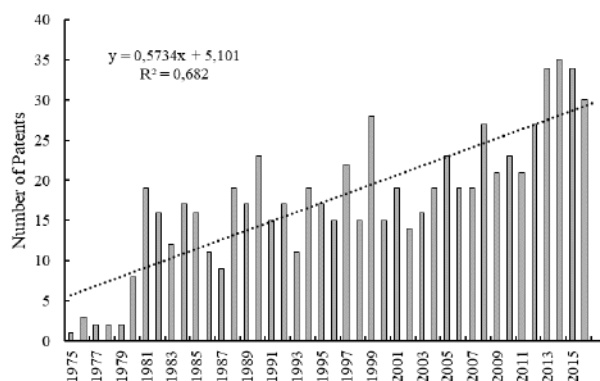


Fig.1. Total patents related to the irrigation system in Brazil.

In the analyzed period, the increase in patent registrations after 1979 was one of the possible causes, due to the approval of the first National Irrigation Policy, Federal Law 6,662 / 1979 [4]. which aims to regulate the rational use of water resources and soil to promote the development of irrigated agriculture in the country [1].

After 1979 onwards, the number of patent registrations over the period is increasing, with the R^2 value found by the linear regression line equal to 0.682, which shows that 68.2% of the data can be explained by the equation of the line explicit in the model and regression

Likewise, the creation of public policies for irrigated agriculture in the period between 1975 and 2015 has also increased over the years, as can be seen in Image 2.

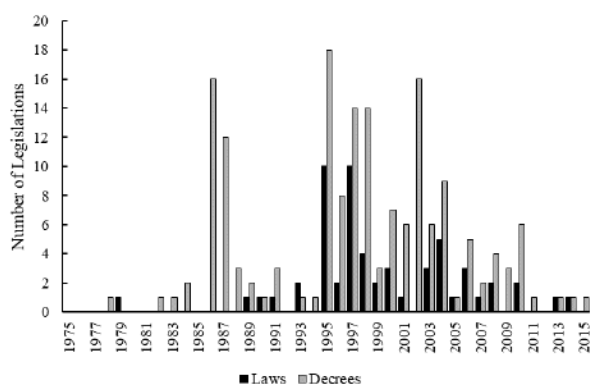


Fig.2. Number of Legislation (Decrees and Laws) created in the period between 1975 and 2015.

There is a total of 54.4% of laws in force between 1995 and 2000, increasing to 71.9% when analyzed until 2005, with 41 laws created by the Federal Congress. In turn, during the same period, the Presidential Decrees accounted for 34.3%.

The high number of laws in the period is emphasized in the historical landmarks of the public policies of agriculture irrigated by the Irrigation Atlas of the National Water Agency, described in Table 2.

Table 2. Historical and political moments of irrigated agriculture.

Ano	Historicmoment
1979	First National Irrigation Policy (Federal Law 6,662 / 1979)
1988	Promulgated the Constitution of the Republic on the use of water resources
1997	Promulgation of the Water Law (Federal Law No. 9.433 / 1997) - National Water Resources Policy
2000	Creation of the National Water Agency (ANA) - Federal Law No. 9,984 / 2000
2001	Approval of CONAMA 284 of 08/30/01 - Environmental licensing on irrigation project
2008	Creation of the Permanent Forum for the Development of Agriculture Irrigated by Ordinance n° 1.869 / 2008
2013	Promulgated the new National Irrigation Policy (Federal Law No. 12.787 / 2013)

Source: Adapted from Atlas of Irrigation [1].

It stands out among the historical moment of irrigated agriculture in Brazil after 1979, five policies influencing the use of water resources in the mid-1990s and 2000, a period of more than 70% concentration of law-making by Congress Federal, along with the period of the conservationist movement, alluding to the productivist logic of agriculture established by the Green Revolution. Pearson's correlations between the variables, Year, Patents, Decrees and Laws, are shown below in Table 3.

Table 1. Pearson Correlation Matrix.

	Year	Patents	Decrees
Patents	0,83*	-	-
Decrees	-0,25**	-0,30*	-
Laws	0,18	0,11	0,10

Meaning $p < 0,05$ *, $p < 0,10$ **

There is a strong positive correlation between the Patents and Year variables, with a correlation value of 0.83 for a significance of 95%. On the other hand, the correlation is considered weak when the number of patents and number of presidential decrees are analyzed for significance of

95%, and the other correlations analyzed were considered negligible at statistical levels.

IV. CONCLUSIONS

There has been an increase in the number of patents related to the technological development of irrigation systems over the years, especially after the installation of the First National Irrigation Policy of 1979.

So that, the period with the greatest number of laws created between 1995 and 2005 is also described as the period of the main public policies dated as a historical landmark of irrigated agriculture in Brazil.

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Layout Optimization using Computer Simulation Tool for Decision Making

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Abstract — *The purpose of this study is to present a case study based on real production data in which the computer simulation was used to analyze the efficiency of the current layout, paying attention to indicators defined by the value stream mapping, which determined the need of layout restructuring. For this purpose, it was used a computer tool for discrete events that permits to explore the features of the system, aiming to provide a more comprehensive view of the assembly line, since the software has several performance analysis tools. The method was developed through "in loco" data collection, in similar cases studied in the literature, and in the computation tool learning, thus creating a virtual environment that allowed simulate various layout restructuring strategies to reach the desired result, verifying a great potential for improvement with this restructuring. Finally, the results obtained with the simulation proved that its use emerges as a powerful tool for evaluating the rationalization of resources and production layout restructuring, making clear the advantages and features of the use of computer simulation as a tool to help making decisions in industrial manufacturing process.*

Keywords — *Digital Manufacturing, Process Layout, Production Simulation, Value Stream Mapping.*

I. INTRODUCTION

The physical arrangement project is very important for a good performance of a manufacturing process, for implanting and layout changes can result in high costs for the company, since experiments in the physical environment can lead to delays and even paralyze production. Therefore, more and more organizations have acquired computer systems that make it possible to view different distributions of the production cells in search of a better performance, avoiding the interruption of production so changes in their physical arrangement can be made.

The correct project of the physical arrangement has a decisive role for the survival and success of a company, since it is strongly connected to the strategy and to its

objectives, and allow the rationalization of space, minimizing the movement of materials and people, leading to reduced costs and increased production system efficiency [20].

This study was developed in a company specialized in automotive manufacturing car radio, having as main objective the use of computer tool in the physical arrangement restructuring, using Tecnomatix Plant Simulation® software, which is a simulation tool for discrete events that allows a greater visualization of manufacturing through simulated experiment, as a tool, it is possible to optimize the flow of materials, production bottleneck and make layout changes in the simulation environment, giving greater security in changes of the production process.

Given the above, based on some decision variables, there was a comparison between the current physical layout and the simulated scenarios, which presented indicators that made it possible to propose a production layout restructuring, using computer simulation as an analysis tool.

Considering the presented facts, the importance of this study is relevant because Digital Manufacturing Implanting is becoming a differentiator within organizations, for digital manufacturing helps with companies' processes changes, in which are involved high investment costs, helping predicting problems and searching for a solution. In short, the use of technological resources help managers make decisions. However, for the desired costs, time and quality results in implementation to be achieved, it is essential to have a careful implanting project.

Thus, in seeking to improve the manufacturing process, it is necessary to create a simulation scenario that allows the control of the production process and evaluate the possibilities of improvements. The simulation environment allows the prediction of resource requirements for the demand increases. Another reason is the search for the best manufacturing environment, aiming to achieve the best results with equipment / existing resources.

II. USE OF SIMULATION IN MANUFACTURING

For a good understanding of simulation, it is essential to know the definitions of systems and models. In short, the system is a set of different elements, which exert on each other an interaction or interdependence. The systems set limits or boundaries. That is, they are limited. Therefore, one can set the system into other systems, and so forth.

A model is an abstraction of reality, where given a system, contains a simplified representation of the various interactions between its parts. Symbolic, mathematical and simulation models are the three basic categories [5].

- **Symbolic Models**, also called diagrammatic or ionic. They represent a static way system through the use of graphic symbols, not taking into account the behavior over time. The lack of quantitative data and the difficulty to represent many details of the same system are among the limitations of this type of model. Its greatest use is in the documentation of projects and as a communication tool.
- **Mathematical Models**, also called analytical models, being interpreted as a set of mathematical formulas. The vast majority of them are models of static nature, and many of these do not have analytical solutions for complex systems, so simplifying assumptions must be used. On the other hand, they are models that possess a fast and accurate solution, when an analytical solution exists.
- **Simulation Models**, which can capture more faithfully the characteristics of real systems, providing, on the other hand, a greater complexity due to its nature, since they change their states over time and have random variables.

The modeling comprises the use of mathematical techniques to describe the operation of a system or part of a production system [2]. A complement is the use of simulation, which consists in the use of computer techniques to simulate the operation of production systems, based on a set of variables in a given area in order to investigate the causal and quantitative relationship between these variables [3].

In literature, one can find various simulation application studies as an analytical tool of production systems [7], presents a study that seeks to simulate the manufacturing system of a company in order to find optimized solutions, analyzing the demanded production levels, lines balancing, cycle times and order processing times.

The simulation makes it possible to recreate a real system in a controlled environment, which allows a possible understanding of the manufacturing performance, safely and at lower cost than would be necessary in analyzes with changes in the real production system form.

