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FOREWORD

I am pleased to put into the hands of readers Volume-5; Issue-7: 2018 (July, 2018) of “**International Journal of Advanced Engineering Research and Science (IJAERS)** (ISSN: 2349-6495(P) | 2456-1908(O)”, an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to Science, Technology, Management and Humanities. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release print issue also, but this decision the journal issue will be available in various library also in print and online version. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind. This journal has DOI (Digital Object Identifier) also, this will improve citation of research papers. Now journal has also been indexed in **Qualis (Interdisciplinary Area) (Brazilian system for the evaluation of periodicals, maintained by CAPES)**.

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

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

With warm regards.

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Validation of TerraClass mapping for the Municipality of Paragominas state of Pará

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An analysis on the application of the Strategic Planning model based on Systems Engineering

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Abstract—The objective of this work is to present an analysis on the application of the systems engineering approach to the elaboration of strategic planning. An evaluation of the proposed model was carried out in three organizations, in comparison to the traditional models of strategic planning. With the analysis it was verified that the strategic planning process that incorporates the systems engineering approach, is more comprehensive than the traditional model. With this, it is expected that this model produces better results, than the traditional strategic planning model.

Keywords—Strategic planning, Strategy, Systems engineering.

I. INTRODUCTION

The objective of this work is to present the results of the application of the strategic planning approach based on Systems Engineering in three organizations.

Strategic Planning can be defined as:

- Strategic Planning is the continuous process of systematically and with the greatest possible knowledge of the future contained, making current decisions that involve risks; to organize systematically the activities necessary to implement these decisions and, through organized and systematic feedback, to measure the outcome of these decisions against the expectations fed (Drucker, 1984).
- Strategic Planning is the managerial process of developing and maintaining a workable fit between an organization's objectives, skills and resources and the opportunities of a continuously changing market. The goal of Strategic Planning is to shape the business and products of a company so that they enable the desired profits and growth (Kotler, 2000).
- Strategic Planning is a process of formulating organizational strategies in which the organization and its mission are sought in the

environment in which it is operating (Chiavenato&Sapiro, 2003).

Strategic Planning is related to medium- and long-term strategic objectives that affect the direction or visibility of the organization. But, applied in isolation, it is insufficient, because we do not only work with immediate and operational actions: in the Strategic Planning process, all the strategic, tactical and operational plans of the organization must be elaborated in an integrated and articulated way.

Planning should maximize results and minimize deficiencies, using principles of greater efficiency, effectiveness, and effectiveness. They are the main criteria of management. In short, strategy points the way. Strategic Planning tells you how to walk in it.

Strategic Planning lacks the tools to shape strategies once the strategic objectives have been defined. In Systems Engineering, on the other hand, after establishing the requirements of the stakeholders, several functional and physical modeling tools are applied, in order to conceptually shape the product or system to be developed, as stated above. As both disciplines have important tools for analyzing and defining actions, the most appropriate ones can be used in each situation, thus making a broader approach to achieve the desired result. In fact, the concern should be with the concept and not with the tools themselves.

Three definitions are commonly used for Systems Engineering:

- A logical sequence of activities and decisions that transform operational needs into descriptions of system performance parameters and the preferred system configuration. (MIL-STD-499A, 1974)
- An interdisciplinary approach encompassing the technical effort to evolve and verify an integrated and balanced lifecycle solution in a people, product, and process-based system that meets customer needs. (EIA Standard / IS-632, 1994)

- A collaborative interdisciplinary approach that stems, evolves and verifies a balanced solution to the life cycle, in which it satisfies customer expectations and meets the public's acceptability. (IEEE P1220, 1994)
- A collaborative interdisciplinary and multidisciplinary approach to derive, evolve and verify a balanced solution / system throughout the life cycle that satisfies stakeholders' expectations (Loureiro, 1999).

Systems Engineering is generally used for the development of complex products or systems. One of the goals of Systems Engineering is to show that the system is designed, built and operational, and that this system fulfills its purpose of cost effectiveness, in the best possible way, considering performance, cost, time and risk.

II. LITERATURE REVIEW: A SYSTEMS ENGINEERING APPROACH FOR ORGANIZATIONAL STRATEGIC PLANNING

This chapter presents the strategic planning approach based on systems engineering, proposed by Andrade (2008) and reported by Andrade and Loureiro (2017).

Figure 1 provides a detailed view of the proposed method for the elaboration of Strategic Planning.

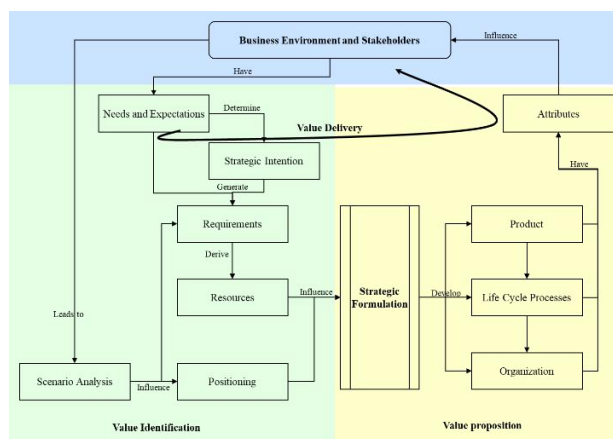


Fig.1: Organizational strategic planning

Source: Andrade (2008)

To implement the method, it is necessary to use tools appropriate to each phase of Organizational Strategic Planning, according to Andrade (2008) and Andrade and Loureiro (2017). These are described in the following subtopics:

- Stakeholder needs and expectations: Product, business processes and organization may have common stakeholders. The objective of this stage is to obtain a list of stakeholders, as complete as

- possible, in order to know the needs, expectations and interests of the stakeholders.
- Strategic conception: The strategic concept is divided into five stages, namely: organization business determination, organizational mission statement, organizational vision design, identification of the organization's core ideology and identification of business processes.
- Strategic Knowledge Management: Strategic knowledge management consists of a management information system that constantly monitors the internal and external environment of the organization. This information is consolidated in an internal and external diagnosis, in the construction and analysis of scenarios, in the analysis of risks and, finally, in the consolidation of strategic knowledge.
- Strategic objectives: The strategic objectives must be generated from the needs and expectations of the stakeholders and the strategic conception, in addition to being influenced by the result of the strategic diagnosis, coming from strategic knowledge management. After validating the strategic objectives, the critical success factors of the organization must be identified. Also, the goals and goals must be deployed downwards, that is, from top to bottom.
- Strategic formulation: The strategies must be elaborated from the specific objectives, from the consolidation of the requirements of the stakeholders and the critical factors of success. With this, we ensure the development of sustainable strategies that meet the needs of all stakeholders in the organization, in the business processes and in the product offered by the organization. For each of the specific objectives, an action plan must be made, which will indicate the actions necessary to achieve each objective. At this point, too, there must be an evaluation of the actions that need to develop the competence of the people of the organization.