The simulation applied to manufacturing enables the resolution of the following issues: a) how to work with the product mix, required through lower investment and operating costs; b) how to allocate resources so that the fulfillment of production targets is possible and great financial results are obtained; c) how to improve the flow of production in terms of total cost, within the cycle time limits.

According to [12] many factors affect in a decision-making, such as: the time available, the importance of the decision, the environment, the risks, certainty / uncertainty, the decision agents and conflict of interests. The influence of these factors in decision-making can be minimized by preventive analysis that enables managers to previously obtain facts and reliable data that add to their experiences.

According to [8], in a computer simulation model it is possible to test various values for variables that can be controlled and modified by the designer. The control of variables enables desired output results and or comparison between models. The variables usually analyzed are: Processing time, lead time, resource utilization index, average quantity produced, queue time, drive time, among others.

III. ELEMENTS FOR SIMULATIONS

For the system behavior to be reproduced reliably, it is necessary to use the elements in the making of simulation models.

Entity: An entity may represent a person or object moving along the system, changing its state;

Resources: Resources are seen as constraints to the flow of the entities in the simulation. The authorities need to make use of resources to move through the model;

Attributes: Attributes are assigned to each individual entity and represent the features that entity must have along the simulation.

Queue: This is an element by which an entity passes when you need a resource. If there are others being served by the resource, this entity is in a queue.

Understand the objectives of a simulation project is one of the most important aspect. The project goals must be clearly defined at the beginning of the work. Additionally, other items should be defined at the beginning, such as:

- Define the problem and objective;
- Analyze the system;
- To get the actual data of the system;
- Create model;
- Validate the model;
- Experiment and analyze the model;
- Evaluate the results;
- Propose improvements.

Although the simulation is an excellent analysis tool, it is necessary to know a little more deeply about the advantages and disadvantages of their use. All simulation models are called input and output models, thus the entry conditions determine that produce output. They cannot generate an optimal solution by themselves, as is the case of the analytical systems. Simulation models only play the role of system behavior analysis tool under certain conditions.

Some of the benefits of using simulation are listed below, according to:

- New policies, operating procedures, decision rules, organizational structures, information flows, etc., can be operated without causing disturbances in the processes in use;
- New layout projects, transportation systems, machines and equipment, software, can be tested before its implementation, thus evaluating the need of purchase or modification;
- Assumptions about how and why certain phenomena occur can be tested;
- The time factor can be controlled, i.e., it may be expanded or compressed, allowing to increase or decrease the speed in order to study a phenomenon;
- Allows the analysis of variables which are significant to system performance and how these variables interact;
- Bottlenecks can be identified;
- A simulation work can be proven important to the understanding of how the system really works.

Despite the many advantages of using simulation, it is important to point some constraints or difficulties in the implementation of a simulation model. The main ones are:

- The need of training, since the quality of analysis depends on the quality of the model and therefore the ability of the analyst;
- Sometimes the simulation results can be difficult to interpret. This is because the simulation try to capture the randomness of a real system, leading to difficulty in identifying if an event occurred due to randomness or the interactions of system elements;
- Analyses made through the use of simulators can be time consuming and expensive, and may even derail its use.

A factory production capacity is directly linked to the better use of the process completion time, and the layout is among the performance factors of any production operation. Set any physical arrangement is to plan and

integrate the ways of the components of a product, in order to achieve an efficient and economical relationship between personnel, equipment and moving material [4]. Structuring steps and improvement of production layouts can be favored by the use of computer simulation, by analyzing the behavior of different layout alternatives before practice deployment. Interrupting a production line so that changes in their physical arrangement can be made, with the intention of performing experiments, would have a high cost to the organization, which is a point in favor of the use of computer simulation. Its application allows you to analyze various process parameters simultaneously where, through the animation dynamism, it is possible to increase the sensitivity on the elaborate proposals.

[13] and [9] present some benefits of using computer simulation in similar conditions to the ones studied here: (i) development of models adaptable to reality, testing different scenarios and operating possibilities of a system, without compromising resources; (ii) simulation capability of complex systems (equipped with stochastic components) which are not adequately described by deterministic mathematical models; (iii) assessment of the distribution of available resources, allocating them appropriately to the process and ensuring high standards of production; (iv) better control over the experimental conditions compared to the practical application in the real system; (v) analysis of long periods time of an operation in a short time simulation; and (vi) determination of bottlenecks in the system and studies related to process optimization.

In scenarios that require rapid and low-cost decision-making responses, the computer simulation is increasingly applied in companies in search of production layout improvement. The computer simulation can avoid unwise decisions that may jeopardize the operation of the company or result in inadequate investment [11].

For, by analyzing the behavior of different layout alternatives before practice implementation, mistakes and unnecessary cost will be avoided.

The use of simulation is justified in the evaluation of the distribution of available resources, allocating them appropriately in the process and ensuring high levels of production and its use in systems characterized by a high number of decision variables [15]. Importantly, the modeling and simulation of manufacturing cells, the features of the cell project in analysis (cell size, layout, types of machines, storage equipment, transportation and material handling and machine loading capacity and workstations) must be considered.

After considering the relevant issues related to the use of computer simulation, follows the approach method of research used.

Tecnomatix Plant Simulation® is a simulation tool for discrete events that allows the creation of different digital scenarios of the production system. With this tool it is possible to do simulation experiments that allow you to exploit the characteristics of systems and optimize their performance, therefore, the results provide information essential for decision-making, since with the creation of hypothetical scenarios it is possible to reach results performance without affecting the existing production system, avoiding stoppage of production to make experiments that could cause injury by production delay or equipment damage.

In addition to providing better visualization to model and simulate production systems and processes, Plant Simulation allows you to optimize the material flow, the resource utilization and the logistics for all factory-planning levels, from production facilities, through local factories to specific lines.

Resources

- Models oriented to the object with a hierarchical structure
- Open architecture with various standard interfaces
- Libraries and Object Management
- Optimization triggered by the genetic algorithm
- Automatic analysis of simulation
- Results report builder based on HTML

Benefits

- Saving of 3% to 6% of the initial investment
- Increase of 15% to 20% of the existing system productivity
- Reduction of 5% to 20% of the costs of new systems
- Optimization of consumption and resource reuse
- Reduction of 20% to 60% of inventories
- Reduction of 20% to 60% of the cycle time

[1] suggest the use of discrete events simulation as a project management tool that allows ongoing management of the project functionality even during implementation.

IV. METHODOLOGY OF RESERACH

According to [6], the great challenge of scientific research is the integration of theory and practice, being in the form of intervention in the study object and the researcher's ability to recognize the relevance of the scenario and draw conclusions.

In order to achieve the goal proposed in this paper, it was done a mapping of the entire manufacturing process in the finished production area of the company in question.

The method was adapted based on the development and implementation stages of simulation models proposed by

[13] and [9]. The steps of the proposed method of work are: (i) Problem formulation and study plan; (ii) Data collection; (iii) Construction of the conceptual model; (iii) Validation of the conceptual model; (iv) Construction of the computer model; (v) Verification and validation of the computer model; (vi) Definition of the experiment (s); (vii) Simulation (s) Experiment (s); and (viii) Analysis of the results. The flowchart with the defined method steps is shown in Fig 1.

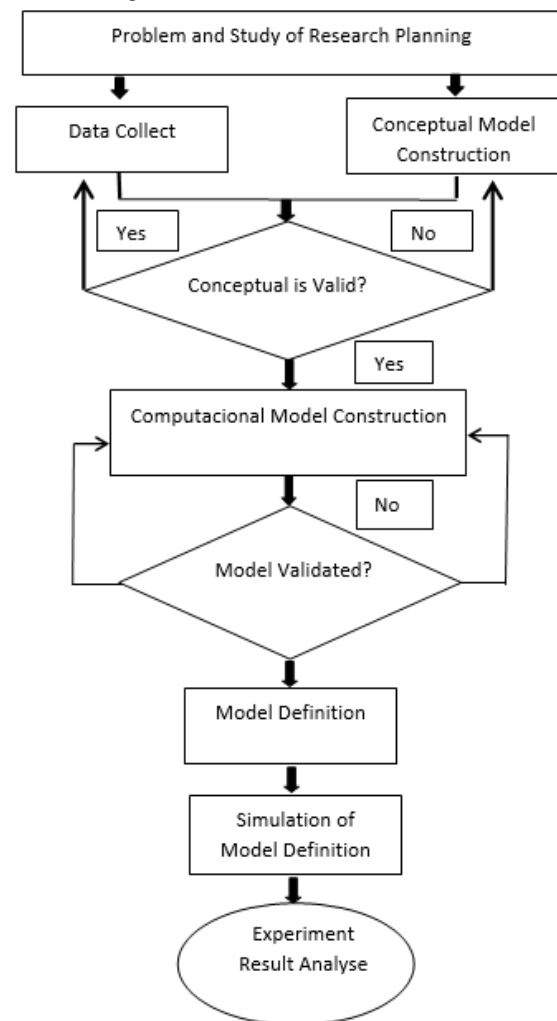


Fig.1: Proposed method for modeling and simulation

In the first step the manufacturing problem to be simulated is identified, for this, a mapping of the value stream was carried out so that the problems to be solved could be identified, and, this way, the new scenario will be planned over the desired purpose. Importantly, in this beginning it is necessary a clear definition of the simulation work objects, so the implications of the problem are evident. It can also be updated if necessary.