- Strategy implementation: The strategic formulation is very important, however, it almost always comes up against implementation. Putting the organizational strategy in motion depends, fundamentally, on its implementation. If the implementation is not executed with care, the strategy, however well formulated, will not succeed. Strategic implementation requires the commitment of everyone within the organization. After the implementation of each planned action, the person responsible for the implementation of the action should standardize

the way the activities of the organization are executed, in face of the new requirements or specifications.

- Strategy verification and validation: Strategic objectives and strategic action plans should be evaluated continuously and not only after their implementation. In this step, we will have two types of evaluation: verification of the implementation of the strategic actions included in the action plans and validation of the results achieved, after the implementation of the strategy. If the result demonstrated after the implementation of the strategy is not as expected, strategic reassessment should be performed.

III. ANALYSIS OF THE APPLICATION OF THE PROPOSED MODEL

With the use of a Systems Engineering approach to elaborate Strategic Planning, the result may be better than that presented in traditional approaches. This demonstration will be carried out by the analysis of the Strategic Planning process, using the traditional method, carried out by three different organizations, being a company producing special actions, an organization providing consulting services and continuing education and financial services and a public sector organization aerospace. All the organizations studied are Brazilian.

In order to carry out this comparative analysis, interviews were conducted with professionals from the organizations mentioned and also consult the materials related to the strategic planning made available by these professionals.

Table 1 presents a comparison of the items in the Strategic Planning process of the three organizations analyzed, compared to the proposed method.

Table.1: Comparison between the models studied and the proposed method

Proposed Method		Traditional Strategic Planning		
		Case 1	Case 2	Case 3
Identification of Stakeholder Needs and Expectations	Identification of Stakeholders	Parti al	Parti al	Parti al
	Identification of Stakeholder Needs	Parti al	Parti al	Parti al
Strategic Design	Determine the Business of the Organization	Yes	Yes	Yes

Proposed Method		Traditional Strategic Planning		
		Case 1	Case 2	Case 3
	Organizational Vision Conception	Yes	Yes	Yes
	Identify the Organization's Central Ideology	Yes	Parti al	Parti al
	Identify business processes	No	No	No
Strategic Knowledge Management	Perform External Diagnosis	Yes	Yes	Yes
	Perform Internal Diagnostics	Yes	Yes	Yes
	Build and Analyze Scenarios	No	Yes	Yes
	Conduct Risk Analysis	No	No	No
	Consolidation of Strategic Knowledge	No	No	No
Establishment of Strategic Objectives	Consolidation of Strategic Objectives	Parti al	Parti al	Parti al
	Critical Success Factors	Yes	Yes	No
	Unfold Objectives and Goals	Parti al	Yes	Parti al
Strategic Formulation	Planning of strategic actions	Parti al	Parti al	Parti al
	Skills Development Plan	No	No	No
Strategy Implementation	Implementation of Strategic Actions	Yes	Yes	Yes
Strategic Verification and Validation	Follow up of the Action Plan	Parti al	Yes	Parti al
	Result Evaluation	Parti al	Yes	Parti al
Strategic Reappraisal	Strategic Evaluation and Reassessment Plan	No	No	No

Case 1: Service Provider

Case 2: Iron and steel industry

Case 3: Public Organization of the Aerospace Industry

Source: Andrade (2008)

With the application of the present analysis it is verified that the proposed Strategic Planning process, which incorporates the Systems Engineering approach, is more comprehensive than the traditional model applied in the three cases studied. With this, it is expected that this model produces better results than the traditional Strategic Planning model.

IV. FINAL CONSIDERATIONS

It was demonstrated that if a Systems Engineering approach is used for Organizational Strategic Planning, according to the proposed method, its final result will be better than the result obtained with the application of the traditional methods, according to the evaluation performed, in which they were analyzed critically the results of the Strategic Planning carried out by three different organizations in comparison with the proposed method.

With the demonstration of the method it was possible to verify the existing gaps between the traditional method and the proposed method.

It is suggested for future works to apply the proposed method in companies of different sizes and sectors of the economy, to allow the corroboration or validation of the proposed method.

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The Effectivity of Interactive E-Book Based on Science Process Skills using Android Application for Excretion System Material on Students Science Process Skills

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Abstract— To identify the effectivity of interactive E-book based on science process skills using Android application for excretion system material on students science process skills, in senior high school. The participants of this research is all of students of class XI Science 2, in SMA Negeri Kalisat, Indonesia. The design applied for this research is One Shoot Case Study, on the three session of the class, with a different sub chapter for each class session. The performance test was used to assess students science process skills. The effectivity of interactive E-book based on science process skills using Android application were analyzed by performance test result of science process skills of each session. The result have shown an increase of values on each session. Hence, the interactive E-book based on science process skills using Android application for excretion system material effective on student science process skills.

Keywords— *Interactive E-book, science process skills, Android, excretion system, senior high school.*

I. INTRODUCTION

The growing digital technology today demonstrates the use of smartphones with the Android operating system among students is increasing so that today's educators or teachers should seek to bring electronic media closer to students as a means of improving students on learning materials (Smith, 2015). Increased knowledge generated from the development of science and technology is directly proportional to the average usage and the number of users of mobile devices (tablets, smart phones, and others). By 2015, 88% of students ages 13-17 have access to smartphones, so schools shift the policy of banning smartphone use so smartphones can be adapted to today's learning (Clayton and Murphy, 2015). This survey showed a change of societies reading habit. Similarly, a new form of reading called the E-book (electronic book) (Çetin *et al.*, 2016).

E-book contains content supported by the material, views, sounds, graphics, animations, videos, movies, and

simulations that are presented more varied and interactive and tailored to the educational needs of today's global era compared to conventional books. E-books contains information about materials designed to learn on digital templates and enable to display on mobile devices (Landoni and Diaz, 2003). The E-book has become a sophisticated innovation that is expected to experience progress over time and substitute textbook for future prospect (Lynch, 2012; Shen, 2017, Lai and Chang, 2011). However, the use of textbooks is still applied in the learning process at school. E-book provides facilities to students to obtain many information sources throughout hyperlink inserted into it so as to contribute to the various needs of teaching and learning process by providing various advances features (Shiratuddin *et al.*, 2006). In addition, to increase the level of student interaction with learning content delivered to students (Gong *et al.*, 2013; Tsang *et al.*, 2013). The use of E-book on mobile devices such as smartphones and tabs, makes it easy for users to access information anywhere and anytime so that learning becomes efficient (Clark *et al.*, 2008; Shelburne, 2009).

The research of interactive E-book has been done by Biranvad and Khasseh (2014) about impact of E-book to academic status, similar research conducted by Fyfe (2014) about E-book in high education, Ebied and Rahman (2015) has done research about interactivity of E-book on students achievement, development of E-book by Çetin *et al.*, (2016), and integrate E-book into akademik learning by Berg and Dawson (2010). Learning using smart phones can not be separated from technological advances, so the use of smart phones in Indonesia is increasing from year to year. The ability of science process skills can be supported by the use of media in learning.