In the second stage are collected "in loco" the necessary data to compose the computer model, conducted through interviews with managers and other process professionals, as well as literature and case study, therefore, it has an exploratory character. It must be considered that the

quality of the input data is essential for the reality to be analyzed is portrayed in the best possible way in the computer development.

The next step is the Construction of the Conceptual Model, which is based on real scenario to build a simulation model that makes it possible to measure the current performance that will be evaluated in the computer modeling. After collecting data and formulating the conceptual model, it must be validated, defining the real characteristics of the system to be modeled and verifying if the model is in accordance with the actual system and the purposes of computer simulation [18].

After validating the conceptual model, the computer model will be developed with the help of the Tecnomatix Plant Simulation® software that allows the creation of environment and a better assessment of production capacity through simulated experiments, as well as enabling analysis of production resources in the system.

Ascertainment and validation of the simulation model. At this stage, it will be verified if the model represents in fact the actual system. The process simulation tests will be performed for the purpose of checking and then validate the computer model, for this is made a comparison of results of the actual process with the proposed ones, in which case it is the layout restructuring. It is at this stage that the information generated are verified, if the settings and the input data were assimilated correctly by the computer model [14].

The definition of the experiment came from the need for change in the production process, identified in the first step of the method, which identified shortcomings in the physical arrangement which caused movement of waste and need for performance improvement.

After defining the experiment, the desired changes will be modeled so the computer model can simulate the improvement changes allowing a comparative analysis of the results, to evaluate the viability of implementation of the proposed changes.

According to [16], the case study it is a methodological approach research especially proper when looking for understand, explore or describe events and complex contexts in which several factors are simultaneously involved.

The planning of case study should be designed carefully considering, in addition to the following operational aspects, the different types of validity that threaten the characterization of the work of a scientific nature research. In addition to predict which types of validity the case study is subjected to, the case description must contain a critical analysis resulting from the research quality in terms of these different types. Unfortunately, this is one of the biggest oversights in the conduction of a case study [16].

V. MANUFACTURING MAPPING

An assembly line consists of work stations, where a certain number of operations are performed in a certain sequence and at a constant speed. Manipulating with the operational composition of the work stations, more or less workers can be allocated on the assembly line in search of a better balance. It is said that an assembly line is perfectly balanced when all work stations are 100% occupied [17].

The Value Stream Mapping (VSM) or value flow mapping is a communication and planning tool that provides an overview of the entire process chain, allowing you to know in detail its manufacturing processes. It is a simple tool which uses pencil and paper and helps to see and understand the flow of materials and information as the product follows the flow value.

To start mapping it is necessary to draw the current state, using as a basis the collection of information: cycle times, number of people involved in each process, operations, material flow, material supply etc.

Once the process is clearer, actions to eliminate or contain waste become easier, because these same actions may be simulated by digital modeling, which, in turn, might indicate the best results.

According to [19], an important factor in creating an effective VSM is collecting information on the operating environment, and the perspective of those involved routinely in the processes, in order to capture the process "as it is" and not "as we think it is." That is why for the realization of the VSM project it is recommended that the mapping is done on the shop floor in the simplest and most objective way.

It was done the mapping of the current state of the organization in order to identify opportunities to improve the process. During the observation period all the information that could indicate improvement or that could be the possible cause of the delay of the process, was collected. The mapping was initiated by the representation of all the steps involved in the production process, making it possible to understand the waste and their generating sources, and from this problem the experiments that will be performed by simulation can begin, using the acquired information by mapping as the basis of an implementation plan, aiming the future scenario projected.

Fig 2 illustrates the current state of the organization by the VSM tool where the information flow is; in it is observed the path of materials and cycles of each process stage, from the arrival of the raw material until the delivery to the final customer.

According to the current state map, reducing the waiting time in front of each workstation is an opportunity to

reduce the lead-time and, consequently, to increase the service level. This is of interest because the focus of the present study is to explore a lean production system design for fishing net manufacturing using lean principles and simulation optimization. However, reducing WIP and

its associated non-value-adding time, while maintaining the required system performance, is not straightforward. In fact, it is quite challenging and is the main concern for any scheduling decision and shop floor control system [22].

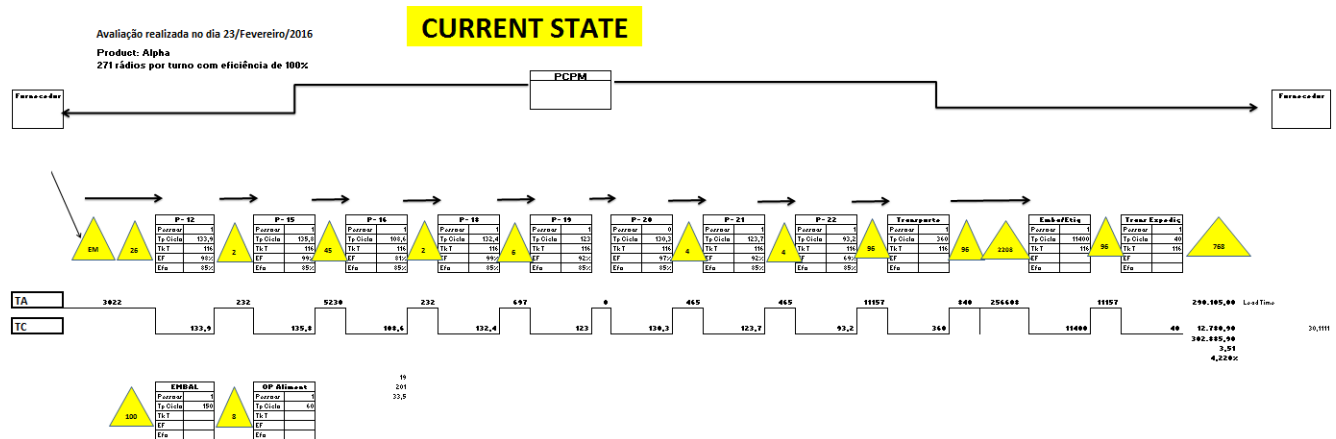


Fig.2: Current State Map

Fig 3 shows the future state proposed by the multifunctional team, in which the potential waste and action plans for activity to reduce the time of crossing of the product were analyzed. It became evident during the analysis that the layout change would increase the opportunity with reduce of movement and over processing waste. This way the point observed and researched in this study was in the layout change project, aiming to reduce waste between the process steps.

Future state map demonstrates the output of the proposed changes based on the gaps identified in the snapshot of

the “as-is” state of the current state. It was asked to involve the supplier earlier in the process to have a high degree of correct information and coordination. It should be achieved by improving communication up front to foster proper information regarding product and process. This will bring the necessary knowledge to execute the steps in correct manner eliminating the need of rework through iterations at back end of the process. It will also help the involved departments to understand and share same vision for future products [21].

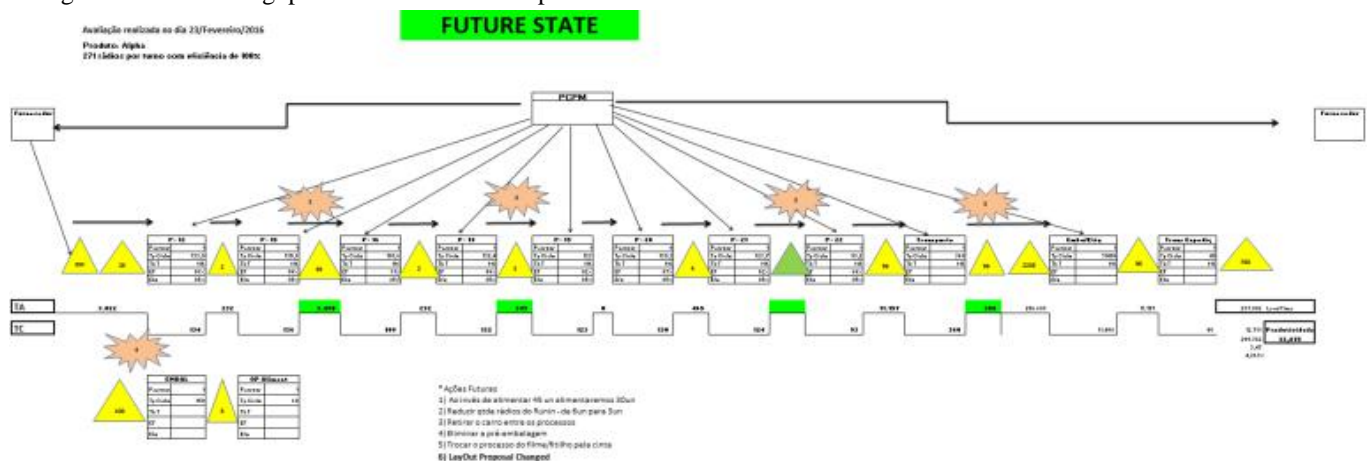


Fig.3: Future State Map

In Fig 4 you can see the real way process, with the two sequences in an illustration that represents the current layout. The choice of layout type depends largely on the process structure - the position of the processes in the array of customer contact for service providers and product-process matrix for the manufacturing process. The four basic types of layout include: (1) by process or

functional or job shop; (2) product; (3) hybrid; and (4) fixed position [10].