Scientific process skills are used to help students gain a more long term memory understanding of the material so they are expected to be able to solve all kinds of daily life problems, especially in the face of global competition (Abungu *et al.*, 2014). Science process skills has contribution to attaining advance knowledge, skills,

and productive communication with society (Gultepe, 2016). Scientific process skills as one of the most important part of curricula (Padilla, 1990), therefore in Curricula 2013 with 2016 revision at Indonesia focuses on science process skills which set forth in Core Competencies (KI) 3, and KI- 4. The content that consist of material and science concepts also process consist of essential skills that students need to gain (Inan, 2010). Science process skills are one of the main goal to be gained in science education because these skills used not only by scientist and students, but also by everyone, to be scientifically educated because scientific process is one of procedure that is fundamentally shape by critical and analytical thinking (Türkmen and Kandemir, 2011). However, research on interactive E-book needs to be further developed, particularly interactive E-book based on science process skills using Android application for excretion system material on student process skill in learning.

II. METHODOLOGY

This type of research is research and development (R and D). This research include research and development because developed an E-book. E-book has developed become interactive E-book based on science process skills using Android application for excretion system material for class XI senior high school. This research uses prototype development which adopted from Sugiyono (2011), include 3 steps, consist of (1) introduction, (2) design, and (3) development. The subject of this research and development research is students in class XI Science 2 SMA Negeri Kalisat, Indonesia academic year 2017/2018. The reaserch design was used One Shoot Case Study, by using one groups of samples that is class XI Science 2, and the measured their science process skills performance based on result observation. Students science process skills measurement were made three times at three session in each class.

III. RESULTS

The research is aim to know the effectivity interactive E-book needs to be further developed, particularly interactive E-book based on science process skills using Android application for excretion system material on student science process skills. The aspects of science process skill that was measured consist of (1) observing, (2) answer or ask question, (3) predict, (4) communicate, and 5 (conclude). These aspects included in basic science process skill. Measurement of student science process skill is using performance test, those each aspects will be scored by two competencied observers. Then, the score of each aspect is summed and changed in the form of value (formula 1), after that described by category. Scoring of each aspect using Likert scale 1 to 5. The category of each science process skills value can be

seen at Table 1. Then, the result of student science skills can be seen in Table 2.

$$V = \frac{\sum \text{total score}}{\text{ideal score} \times N} \times 100 \dots\dots\dots (1)$$

Table.1: The category of science process skills value

No	Values	Category
1	20 ≤ x < 36	Very Low
2	36 ≤ x < 52	Low
3	52 ≤ x < 68	Medium
4	68 ≤ x < 84	High
5	84 ≤ x ≤ 100	Very High

Tabel.2: The performance test result of students science process skills after use interactive E-book based on science process skills using Android application for excretion system material

Number of Students	Session	Total Score		Score Average	Science Process Skills Value	Category
		Obs 1	Obs 2			
39	1	661	639	650	66.67	Medium
	2	710	704	707	72.51	High
	3	746	807	776.5	79.64	High
The Average of Science Process Skills Score & Value				711.17	72.94	High

Table 2 is showed the result science process skills of each session. The science process skills value in the session 1 to 3 are follows 66,7, 72,5, and 79,6. The value in session 1 can be categorized students science process skills is “medium”, and then session 2 to 3 is “high” based on Table 1, because of value increases affect to categorization. The average of students science process skills value from session 1 to 3 is 72,9, and its category is “high”.

IV. DISCUSSION

Based on the Table 2, it can be seen that students science process skills values from session 1 to 3 is increased. It mean that interactive E-book based on science process skills using Android application for excretion system material is effective on student science process skills. That happen because the availability of material features, videos, pictures, and “Challenge” feature is the form of bases science process skills in E-book that developed in this research. Games provide energy in teaching, trigger innovative thinking, and make learning concepts easier for students to understand. The game offers a medium for students to explore and introsperse information in a fun way (Fuszard, 2001). Supported by statement from Siahaan (2017), that use of technology will stiumulate students to be more active during the learning process and engage student in beahvior and mental processes. Hence, with the support of technology will give

students the opportunity to work with science, and obtain knowledge well because they understand the facts and concepts of science

Studying activities that involving students with technologies are very entertaining with the rapid of technological development of today, feels enjoy and happy, can support students learning process (Biggs, 2014). In line with the Kalemkuş *et al.*, (2016), if science and technology has an important role in training individuals who have science process skills observing, collecting data, answer question, critical thinking, communicate, identify problems, troubleshoot, predicting, conclude, and well searching information skills.

V. CONCLUSION AND SUGGESTIONS

Based on the result and discussion, there is an increase in the value of students science process skills while using interactive E-book based on science process skills using an Android application in excretion system material in the learning process. So it can be inferred that the interactive E-book based on science process skills using Android application in excretion system material is effective to students science process skills.

Use of the interactive E-book based on science process skills using Android application in excretion system material can be done if there is internet connection. Hence, suggestions that can be given for further research are 1) interactive E-book based on science process skills using Android application in excretion system material can be used without internet connection, so could economically saving; 2) interactive E-book based on science process skills using Android application in excretion system material can be installed on other operation system in smartphone, example iOS; and 3) interactive E-book based on science process skills using Android application in excretion system material can be supplemented with other Biology material.

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Economic and multivariate analysis of banana production (*Musa sp.*) Cultivated in the semi-arid region of northeast Brazil

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Abstract— *The objective of this work was to evaluate the economic viability and develop a multivariate analysis for banana crop data in the semi-arid region of Brazilian Northeastern. The study adopted a methodology widely disseminated in scientific research and income evaluations for the economic analysis. Through the economic indexes, we could evaluate the efficiency of the administrator and his workforce. Hierarchical clustering and Principal component analysis were used as multivariate analysis. The result of the economic analysis revealed that, on average, the total gross revenue from conventional management exceeded by 2.24 times the total gross income from agroecological management. However, the production costs of the conventional management exceeded by 2.15 times agroecological management. The multivariate analysis revealed that the variables are divided into three distinct groups formed between the equilibrium price and the profitability index, which do not correlate with each other or with the others, and by the subgroup formed by the return rate index, total operating profit and gross income, which are correlated with each other and not correlated with the others. We conclude that the multivariate analysis confirmed that the methodology used in the composition of all the economic indexes studied was correct.*

Keywords— *Total gross revenue, total operating cost, economic indices.*

I. INTRODUCTION

Banana is the most tasted tropical fruit and the second most harvested in the world, losing only to the orange. Nutritive, accessible to the majority of the

population and available during all year, banana is the fourth most consumed food product in the world. It accounted, in 2010, of about 4,771,944 ha of production having main producers India, China, The Philippines and Ecuador [3]. Brazil is the fifth in the world ranking of banana crop production, with a total production area of 486,991 ha, producing 6,978,310 tons and average annual productivity of 14.33 t/ha [3].

In Brazil, the banana production loses only to orange production [2]. An equivalent of 97,076,479 tons of banana was produced in 2013, grown in an area corresponding to 483,915 hectares. The States of Bahia, São Paulo, Minas Gerais, Santa Catarina, Pará, Ceará, and Pernambuco were the main responsible for the national production. Banana cultivation plays a prominent socioeconomic role in many emerging countries, being produced mostly by small farmers, contributing not only to the generation of income but to fix the workforce in rural areas. Estimates indicate that the culture is responsible for more than 500 thousand direct jobs [2].

Rio Grande do Norte is the eleventh National producer. But, the indices obtained for the States of Ceará and Rio Grande do Norte together are similar to those of São Paulo. Together, the two states are the second in planted area (52,470.00 ha) and the fifth in amount of production. They account for 623,602.00 tons of production, the sixth average yield (11,884.96 kg/ha), and the fourth in gross income, with the total sale value of R \$ 470,670,000.00 [6], [11].

The similarity of the productive aspects in the agribusiness gives the two states a level playing field about the economic indices above mentioned, besides they have

a large border in common, competing directly in the same socioeconomic and edaphoclimatic conditions, and the logistics of transportation and sales of its products in the rural environment [5].

[16] found a cost of production of banana-cultivated with coffee in Ivinhema, MS, Brazil, in the implantation phase (Year 1) of R\$ 15,758.26, in the formation phase (Year 2) of R\$ 8,127.90 and production (Year 3) of R\$ 10,146.31. The authors argue that the intercropping of banana coffee in the agroecological system is economically efficient.

For banana from the type Cavendish cultivated in Araçatuba, SP, Brazil, [4] found a total operational cost (implementation cost + cost of production) of R\$ 14,806.85, gross income of R\$ 16,660.00, total operating profit of R\$ 2,425.27, balance price of R\$ 0.41/kg, and a profitability index 0.15 and return rate of 1.17 [8].

We aim, with this work evaluate the economic viability and develop a multivariate analysis of banana crop data cultivated in the Brazilian Northeastern semi-arid region.

II. MATERIAL AND METHODS

The economic and multivariate analysis of the banana crop was carried out to obtain the degree of competitiveness between treatments in two experiments. The experiments were realized in the region named Chapada do Apodí, in the semi-arid of the Brazilian Northeast. The climate of the region is classified as hot and dry, type BSw_h' according to Köppen classification.

The first experiment was carried out at the Experimental Farm Rafael Fernandes (Mossoró Municipality/RN) (5°03'36.7"S and 37°24'6.6"W) to test the behavior of banana cultivars propagated in agroecological system. The second one was carried out at Fazenda Terra Santa (Municipality of Quixeré/CE) (5°05'07.57"S and 37°51'51.59"W) to test the behavior of banana cultivars propagated in conventional system of crop production.

For economic analysis we adopted a disseminated methodology in scientific research, as recommended by [15], observing parameters demonstrated by [13], [12] and [10]. The analysis of income, through indexes of economic result, served to verify the efficiency of the administrator and his work force.

We randomly selected the treatments between bananas from the types Pacovan and Prata-anã. For treatments with "Pacovan" cultivar, we choose seedlings with a mean weight greater than 1.0 kg, propagated by rhizomes with and without 'ceva'³, both in the agroecological and conventional system. For the cultivar "Prata-anã", we selected seedlings with an average weight higher than 1.5 kg, propagated by rhizomes with and

without 'ceva', both in the agroecological and the conventional system.

For the treatments in the agroecological system, the sampling of unities for the rhizome propagation with "ceva" was realized through the removal of the rhizome tiller from the selected cultivar for propagation in the study areas of the farm. The leaves were removed, and the seedling conditioned in a greenhouse covered by a shade cloth for a period of 15 days. One day before the final transplanting, the seedling was prepared, performing the scraping of the rhizome with a knife, eliminating the excess roots and removing the necrotic parts. The rhizomes were weighed and separated for the treatments of each cultivar. Seedling management was also used for the rhizome propagation of the experiments without "ceva".

The sampling of seedlings for rhizome propagation with "ceva" for the conventional system treatments was done by removing the rhizome tiller of the selected cultivar in the cultivated areas of the farm. The seedlings were laid to rest under shade field conditions at the soil surface. One day before its final transplanting the seedlings were prepared to eliminate the leaves and excess of roots. The rhizomes were then immersed in a solution with the active ingredient carbofuran in liquid form at 1%, dissolved in water for a period of approximately 15 minutes. The same procedure was used for the treatments for propagation by rhizome without "ceva" and the procedure of seedlings harvesting similar to that of agroecological management.

We used a randomized block design in a factorial scheme of 2 x 2 x 2, and four replicates by treatment. Therefore, we used three factors with two levels each: cultivars (Pacovan or Prata-anã), propagation methods (with or without ceva) and management methods (Conventional or agroecological). The randomization was performed for the following treatments distribution: Treatment 1 (T1), Banana plants of the cultivar Pacovan, with seedling propagated without "ceva" in the agroecological system; Treatment 2 (T2), Banana plants of the cultivar Pacovan, with seedling propagated with "ceva" in the agroecological system; Treatment 3 (T3), Banana plants of the cultivar Pacovan, with seedling propagated without "ceva" in the conventional system; Treatment 4 (T4), Banana plants of the cultivar Pacovan, with seedling propagated with "ceva" in the conventional system; Treatment 5 (T5), Banana plants of the cultivar Prata-anã, with seedling propagated without "ceva" in the agroecological system; Treatment 6 (T6), Banana plants of the cultivar Prata-anã, with seedling propagated with "ceva" in the agroecological system; Treatment 7 (T7), Banana plants of the cultivar Prata-anã, with seedling propagated without "ceva" in the conventional system; Treatment 8 (T8), Banana plants of the cultivar Prata-anã,

with seedling propagated with "ceva" in the conventional system.

The variables analyzed to evaluate the production and plant precocity in the alignment of the treatments were: TGR → total gross revenue (R\$); TOP → total operating profit (R\$); PI → profitability index (dimensionless); RRI → return rate index (dimensionless); EQP → equilibrium price (R\$ / kg).

The total gross revenue for each treatment (TGR) is calculated through the ratio between the productivity by area of each treatment (Prod.T_i) and the average price per kg of banana fruit sold (Eq. 01):

$$TGR = Prod.T_i \times R\$1.10 \quad (\text{Eq. 01})$$

The total operational profit per treatment (TOP) was obtained by the difference between the total gross income for each treatment (TGR) and the total operational cost per treatment (OPC) (Eq. 02):

$$TOP = GI - OPC \quad (\text{Eq. 02})$$

The total operational costs (TOPC) for the conventional system treatments were provided by [14] and for the agroecological system by [11] (Tables 1 and 2).

The statistic was realized using the software STATISTICA 13® [1]. We performed an ANOVA, using the F test to compare the means by treatments and the effects of the factors (GOMES, 2009). As multivariate analysis, we used a Hierarchical clustering analysis and the Pearson coefficient and Principal Component Analysis (PCA) by the correlation matrix and coordinate factors [9], [7].

We described only the possibilities that best explained the results of the analyzed variables.

Table.1: Total operational cost for the conventional model management.