The layout for process involves three basic steps, either to a new layout, either for a review of an existing layout: (1) collect information; (2) develop a general plan; and (3) design a detailed layout [10].

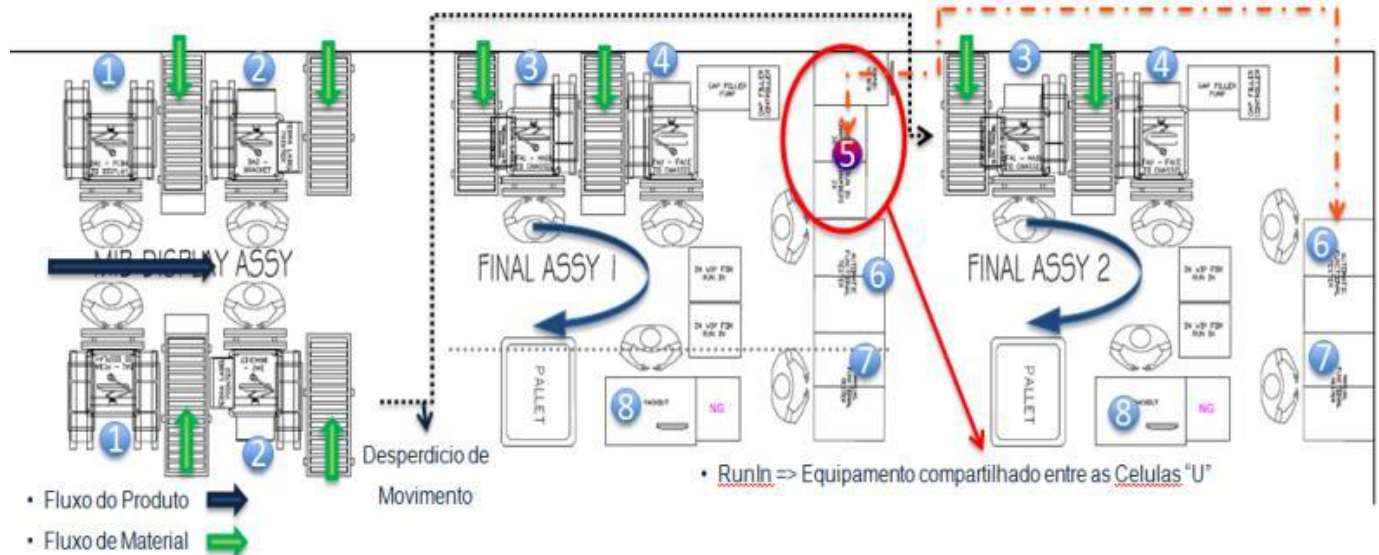


Fig.4: Stage of Manufacturing Process

Computer simulation of the proposed physical arrangement

Based on the model of the current layout, experiments using Tecnomatix Plant Simulation® software were initiated, which made it possible to design a physical arrangement more suitable for the production sequence, in

order to increase productivity, making a distribution of work stations and equipment in order to eliminate the waste of movement from work stations 2 and 5, tracing a sequence that would enable the increase in production capacity. According to Fig 5.

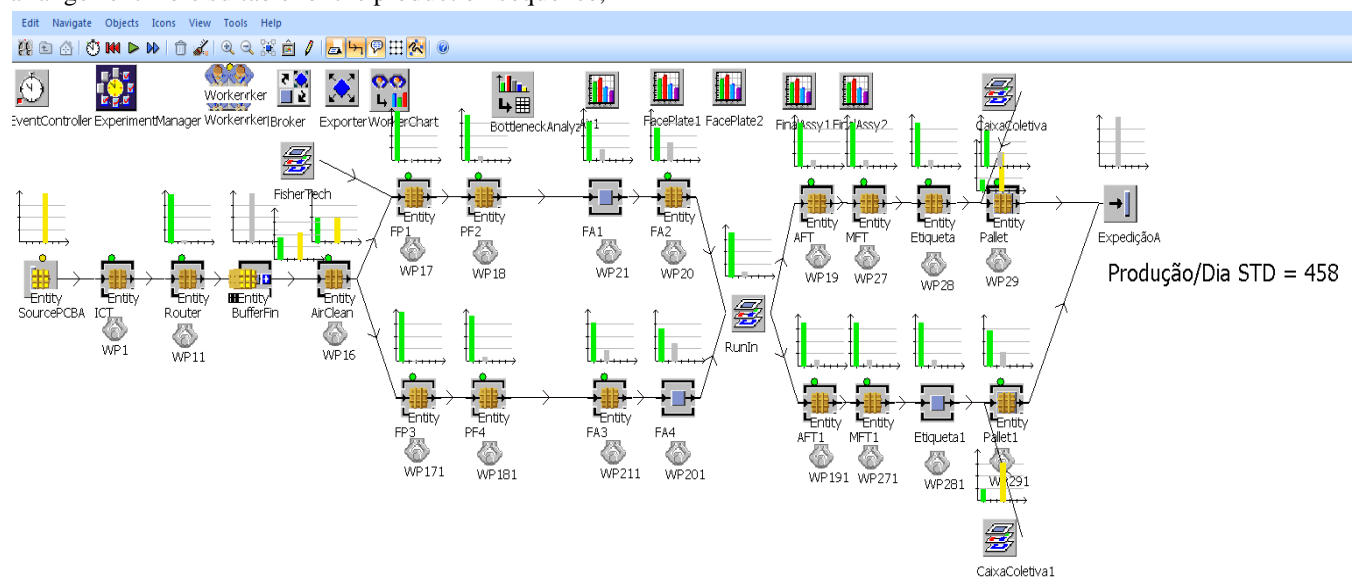


Fig.5: Virtual Simulation with New Arrangement

Process Mapping - New Physical Arrangement

Considering that the computer simulation of the redesigned process showed satisfactory results, it was

proposed a new arrangement to share resources in order to mitigate costs and increase productivity, eliminating the handling of waste, as shown in Fig 6.

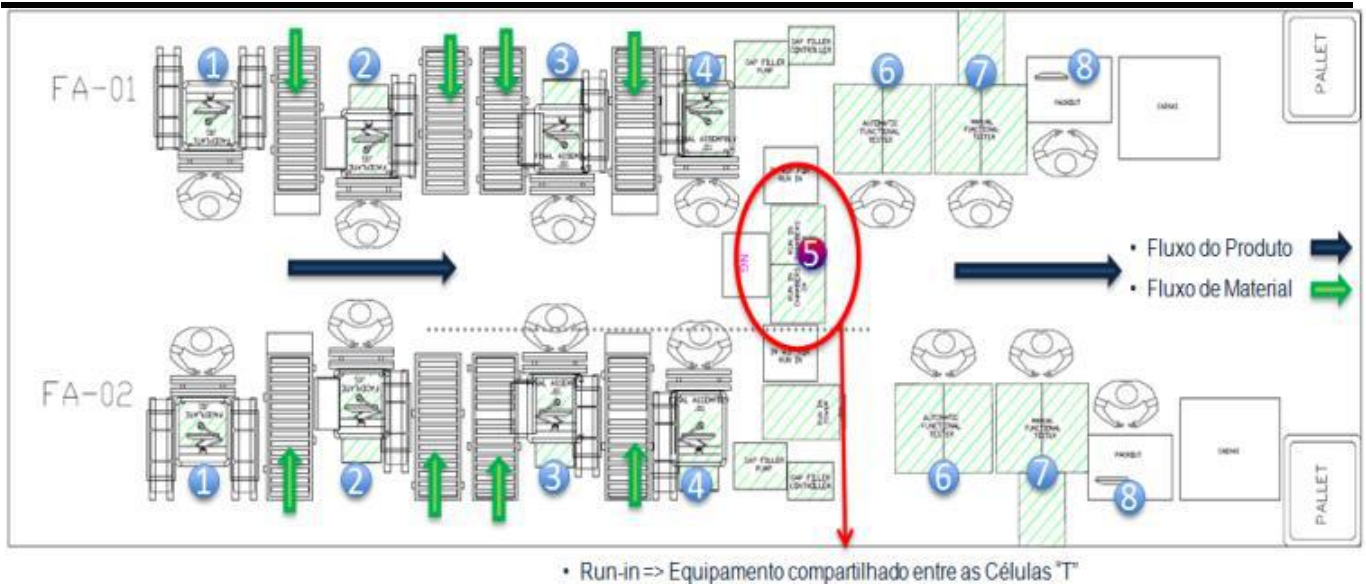


Fig.6: New Physical Arrangement – “T” Cells

VI. RESULTS ANALYSIS

Based on the information that the monthly demand of radios is 20,000, and from the simulation of the proposed model used, such improvement will be exemplified by results of comparative charts of production results obtained before and after the improvement proposal shown in Fig 7, that shows the Production Evolution per hour.

In the chart, which represents the production of radio per operator. Shown in Fig 7, it is noted that in the 29th week

of 2018 before commencing the restructuring changes, the production rate was 208 radios per person per month, reaching a total of 96 people to reach the desired volume of production by the client was 20,000 radios.

After the changes proposed layout, the results showed that there was a decrease of persons, from 96 to 77, and an increase in monthly production per person 208 to 259, since there was a reduction in wasted motion, thus increasing the production capacity and reducing cost labor, since there was a decrease of 19 people.