Item	Description	Amount	Unit	Unit Price (R\$)	Subtotal (R\$)	%
Inputs used in plant nutrition					6,960.00	37.05%
01	- Source of organic matter: Cattle manure	10.00	ton.	120.00	1,200.00	6.39%
02	- Source of N: Urea	880.00	kg	1.60	1,408.00	7.49%
03	- Source of P ₂ O ₅ : MAP	400.00	kg	1.80	720.00	3.83%
04	- Source of K ₂ O: KCl	1,400.00	kg	1.70	2,380.00	12.67%
05	- Source of N and S: (NH ₄) ₂ SO ₄ - Ammonium sulfate	300.00	kg	1.15	345.00	1.84%
06	- Source of K ₂ O and S: K₂SO₄ - Potassium sulfate	200.00	kg	2.30	460.00	2.45%
07	- Source of Mg and S: Magnesium sulfate	100.00	kg	1.30	130.00	0.69%
08	- Source of Zn and S: ZnSO₄. 7H₂O - Zinc sulfate	30.00	kg	2.60	78.00	0.42%
09	- Source of Cu and S: CuSO₄. 5H₂O - Copper sulfate	10.00	kg	5.50	55.00	0.29%
10	- Source of Mn and S: MnSO₄. 3H₂O - Sulf. of manganese	10.00	kg	4.00	40.00	0.21%
11	- Source of B: H₃BO₃ - Boric acid	40.00	kg	3.50	140.00	0.75%
12	- Source of Cu and Mo: Comol	0.20	L	20.00	4.00	0.02%
Inputs used in phytosanitary protection of plants					473.00	2.52%
13	- Furadan in the liquid form	1.00	L	30.00	30.00	0.16%
14	- Furadan in the granulate form	1.00	kg	15.00	15.00	0.08%
15	- Inseticide Ópera	0.40	L	150.00	60.00	0.32%
16	- Talstar	0.20	kg	40.00	8.00	0.04%
17	- Herbicide Roundup	12.00	L	30.00	360.00	1.92%
Eletric energy costs					800.00	4.26%
18	- For one hectare of area in the first productive cycle				800.00	4.26%
Costs for the acquisition of the irrigation system					500.00	2.66%
19	- For one hectare of area in the first productive cycle				500.00	2.66%
Manpower costs					5,000.00	26.62%
20	- For one hectare of area in the first productive cycle				5,000.00	26.62%
Costs of mechanized activities, for the area of one hectare in the first productive cycle					1,300.00	6.92%
21	- Soil preparation				600.00	3.19%
22	- Weed mechanization control				100.00	0.53%
23	- Application of pesticides				100.00	0.53%

24 - Harvesting	500.00	2.66%
Costs for the acquisition of seedlings	2,250.00	11.98%
25 - For one hectare of area in the first productive cycle	2,250.00	11.98%
Other costs	1,503.30	8.00%
26 - Pro-labore of the producer, office supplies and other logistics costs for the area of 1 hectare in the 1st productive cycle	1,503.30	8.00%
Grand Total (R\$):	18,786.30	100.00%

Source: [14]

Table.2: Total operational cost for the agroecological model management.

Item	Description	Amount	Unit	Unit Price (R\$)	Subtotal (R\$)	%
Inputs used in plant nutrition					2,216.45	25.47%
01	- Source of organic matter: Cattle manure	1.19	ton.	120.00	142.67	1.64%
02	- Source of N: Urea	270.20	kg	1.60	432.32	4.97%
03	- Fonte de N-P ₂ O ₅ -K ₂ O: fertilizer formulation 4-14-8	303.98	kg	1.80	547.16	6.29%
04	- Source of K ₂ O: KCl	540.40	kg	1.70	918.68	10.56%
05	- Source of N and S: (NH ₄) ₂ SO ₄ - Ammonium sulfate	0.00	kg	1.15	---	---
06	- Source of K ₂ O and S: K₂SO₄ - Potassium sulfate	0.00	kg	2.30	---	---
07	- Source of Mg and S: Magnesium sulfate	135.10	kg	1.30	175.63	2.02%
08	- Source of Zn and S: ZnSO₄. 7H₂O - Zinc sulfate	0.00	kg	2.60	---	---
09	- Source of Cu and S: CuSO₄. 5H₂O - Copper sulfate	0.00	kg	5.50	---	---
10	- Source of Mn and S: MnSO₄. 3H₂O - Sulf. of manganese	0.00	kg	4.00	---	---
11	- Source of B: H₃BO₃ - Boric acid	0.00	kg	3.50	---	---
12	- Source of Cu and Mo: Comol	0.00	L	20.00	---	---
Inputs used in phytosanitary protection of plants					0.00	0.00%
13	- Furadan in the liquid form	0.00	L	30.00	---	---
14	- Furadan in the granulate form	0.00	kg	15.00	---	---
15	- Inseticide Ópera	0.00	L	130.00	---	---
16	- Talstar	0.00	kg	20.00	---	---
17	- Herbicide Roundup	0.00	L	25.00	---	---
Eletric energy costs					800.00	9.19%
18	- For the area of one hectare in two years of cultivation				800.00	9.19%
Costs for the acquisition of the irrigation system					500.00	5.74%
19	- For one hectare of area				500.00	5.74%
Manpower costs					2,095.80	24.08%
20	- For the area of one hectare in two years of cultivation				2,095.80	24.08%
Costs of mechanized activities (for 1ha in two years of cultivation)					1,100.00	12.64%
21	- Soil preparation				600.00	6.89%
22	- Weed mechanization control				0.00	0.00%
23	- Application of pesticides				0.00	0.00%
24	- Harvesting				500.00	5.74%
Costs for the acquisition of seedlings					0.00	0.00%
25	- For the area of 1 hectare in the 1st production cycle				0.00	0.00%
Other costs					791.23	9.09%
26	- Business remuneration, office supplies and other logistics costs for the area of 1 hectare in the 1st production cycle				791.23	9.09%
Grand Total (R\$):					8,703.48	100.00%

Source: Paula (2015)

III. RESULTS AND DISCUSSION

The results of ANOVA (Table 3) showed a significant effect of the method of propagation 1, at a probability level of 1%, on the total gross revenue (TGR) and total operating profit (TOP). The method of propagation 1 was composed of the forms of agroecological and conventional management. And, a significant effect of the interaction between cultivars and the propagation method 2 (C x M2P) on both variables, at

5% probability. For the profitability index (PI), significance was observed at 5% probability, for cultivars and, at 1% probability for the interaction between cultivars and propagation method 2 (C x M 2 P).

The return rate index (RRI) and equilibrium price (EQP) were not affected for any of the sources of variations studied (Table 3). Therefore, we will discuss only the mean values of the RRI and EQP variables.

Table.3: Results of the analysis of variance by the F test for the financial characteristics of the production of banana fruits (*Musa sp.*) from experiments developed in the semi-arid region of the Brazilian Northeast. 2017¹

Factor of variation	DF	TGR	TOP	RRI	PI	EQP
Cultivar (C)	1	0.364428 ^{ns}	0.364427 ^{ns}	0.514733 ^{ns}	0.045211*	0.769875 ^{ns}
Propagation method 1 (M1P)	1	0.000000**	0.002324**	0.462686 ^{ns}	0.713708 ^{ns}	0.752839 ^{ns}
Propagation method 2 (M2P)	1	0.201128 ^{ns}	0.201127 ^{ns}	0.182062 ^{ns}	0.263866 ^{ns}	0.179819 ^{ns}
C x M1P	1	0.855187 ^{ns}	0.855187 ^{ns}	0.973775 ^{ns}	0.263402 ^{ns}	0.395482 ^{ns}
C x M2P	1	0.048415*	0.048414*	0.210611 ^{ns}	0.008977**	0.274192 ^{ns}
M1P x M2P	1	0.755894 ^{ns}	0.755893 ^{ns}	0.446998 ^{ns}	0.830822 ^{ns}	0.421017 ^{ns}
C x (M1PxM2P)	1	0.098098 ^{ns}	0.098098 ^{ns}	0.397686 ^{ns}	0.618885 ^{ns}	0.407041 ^{ns}
Average		R\$ 17,072.30	R\$ 3,327.41	1.23	0.19	R\$ 0.90

¹ ns, not significant; **, significant at 1% of probability and; *, significant at 5% of probability; DF, Degree of Freedom.

² TGR, total gross revenue (R\$); TOP, total operational profit (R\$); RRI, return rate index (dimensionless); PI, profitability index (dimensionless); EQP, equilibrium price (R\$/kg).

The economic analysis of the experiments revealed that, on average, the total gross revenue (TGR) of conventional management (R\$ 23,623.06) exceeded 2.24 times the total gross income of agroecological management (R\$ 10,521.54) (Table 4). While, in the

comparison of production costs (TOPC), the conventional management (R\$ 18,786.30) surpassed 2.15 times the agroecological management (R\$ 8,703.48) (Tables 1 and 2). Both forms of cultivation had a gross income higher than the total operation cost (Tables 1, 2 and 4).

Table.4: Average values of TGR and TOP in the conventional (CVM) and agroecological management (AGM) at the experiments developed in the semi-arid region of the Brazilian Northeast

	DF	TGR	TOP
Conventional management	1	R\$ 23,623.06 ^A	R\$ 4,836.76 ^A
Agroecological management	1	R\$ 10,521.54 ^B	R\$ 1.818.06 ^B

¹ Similar letters mean a non-significant difference inside the columns, by the F test.

² TGR: total gross revenue (R\$); OP: total operational costs (R\$).

The total operating profit (TOP) was two times (almost four times) higher in the conventional management (R\$ 4,836.76) than in the agroecological management (R \$1,818.06) (Table 4). The results found here showed a higher total operational profit than the results presented by [18] for bananas of the type “banana-maçã” or “apple banana” (R \$ 1,468.07) cultivated in conventional management, in the region of São Paulo. The worst result, in the agroecological management, was 24% higher than the results found by [18], and the best

result, in the conventional management, exceeded by more than two times those obtained by [18] (R\$ 1,976.60).

The production costs obtained in our experiments, for agroecological management [11], represented about 47% ($100 \times R \$ 8,703.48 \div R \$ 18,274.21$) of the total production cost in banana cultivation developed in a consortium with coffee in agroecological management in Ivinhema/MS [16]. The costs of the Ivinhema/MS agroecological crop (R\$

18,274.21) were similar to the results found for the conventional management (R\$ 18,786.30) [14], [17].

The results of production costs together with the production efficiency achieved at relatively low production costs, reinforce the idea that the technological development in the cultivation system of the banana tree in the Brazilian semi-arid region has provided a higher income, besides the consolidation of regional development models based on the models of highly competitive productive poles in the country [5].

The ANOVA results for profitability index revealed that the Pacovan cultivar exceeded the values obtained by the Prata-anã cultivar by 8% (Table 5). This result shows that into the decomposition between operational profit and gross revenue there must be some other predominant factor that was not clearly explained in the current study, leading to a favorable high index of the Pacovan cultivar. Factors like fruit size, fruit weight and, others, for each cultivar, may be associated with productivity and affect the profitability index, but they were not investigated in the present study.

Table.5: Mean values for PI as a function of the Pacovan and Prata-anã cultivars of the experiments developed in the semi-arid region of Northeast Brazil. 2017¹

	PI ²
Pacovan cultivar	0.23 ^A
Prata-anã cultivar	0.15 ^B

¹Similar letters mean a non-significant difference inside the columns, by the F test.

²PI: Profitability index (dimensionless).

The low results of the profitability indices for Prata-anã cultivar found here (0.15) were similar to results found a study in Araçatuba, SP, while, the results found for Pacovan cultivar where 8% higher than the found for banana of the Cavendish subgroup, developed in the same local conditions [4]. The results confirm the superiority of the cultivar Pacovan for use in commercial areas of the Brazilian semi-arid (table 5).

The best results for total gross income and total operating profit were obtained when banana Pacovan was propagated by rhizome without "ceva" and banana Prata-anã by rhizome with 'ceva' (Table 6). On the other hand, for the profitability index, the best results were found for both Pacovan and Prata-anã with "ceva".

Table.6: Mean values of TGR, TOP and PI of the cultivars of banana Pacovan and Prata-anã depending on the propagation method (with and without 'ceva') on experiments developed in a semi-arid region of Northeast Brazil. 2017¹

		TGR ²	
		Propagation by rhizome without "ceva"	Propagation by rhizome with "ceva"
'Pacovan'	R\$ 17,821.12 ^{Bb}		R\$ 17,142.91 ^{Aa}
'Prata-anã'	R\$ 15,158.45 ^{Aa}		R\$ 18,166.72 ^{Bb}
		TOP	
		Propagation by rhizome without "ceva"	Propagation by rhizome with "ceva"
'Pacovan'	R\$ 4,076.23 ^{Bb}		R\$ 3,398.02 ^{Aa}
'Prata-anã'	R\$ 1,413.55 ^{Aa}		R\$ 4,421.83 ^{Bb}
		PI	
		Propagation by rhizome without "ceva"	Propagation by rhizome with "ceva"
'Pacovan'	0.17 ^{Aa}		0.22 ^{Bb}
'Prata-anã'	0.17 ^{Aa}		0.20 ^{Ab}

¹Similar letters mean a non-significant difference inside the columns (Uppercase) or rows (lowercase), by the F test.

²TGR: total gross revenue (R\$); TOP: total operational costs (R\$); PI: profitability index (dimensionless).

Comparing the results of the equilibrium prices of conventional management by [4] and agroecological management (R\$ 0.41/kg and R\$ 0.90/kg, respectively) and the total operating profit of agroecological management (R\$ 2,425.27 against R \$ 1,818.06) showed

unfavorable results for the proposal of production in semi-arid areas using the propagation method 1 (Table 4). The other indices (TGR, PI and, RRI) were equal or of superior quality to those tested in the banana subgroup Cavendish of the interior of São Paulo. These results

proved successful management for the Brazilian semi-arid showed through the better values of 70% of the economic variables studied.