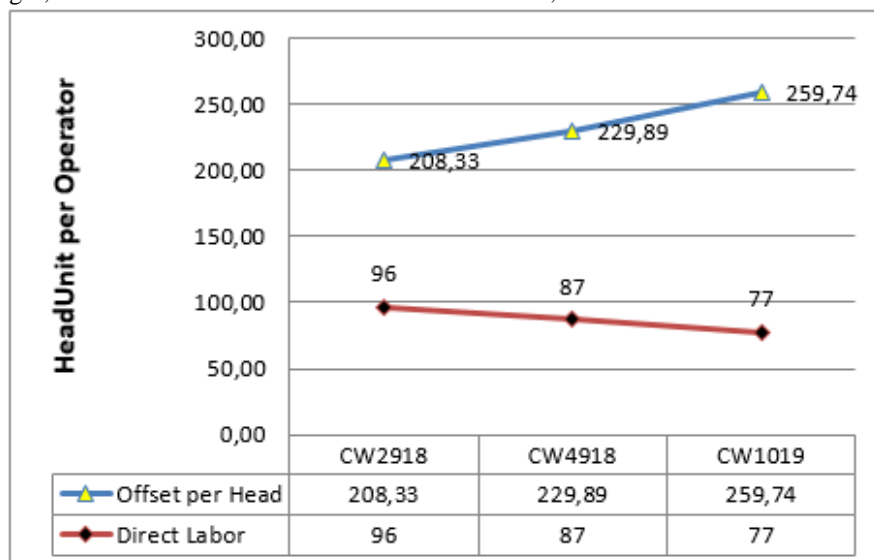


Fig.7: Comparison chart of increase productivity per operator

According to Fig 8, that represents the Evolution of production per hour, it shows that after the improvement with the restructuring of the layout there was an increase in production, which went from 22 units per hour to 32,

with improvements in the production of three models produced between weeks 29/2018 and 10/2019, layout change period.

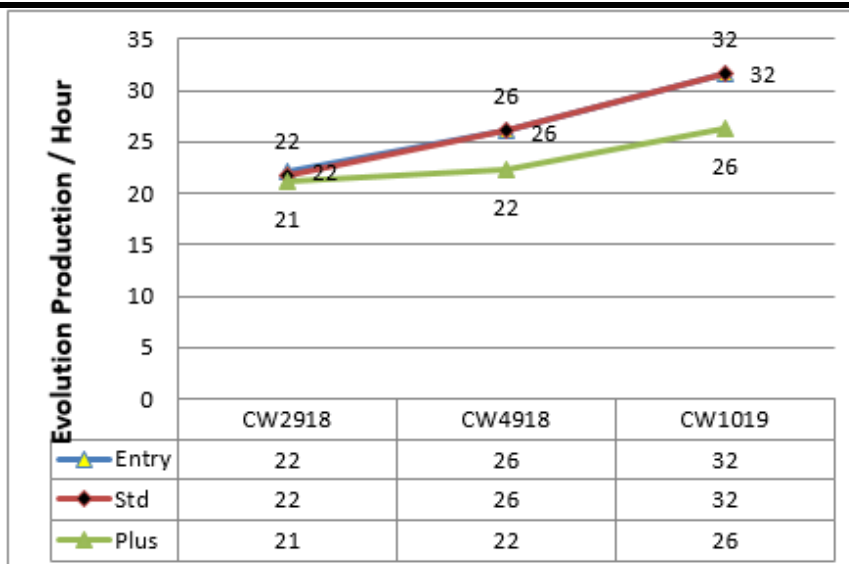


Fig.8: Comparative chart of output per hour evolution

VII. CONCLUSION

This research, developed a model that aims to construct manufacturing simulation using existing computer tool due to it being easily understood, a simulation model is often simpler to be justified than some analytical models. Furthermore, a simulation model usually has more reliability since it can be compared with the real system or because they require little simplification, capturing the actual characteristics of the system and shows results of snapshots manufacture daily.

Therefore, it was seen in this research that there is much room for gains and improve production of car radios, because the software includes features that allow deeper analysis in a simple way. Remember that with the mapping was clear the evidence of work stations with higher capacity than required. Especially with the excessive use of buffers among various work stations, making the cost of in-process inventory is very high. Thus, we suggest the continuity of the work, therefore, there is already a virtual structure built and new scenarios can be created in order to seek new proposals for improvement.

It is good to remember that this subject was addressed during the construction of the Value Stream Mapping, where it has been suggested to reduce buffers in order to reduce the crossing time, however to meet the customer demand because the deployed logistics characteristics, it is need a week of inventory of finished product and two weeks of production on the road, not to run the risk of the client stop. Because of this feature is not possible to improve this external logistics process, but the other intermediate phases must be addressed with a more forceful approach by the multifunctional team.

It is recommended a new balance after the change of the physical arrangement, particularly where work stations are over the capacity, therefore, must be added some functions and achieve the same result, so that the organization can reduce costs and keep more competitive in the current market, so the standardization of this work format needs to be implanted so the engineering group can always work in the pursuit of operational excellence. It is also recommended the analysis of other projects discussed during the VSM in order to seek constant improvements to the process and use the simulation environment created for quick decision-making and when necessary make the changes and simulations to support the decision of the organization's managers.

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Ternary Complexes of Essential Metal Ions with L-Arginine and Succinic Acid in Cationic Surfactant Medium

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Abstract— Chemical speciation of ternary complexes MLX , ML_2X and $MLXH$ formed by $Co(II)$, $Ni(II)$, $Cu(II)$ and $Zn(II)$ with L-arginine as primary ligand (L) and succinic acid as secondary ligand (X) was studied in various concentrations (0.0-2.5% w/v) of cationic surfactant solution maintaining an ionic strength of 0.16 mol dm^{-3} ($NaNO_3$) at 303K. Titrations were carried out in the presence of different relative concentrations ($M: L: X = 1:2:2, 1:2:4, 1:4:2$) of metal to L-arginine to succinic acid with sodium hydroxide as titrant. The observed extra stability of ternary complexes compared to their binary complexes was explained based on the electrostatic interactions of the side chains of the ligands, charge neutralization, chelate effect, stacking interactions and hydrogen bonding. The trend in $\log \beta$ values with mole fraction of the surfactant and distribution diagrams were presented. Structures of plausible ternary complexes were also presented.

Keywords— Ternary complexes, L-arginine, succinic acid, essential metals, cationic surfactant.

I. INTRODUCTION

L-arginine (Arg) is an essential amino acid required for polyamine biosynthesis¹ in bacteria, fungi and higher eukaryotes. It also serves as the precursor to nitric oxide (NO) synthesis. Succinic acid (Suc) is involved in citric acid and glyoxalate cycles. For energy production and biosynthesis many plants and bacteria convert acetyl units into succinate units in glyoxalate cycle. It can be used² to manufacture medicaments or nutritional supplements effective for treating insulin resistance in mammals.

Aqueous solution of Cetyltrimethylammonium bromide (CTAB) exhibits complex behaviour with respect to a number of micellar properties, especially when

additives like electrolytes and different organic compounds are present.³⁻⁷ The micellar properties are highly specific and depend on the associated counter ions and structure of the additives.

The role of trace metals in biological systems is well recognized.⁹ Trace metal ions like $Co(II)$, $Ni(II)$, $Cu(II)$ and $Zn(II)$ are essential and any variation in their homeostasis leads to metabolic disorders.¹⁰ Hence, the chemical speciation of title systems has been carried out to examine the speciation behaviour and effect of micelles on ternary complexes with selective bio-ligands.

II. EXPERIMENTAL

Cetyltrimethylammonium bromide (CTAB, AR, Qualigens, India), was used and its purity was checked by determining critical micellar concentration (CMC) conductometrically. The CMC value of CTAB was $9.2 \times 10^{-4} \text{ mol dm}^{-3}$ at 303K. Aqueous solutions of L-arginine, succinic acid, $Co(II)$, $Cu(II)$, $Ni(II)$ and $Zn(II)$ chlorides, nitric acid, sodium hydroxide and sodium nitrate have been prepared by using GR Grade (Merck, India) samples in triple distilled water. All the metal solutions were standardized by usual standard methods.¹¹

To increase the solubility of Arg and Suc and to suppress the hydrolysis of metal salts, nitric acid concentration has been maintained at 0.05 mol dm^{-3} . To assess the errors that might have crept into the determination of the concentrations, the data were subjected to analysis of variance of one way classification (ANOVA). The strengths of alkali and acid were determined using the Gran plot method.¹²

Apparatus

An ELICO (Model LI-120) pH-meter (readability 0.01) was used to monitor the changes in H^+ concentration. The pH meter was calibrated as mentioned in our earlier papers.¹³ The glass electrode has been equilibrated in a well stirred aqua-surfactant solution containing the inert electrolyte ($NaNO_3$). The effects of variations in asymmetry, liquid junction potential, activity coefficient, sodium ion error and dissolved carbon dioxide on the response of glass electrode were accounted for in the form of the correction factor.¹⁴

Procedure

The alkalimetric titrations were carried out in the medium containing varying concentrations (0.0-2.5% w/v) of surfactant in water maintaining an ionic strength of 0.16 mol dm^{-3} with sodium nitrate at $303.0 \pm 0.1K$. The strong acid was titrated with alkali at regular intervals to check whether complete equilibration was achieved. Free acid titrations have been carried every day prior to the mixed-ligand titrations to calculate the correction factor. In each of the titrations, the titrand consisted of approximately 1 mmol of mineral acid, metal ion, ligands and the inert electrolyte in a total volume of 50 cm^3 . Titrations with different ratios (M: L: X = 1:2:2, 1:2:4, 1:4:2) of metal to primary ligand to secondary ligand were carried out with 0.4 mol dm^{-3} sodium hydroxide solution. Other experimental details are given elsewhere.¹⁵

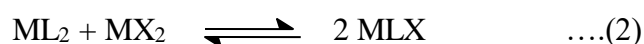
Modeling strategy

The approximate stability constants of ternary complexes were calculated with the computer program SCPHD.¹⁶ Different models containing varied number of ternary species were generated using the expert system CEES.¹⁷ The best fit chemical models for each ternary system investigated were arrived at using the computer program MINQUAD75.¹⁸

III. RESULTS AND DISCUSSION

Complex equilibria

$$\log X = 2\log K_{MLX}^M - \log K_{ML_2}^M - \log K_{MX_2}^M \quad \dots(1)$$



Under these equilibrium conditions one can expect 50% ternary complex and 25% each of the binary complexes to be formed and the value of $\log X$ was reported²⁴ to be 0.6.

A preliminary investigation of alkalimetric titrations of mixtures containing different mole ratios of Arg and Suc in the presence of mineral acid and inert electrolyte inferred that no condensed species are formed. The binary metal complexes were fixed in the refinement of the ternary complexes in testing various chemical models using MINQUAD75. The best fit models were chosen as those with low standard deviation in the formation constants and minimum U (sum of squares of deviations in the concentrations of ingredients at all experimental points) corrected for degrees of freedom, which was corroborated by other statistical parameters like χ^2 , R-factor, skewness and kurtosis given in Table 1. The species detected for all the metal ions (M = Co(II), Ni(II), Cu(II) and Zn(II)) are MLX , ML_2X and $MLXH$, where L is the primary ligand (Arg) and X is the secondary ligand (Suc).

A very low standard deviation in $\log \beta$ values indicates the precision of these parameters. The small values of U_{corr} indicate that the experimental data can be represented by the model. Small values of mean, standard deviation and mean deviation for the systems corroborate that the residuals are around a zero mean with little dispersion. For an ideal normal distribution, the values of kurtosis and skewness should be three and zero, respectively. The kurtosis values in the present study indicate that most of the residuals are leptokurtic and a few form mesokurtic patterns.¹⁹ The values of skewness recorded in Table 1 are between -1.92 to 1.54. These data evince that the residuals form a part of normal distribution; hence, least-squares method can be applied to the present data. The sufficiency of the model is further evident from the low crystallographic R-values.

Extra stability of ternary complexes compared to binary complexes

The change in the stability of the ternary complexes as compared to their binary analogues was quantified²⁰⁻²³ based on the disproportionation constant ($\log X$) given by Equation 1, corresponding to the Equilibrium given in Equation 2.

The $\log X$ values calculated from binary and ternary complexes are included in Table 2. These values could not be calculated for some systems due to the absence of

relevant binary species. In the present study, the log X values range from 2.46 to 13.94 which are higher than those expected on statistical basis (0.6). These higher values account for the extra stability of the ternary complexes. The extra stability of these complexes may be due to interactions outside the coordination sphere such as the formation of hydrogen bonds between the coordinated ligands, charge neutralization, chelate effect and stacking interactions.²⁵

Effect of systematic errors on best fit model

In order to rely upon the best chemical model for critical evaluation and application under varied experimental conditions with different accuracies of data acquisition, an investigation was made by introducing pessimistic errors in the influential parameters²⁶ like concentrations of alkali, mineral acid, ligands, metal and logF shown in Table 3. The order of the ingredients that influence the magnitudes of stability constants due to incorporation of errors is alkali > acid > Arg > Suc > metal > logF. Some species are even rejected when errors are introduced in the concentrations. This study confirms the appropriateness of the concentrations of the ingredients and the chosen best fit models.

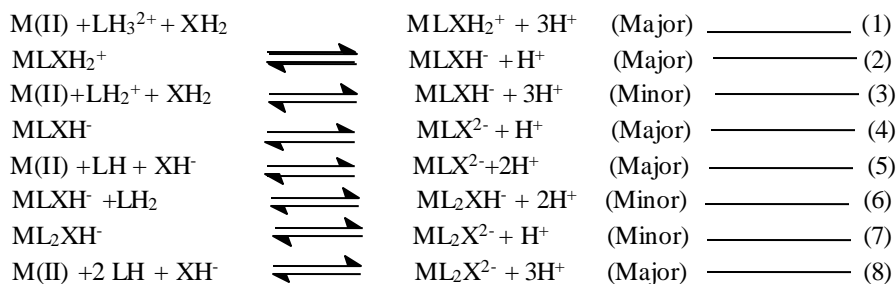
Effect of micelles

The CTAB micelles have positive surface charge and negatively charged complexes are stabilized on the

micellar surface. The number of micelles increases with the concentration of surfactant the anions are concentrated in the Stern layer.²⁷ The variation of log β values of ternary complexes as a function of the mole fraction of the surfactant is shown in Figure 1. Similar to binary complexes,²⁸ the stabilities of ternary complexes also exhibit non-linear trend may be due to considerable contribution from non-electrostatic forces and decreased dielectric constant of the medium with increased surfactant.²⁹

Distribution diagrams

A perusal of the distribution diagrams (Figure 2) reveals that the concentrations of the ternary species increases with increase in pH. The protonated ternary species, $MLXH^+$ is distributed at lower pH (6.0-10.0) than the unprotonated species, MLX^{2-} and ML_2X^{2-} . The lower concentrations of binary species than those of the ternary species indicate the existence of more stable ternary complexes. The ternary species exist in the pH ranges 6.0–8.0 and 9.0-10.5 for Co(II) and Ni(II), respectively, where as in the case of Cu(II) and Zn(II), the complex species are distributed in the pH range 3.0-7.5 and 8.5-10.0. The formation of the complex species can be represented by the following equilibria.



In the pH regions 1.5-11.5 and 1.9-7.5, Arg³⁰ and Suc^{31,32} exist as LH_3^{2+} and XH_2 , respectively. These protonated ligands interact with the metal ion to form $MLXH_2^+$ (Equilibrium 1). The species may successively be deprotonated to form $MLXH^+$ and MLX^{2-} (Equilibria 2 and 4). Existence of $MLXH^+$ species can be explained based on the deprotonation of $MLXH_2^+$ species and also due to interaction of the metal ion with ligand species (Equilibrium 3). For the formation of $MLXH^+$ Equilibrium 2 is more appropriate because the concentration of $MLXH^+$ increases where as that of MLX^{2-} decreases. In the pH region 4.0-9.0 Arg and Suc exists as LH and XH^- , respectively. These ligands interact with the metal ion to form MLX

(Equilibrium 5). ML_2X^{2-} is formed by the deprotonation of $ML_2XH_2^+$ (Equilibria 6 and 7) and also by the interaction of metal ion with two LH species and one XH^- species (Equilibrium 8) which is more appropriate than the former because $ML_2XH_2^+$ and its deprotonated species are not refined and during its formation the concentrations of LH and XH^- are decreasing. Depending upon the coordinating atoms in the ligands and the nature of the metal ions, structures were proposed for the species detected as shown in Figure 3.

IV. CONCLUSIONS

A study of the chemical speciation of ternary complexes of Co(II), Ni(II), Cu(II) and Zn(II) with Arg and Suc in micellar media reveals the compartmentalization of metabolic reactions. The following conclusions have been drawn from the modeling studies:

- The species detected are MLX^{2-} , $MLXH^{-}$, ML_2X^{2-} for Co(II), Ni(II), Cu(II) and Zn(II) of L-arginine and succinic acid.
- The change in the stability of the ternary complexes as compared to their binary analogues shows that the ternary complexes are more stable than the binary complexes due to the interactions outside the coordination sphere.
- The existence of ML_2X^{2-} and absence of MLX_2 indicates that LH has more affinity than XH towards the metal ion. This also supports the tridentate behavior of Arg and bidentate nature of Suc.
- The order of the ingredients that influence the magnitudes of stability constants due to incorporation of errors is alkali > acid > Arg > Suc > metal > logF.
- The study also gives an insight into the metal availability/metal transport in biofluids. The ternary complexes are more amenable for metal transport because of their extra stability and the binary complexes make the metal available in biological systems due to their decreased stability.