The multivariate analysis (Figure 1) revealed that the tested variables are divided into three distinct groups formed between the equilibrium price (EQP), profitability index (PI) and the subgroup formed by the return rate index (RRI), total operating profit (TOP) and gross income (TGR). This division separates the EQP that was not correlated with the others, whereas the PI, OP and,

TGR are more correlated with each other than and not the others.

With the results of the hierarchical clustering (Figure 1) we could better understand why in the economic analysis the TOP and TGR variables had similar results between them (Tables 4 and 6) and the results for the PI variable were divergent from the other variables studied (Tables 5 and 6). However, a more evident discussion between the EQP and PI variables could not be made since the ANOVA for these variables showed a non-significant effect (table 3).

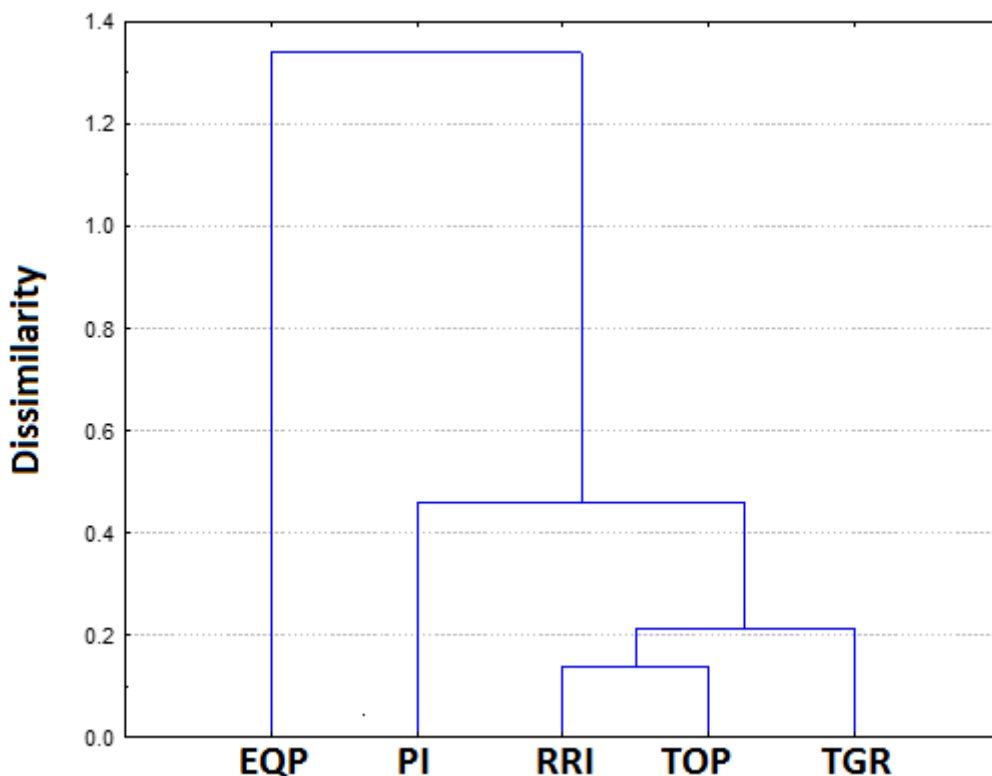


Fig.1: Dendrogram of the hierarchical clustering analysis for the equilibrium price (EQP), profitability index (PI), return rate index (RRI), total operating profit (TOP) and total gross revenue (TGR) for banana cultivation carried out in the semi-arid region of Northeast Brazil. 2017

The analysis of the correlation matrix of the principal components (Table 7) confirmed the lack of correlation (or low correlation) between the profitability index and the equilibrium price (-37.04%), and between the equilibrium price and the other variables analyzed. It shows, however, that there is a high correlation between total operating profit and total gross revenue (78.60%) and between total operating profit and the profitability index (85.68%), but a low correlation between total operational profit and the return rate index (44.39%).

It was also observed from the analysis that the equilibrium price has an inverse correlation with the

profitability index (-93.75%) and total operating profit (-77.27%), and not a lack of correlation low correlation) as the analysis of Pearson's correlation coefficient points out. This results demonstrates that the Pearson test was imprecise to explain all the characteristics among variables proposed in the present study, but we do not completely rule out this test as a way to obtain results since the results presented in the other analyzed variables had good precision, that is, they were aligned with the results of the Principal Component Analysis (Table 7 and Figure 1).

Table.7: Correlation matrix result of the Principal Components Analysis for the experiments developed in the semi-arid region of Northeast Brazil. 2017¹

Variable	TGR	TOP	RRI	PI	EQP
GI	1.000000	0.78604	0.443879	0.1879	-0.3704
OP	0.786035	1.00000	0.856831	0.5416	-0.7727
RRI	0.443879	0.85683	1.000000	0.5599	-0.9375
PI	0.187926	0.54158	0.559861	1.0000	-0.3393
EQP	-0.370389	-0.77273	-0.937508	-0.3393	1.0000

¹ All values are dimensionless.

TGR: total gross revenue (R\$); TOP: total operational profit (R\$); RRI: Return rate index; PI: profitability index (dimensionless); EQP: equilibrium price ((R\$/kg).

The adverse results observed for the relation among EQP, TOP and, RRI between the analysis of Hierarchical groupings and the Principal Components Analysis (Figure 1 and Table 7) is due to the occurrence of specificities and or demandability presented in each research proposal developed and the need for the correct choice to use one or more of the several methods available for multivariate statistical data analysis [9], 2017; [7].

After analyzing the cumulative effect of the correlation factors (Table 8), it was observed that 5 were the number of factors that explained 100% of the events of the analysis under study. And that in only 2 factors it was possible to explain 85.48% of the possibilities of the trial. For this reason, it we explain the results by only addressing the factors 1 and 2 (Table 9).

Table.8: Cumulative distribution of the correlation matrix factors from the experiments developed in the semi-arid region of Northeast Brazil. 2017¹

Variable	Eigenvalue	Percentage of total variance (%)	Cumulative Eigenvalue	Cumulative Percentage (%)
Factor 1	3.412889	68.25779	3.412889	68.2578
Factor 2	0.860911	17.21822	4.273801	85.4760
Factor 3	0.669605	13.39211	4.943406	98.8681
Factor 4	0.030244	0.60488	4.973650	99.4730
Factor 5	0.026350	0.52700	5.000000	100.0000

The analysis of the coordinate factors developed for the experiments (table 9) revealed that the variables that best explained the events studied were EQP (87.34%), TOP (-97.06%) and RRI (-94.78%). This indicates that in the whole analysis process if the equilibrium price rises, there

would be a loss of total operating profit values and the profitability index of the activity. A result that is exactly expected by the application of the methodology under study.

Table.9: Explanation of variables in the experiment developed in the semi-arid region of the Brazilian Northeast. 2017¹

Variável	Fator 1	Fator 2
TGR	-0,677747	-0,656246
TOP	-0,970626	-0,155670
RRI	-0,947818	0,149923
PI	-0,594226	0,595973
EQP	0,873400	-0,114065

¹ All values are dimensionless.