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Table 1. Parameters of best fit chemical models of Co(II), Ni(II), Cu(II) and Zn(II)-Arg-Suc complexes in CTAB-water mixtures

% w/v CTAB	Log β (SD)			NP	U _{corr}	Skew- ness	χ^2	R- Factor	Kurtosis	pH- Range
	MLX	ML ₂ X	MLXH							
Co(II)										
0.0	13.97(4)	18.70(8)	20.69(18)	101	5.71	0.65	34.22	0.0822	7.32	2.0-10.5
0.5	12.62(4)	17.10(8)	19.16(20)	85	5.00	0.54	28.92	0.0741	5.42	2.0-10.0
1.0	12.54(5)	16.53(7)	18.59(14)	87	5.83	0.34	21.05	0.0452	3.82	2.0-10.2
1.5	12.74(5)	16.75(7)	18.67(15)	81	8.33	-0.09	33.03	0.0624	4.97	2.0-10.0
2.0	12.95(3)	16.79(7)	18.73(18)	95	1.55	0.74	31.08	0.0714	5.77	2.0-10.5
2.5	12.99(4)	16.87(9)	18.85(170)	97	5.47	0.87	35.71	0.5250	6.47	2.0-10.5
Ni(II)										
0.0	13.97(3)	18.50(10)	20.90(19)	99	5.74	-1.27	105.02	0.0714	6.54	2.0-10.5
0.5	12.27(3)	16.40(12)	18.88(17)	88	5.52	-1.22	103.21	0.0683	5.92	2.0-10.0
1.0	12.29(4)	16.55(12)	18.87(14)	92	1.23	-1.33	98.390	0.0793	3.94	2.0-10.5
1.5	12.38(4)	16.67(10)	18.98(20)	97	2.02	-1.48	110.42	0.0954	7.05	2.0-10.5
2.0	12.57(2)	16.83(9)	18.76(21)	95	5.10	-1.54	121.92	0.0763	6.92	2.0-10.5
2.5	12.76(3)	16.75(10)	18.73(20)	100	3.81	-1.65	118.65	0.0895	5.55	2.0-11.0
Cu(II)										
0.0	16.73(5)	18.50(10)	21.50(20)	101	3.18	1.09	54.41	0.0931	8.07	2.0-10.5
0.5	15.82(6)	17.67(12)	20.40(21)	81	0.76	-1.22	39.02	0.0720	7.03	2.0-10.0
1.0	15.92(4)	17.82(10)	20.53(18)	85	2.78	-1.39	49.05	0.0825	8.64	2.0-10.2
1.5	15.49(3)	17.59(12)	20.94(17)	88	7.76	-1.92	59.34	0.0734	7.94	2.0-10.5
2.0	15.56(2)	17.87(12)	20.77(18)	95	8.91	1.54	39.36	0.0847	6.74	2.0-10.5
2.5	15.83(2)	17.57(9)	20.96(19)	91	2.61	1.30	45.08	0.0733	5.97	2.0-10.5
Zn(II)										
0.0	12.94(3)	18.73(9)	20.97(18)	97	5.53	0.29	39.82	0.0744	7.04	2.0-10.5
0.5	11.35(3)	17.33(8)	18.87(17)	81	0.38	0.07	64.06	0.0811	7.37	2.0-10.0
1.0	11.49(2)	17.48(10)	18.80(19)	88	9.29	-0.21	50.51	0.0722	6.24	2.0-10.2
1.5	11.58(3)	17.32(12)	18.98(20)	83	9.00	-0.70	48.21	0.0655	5.32	2.0-10.6
2.0	11.69(4)	17.20(14)	18.77(21)	95	2.93	0.79	37.03	0.0534	4.94	2.0-10.5
2.5	11.74(4)	17.51(11)	18.89(18)	97	5.36	0.69	40.05	0.0443	4.99	2.0-10.5

$U_{\text{corr}} = U/(NP-m) \times 10^8$, where m = number of species; NP=Number of experimental points, SD= standard deviation

Table 2. Variation of stability of ternary complexes of Arg and Suc in CTAB-water mixtures.

% w/v CTAB	log X_{MLX}	log $X_{\text{ML}_2\text{X}}$	Log X_{MLXH}
Co(II)			
0.0	10.54	13.91	6.93
0.5	8.68	11.64	4.27
1.0	8.43	10.45	2.9
1.5	8.57	10.66	2.69
2.0	8.73	10.42	2.46
2.5	8.73	10.47	3.64
Ni(II)			

0.0	9.53	9.75	-
0.5	8.52	8.77	-
1.0	10.15	8.79	-
1.5	4.65	13.94	-
2.0	5.63	10.45	-
2.5	7.56	8.25	-
Cu(II)			
0.0	11.53	12.17	-
0.5	11.86	12.56	-
1.0	12.5	13.25	-
1.5	12.02	13.08	-
2.0	12.69	13.94	-
2.5	13.65	13.92	-
Zn(II)			
0.0	4.89	8.38	-
0.5	6.76	2.75	-
1.0	4.69	8.68	-
1.5	5.56	8.79	-
2.0	6.24	8.77	-
2.5	6.79	9.75	-

Calculations:-

$$\log X_{MLX} = 2 \log \beta_{MLX} - \log \beta_{ML_2} - \log \beta_{MX_2}$$

$$\log X_{MLXH} = 2 \log \beta_{MLXH} - \log \beta_{ML_2H} - \log \beta_{MX_2H}$$

$$\log X_{ML_2X} = 2 \log \beta_{ML_2XH} - \log \beta_{ML_2} - \log \beta_{MXH}$$

Table 3. Effect of errors in influential parameters on the stability constants of ternary complexes of Cu(II) and Ni(II) with Arg - Suc in 1.0 % (w/v) CTAB-water mixture

Ingred- ient	% Error	log β (SD)					
		Cu(II)			Ni(II)		
		MLX	ML ₂ X	MLXH	MLX	ML ₂ X	MLXH
	0	15.92(4)	17.82(10)	20.53(19)	12.29(4)	16.55(12)	18.87(14)
Alkali	-5	16.20(55)	18.25(62)	21.24(31)	13.12(25)	17.25(41)	Rejected
	-2	Rejected	18.11(51)	21.00(25)	Rejected	Rejected	20.99(36)
	+2	16.08(42)	Rejected	Rejected	13.02(33)	17.18(20)	20.12(44)
	+5	Rejected	Rejected	Rejected	13.13(35)	Rejected	Rejected
Acid	-5	Rejected	17.62(42)	20.58(32)	11.31(59)	15.35(25)	18.42(32)
	-2	15.59(61)	Rejected	Rejected	Rejected	Rejected	18.25(58)
	+2	15.32(59)	17.51(78)	20.67(30)	11.13(24)	15.26(36)	Rejected
	+5	Rejected	Rejected	Rejected	Rejected	Rejected	18.37(53)
Arg	-5	15.74(29)	17.98(20)	20.89(45)	12.23(20)	16.02(38)	19.36(60)
	-2	15.69(61)	18.02(20)	20.98(20)	12.44(39)	16.43(39)	20.09(24)
	+2	15.34(35)	Rejected	20.74(54)	12.56(35)	15.02(38)	18.80(42)
	+5	Rejected	17.91(22)	Rejected	12.95(30)	15.82(38)	Rejected
Suc	-5	16.01(29)	17.88(45)	20.87(22)	Rejected	16.00(32)	18.65(60)
	-2	15.84(39)	Rejected	20.68(49)	12.32(52)	Rejected	Rejected

	+2	16.06(21)	17.89(23)	20.05(25)	12.65(33)	16.10(25)	18.74(43)
	+5	Rejected	Rejected	Rejected	13.05(46)	Rejected	18.90(55)
Metal	-5	15.64(29)	17.89(25)	20.05(30)	12.24(44)	16.45(51)	19.17(33)
	-2	15.94(45)	17.99(26)	20.92(27)	13.92(48)	16.52(42)	18.69(44)
	+2	15.72(39)	Rejected	20.71(28)	13.54(46)	16.41(34)	18.91(29)
	+5	Rejected	Rejected	Rejected	Rejected	16.32(33)	18.82(38)
Log F	-5	16.71(42)	Rejected	20.82(35)	13.82(49)	Rejected	19.06(21)
	-2	16.69(22)	17.89(24)	20.77(28)	12.44(50)	Rejected	Rejected
	+2	16.54(19)	18.06(42)	20.65(38)	12.48(56)	17.05(39)	18.91(55)
	+5	Rejected	Rejected	Rejected	12.83(50)	Rejected	Rejected

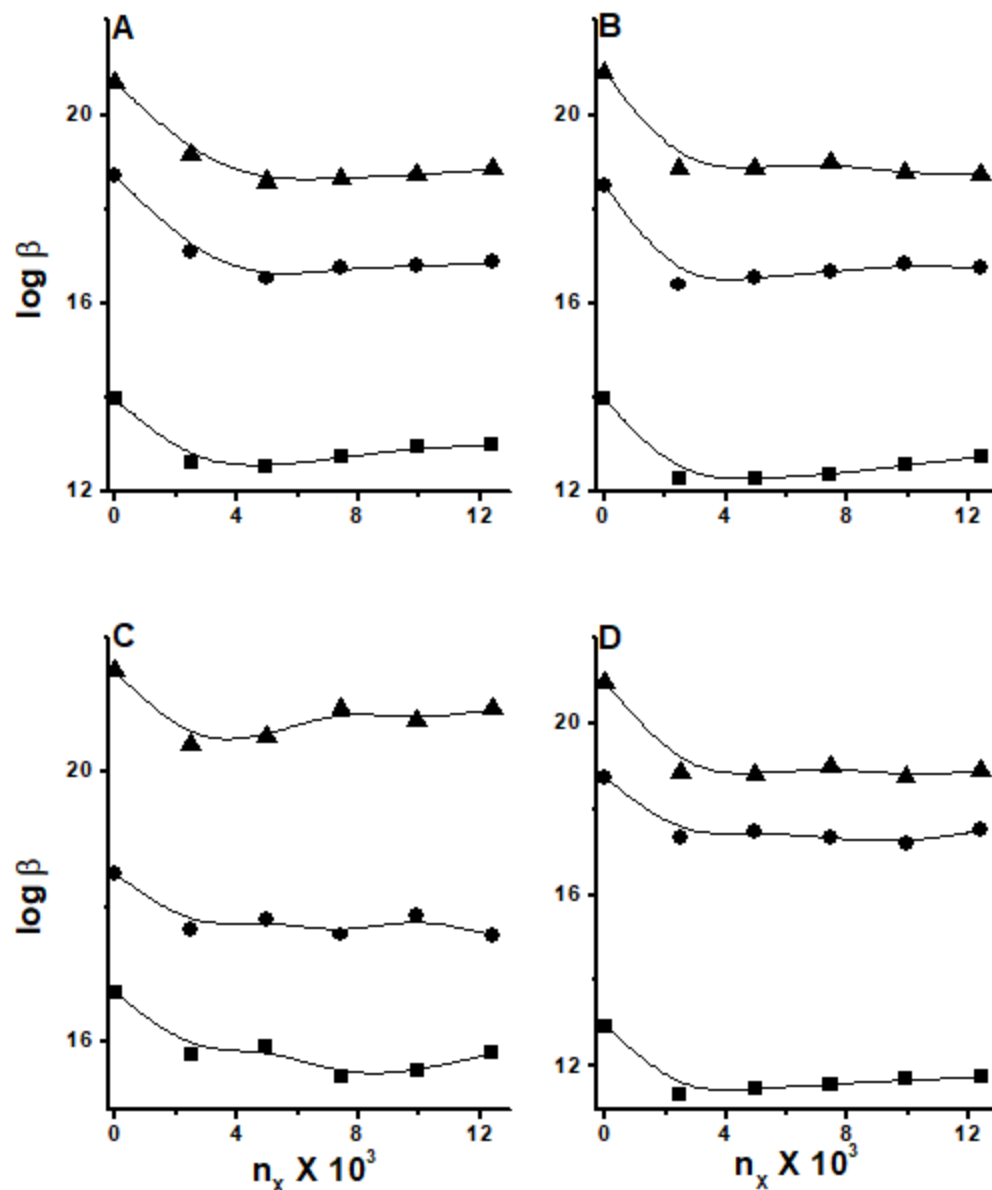


Fig1: Variation of stability constant of ternary complexes with mole fraction of CTAB. (A) Co(II) B) Ni(II) C) Cu(II) and D) Zn(II) (■) $\log \beta_{MLX}$, (●) $\log \beta_{ML_2X}$, (▲) $\log \beta_{MLXH}$.

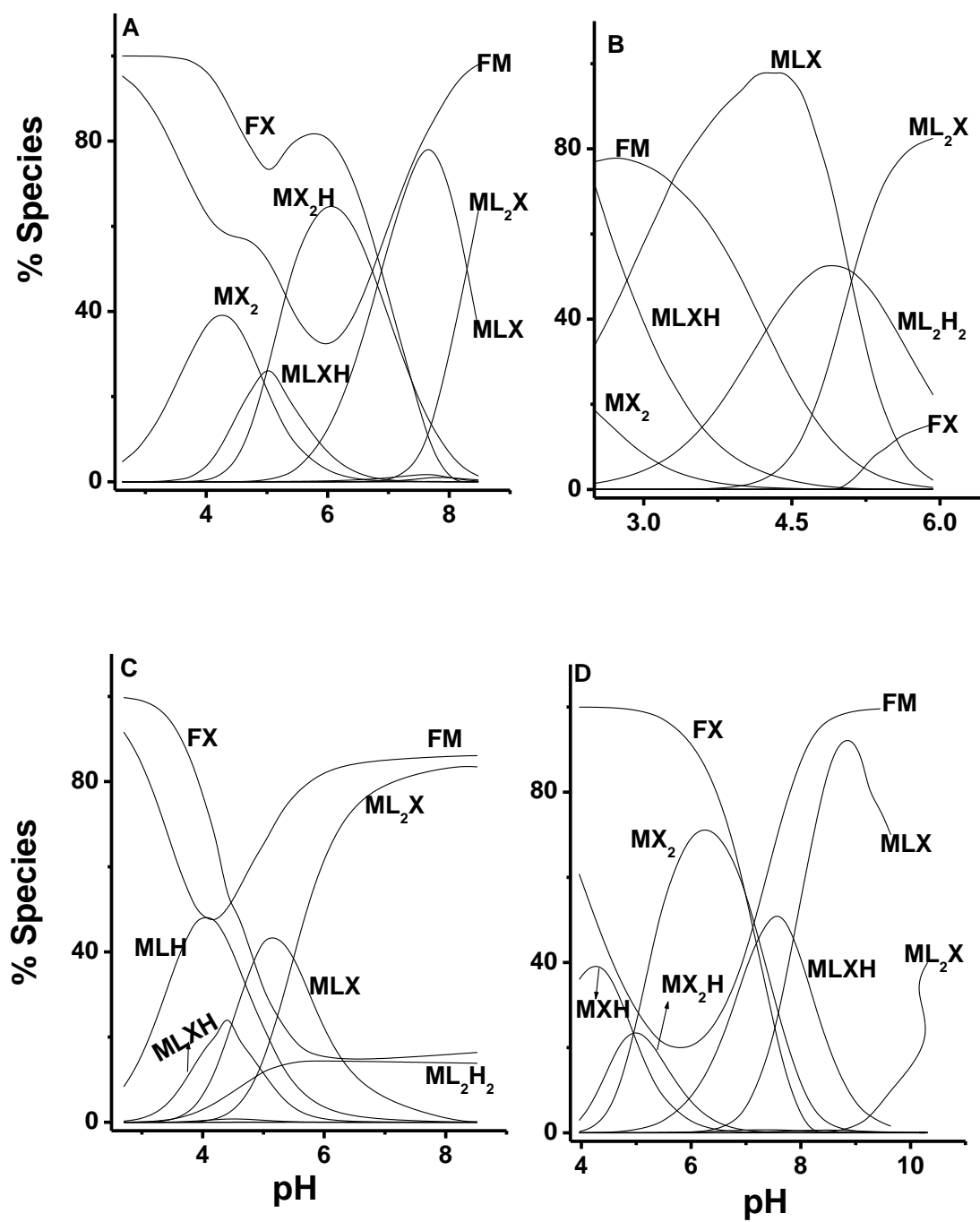
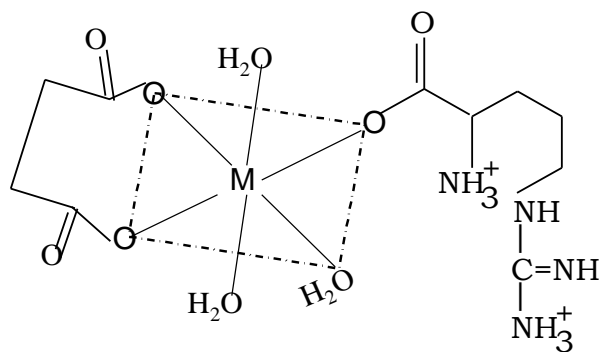
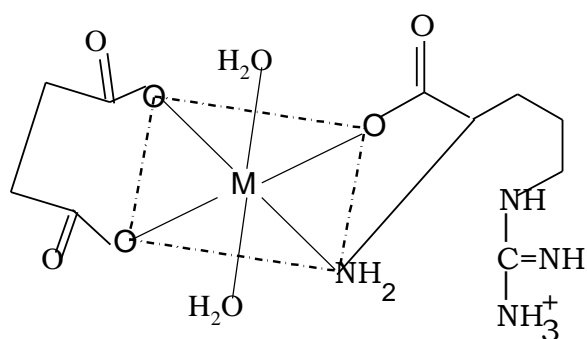


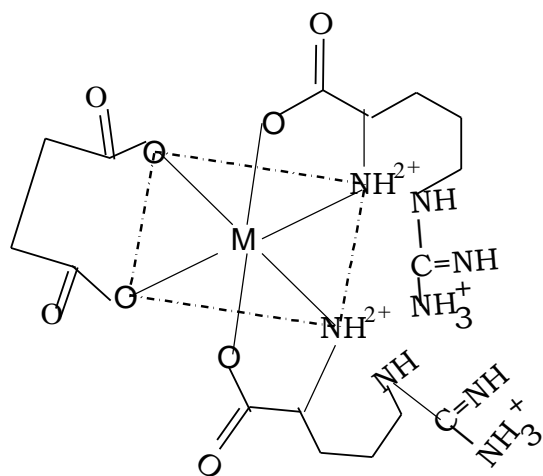
Fig2: Distribution diagrams of ternary complexes of Arg-Suc complexes in 1.0% v/v CTAB-water mixture. (A) Co(II), (B) Ni(II), (C) Cu(II) and (D) Zn(II).



MLXH



MLX



ML₂X

Fig3: Plausible structures of ternary complexes of Co(II), Ni(II), Cu(II) and Zn(II) ions with Arg (L) and Suc (X).