TGR: total gross income (R\$); TOP: total operational profit (R\$); RRI: Return rate index; PI: profitability index (dimensionless); EQP: equilibrium price ((R\$/kg).

All the results obtained for the multivariate analysis confirmed what theoretical studies [9]; [7] predict as fundamentals for the use of economic analysis in the interpretation of results of experimental data. Therefore, using the interpretation of both the economic analysis and the multivariate analysis we understand that the variables TOP and TGR were the ones that best explained the results obtained in the test.

In the present study, the multivariate analysis was used to indicate that the methodology (Multivariate analysis) applied to the composition of all the economic indexes was the correct one since that the results of the analysis were expected when applied the methodology adopted.

IV. CONCLUSIONS

Based on the discussion of the results from the economic and multivariate analysis developed in the trial, we concluded that:

- Both the gross revenue and the total operating profit at the conventional management showed values more than two times higher than those of the agroecological management. And, the best results were found for banana 'Pacovan' propagated by rhizome without 'ceva' and banana 'Prata-anã' propagated by rhizome with 'ceva';
- The multivariate analysis of the test confirmed that the use of the applied methodology in the composition of all economic indexes studied was correct.

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Economic indexes of banana production (*Musa Sp.*) in the Brazilian semiarid region

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Abstract— *Applying several economic indexes commonly used in national scientific research, we assessed the productive efficiency of banana crops in commercial areas of the Brazilian semi-arid region. The analysis of income, through economic indexes, provided an overview of the effectiveness of administration and workforce. The result of the multivariate analysis revealed (i) three independent groups composed by the total net profit, and (ii) a subgroup joined by the opportunity cost, the interest rate for the period from planting to harvest, and the leveling point. The best options for net return on banana propagation in the Brazilian semiarid region were (i) the use of conventional management, (ii) the cultivation of Pacovan cultivar propagated by rhizome without "ceva" and, (iii) use of the Dwarf Prata cultivar propagated by rhizome with "ceva". The economic resources applied to the banana production provided the best output among those evaluated since it exceeded four folds the obtained with the capital remuneration in the financial application.*
Keywords—: *Leveling point; opportunity cost; total net income.*

I. INTRODUCTION

The banana stands out as the most consumed and the second most harvested tropical fruit in the world. Accessible to the majority of the population and available year-round, the total area planted in the world in 2014 was estimated in 5,393,811 ha, yielding a total of 114,430,151 t. India, China, and the Philippines comprised the primary producers. Brazil ranked fourth in the world ranking and second in the classification of the Americas, surpassing even Countries like Ecuador and Guatemala in the production with the culture. In 2014, Brazil planted a total area of 478,765 ha, producing of 6,953,747 t, with average annual productivity of 14.52 t/ha [5].

In Brazil, the volume of production of banana loses only to orange [3]. The leading producers are the

states of Bahia, São Paulo, Minas Gerais, Santa Catarina, Pará, Ceará, and Pernambuco. The main feature of this production is that it relies mostly on small farmers. Thus, the banana tree plays an important socio-economic role in many emerging countries, contributing not only to income generation but also to keep labor in rural areas. The banana culture answers by more than 500 thousand direct jobs [3].

The state of Rio Grande do Norte comprises the eleventh leading Brazilian production of banana. However, joining the indexes of Ceará and Rio Grande do Norte, we obtain values similar to São Paulo. Thus, the semiarid of Brazil rise in the rank of several categories, such as: to the second place of area harvested (10.98% of the total); fifth place in quantity produced (9.00%); second in the increase of production relative to previous harvest (19.92%); fourth in gross income (value of R\$ 470,670,000.00); and sixth in profit per unit area (R\$ 8,970.27/ha/year) [8], [12].

The Ceará and Rio Grande do Norte share a vast frontier. They have the same conditions of socio-economy, climate, soil, logistics of transport, and sales of its products in rural areas [7]. The similarity of the productive aspects of the agribusiness allows assessing the two states with the same approaches of the economic indexes mentioned above.

Richett [18] analyzed the economic performance of the banana-coffee intercropping in agroecological management in Ivinhema, Mato Grosso do Sul. They found that the cost of production in the first year (implantation phase) was R\$ 15,758.26, in the second year was R\$ 8,127.90, and in the third year was R\$ 10,146.31. The net income was R\$ -15,758.26, R\$ 11,515.46, and R\$ 12,843.19, consecutively. These results show the economic efficiency of intercropping banana and coffee.

Studied the economic viability of *in vitro* micropropagation of seedlings against the conventional production systems of "Maçã" banana cultivar in the Jales region, northwest of São Paulo [20]. The two production

systems were profitable, but crops with micropropagated seedlings yielded the highest net revenue (R\$ 1,976.60), which was 34% higher than the conventional method (R\$ 1,468.07), while profitability indexes in both systems were very good, 31% and 33%, respectively.

Studied the Cavendish banana plants under the density of 1,666 plants/ha in Araçatuba, São Paulo. The total operating cost (implementation cost + cost of production) was R\$ 14,806.85; the gross receipts was R\$ 16,660.00; total operating income of R\$ 2,425.27; the total net income of R\$ 1,735.51; and opportunity cost of R\$ 689.76 [6].

II. MATERIAL AND METHODS

The economic analysis of the banana crop was carried out to assess the degree of competitiveness between treatments in two experiments located in the microregion of Chapada do Apodí, in the northeastern region of Brazil.

The first experiment, sited at the Experimental Farm Rafael Fernandes (5°03'36.7"S-37°24'6.6"W; Mossoró/RN), tested the behavior of banana cultivars propagated in the agroecological system. The second experiment, sited at the Terra Santo Farm (5°05'07.57"S-37°51'51.59"W; Quixeré/CE), tested the behavior of banana cultivars propagated through the conventional system of crop production. Both regions have hot and dry weather, comprising BSwh' climate according to the Köppen classification.

We applied the economic analysis described by [17], observing parameters demonstrated by [14], [11]. The study of income, through the indexes of the economic result, assessed the effectiveness of the administrator and his workforce.

We choose the sample through randomization of treatments between the cultivar kinds. The sampling comprised a Randomized Block Design in a factorial scheme 2x2x2, with four blocks and the repetitions composed of the mean values obtained by each treatment in each block. All treatments were randomized within each block.

The randomization resulted in the following treatments. (T1 and T2) Banana of the Pacovan cultivar, with seedling propagated with and without "ceva" in the agroecological system. (T3 and T4) Banana of the Dwarf Prata cultivar, with seedling propagated with and without "ceva" in the agroecological system. (T5 and T6) Pacovan banana, with seedling propagated with and without "ceva" in the conventional system. (T7 and T8) Dwarf Prata banana, propagated with and without "ceva" in the conventional system.

In the agroecological system, the collection of the experimental units for propagation with "ceva"¹ was done with the removal of the sprout with the rhizome of the

cultivar of each treatment, in the areas of exploitation of the banana tree in the experimental farm of the UFERSA. Subsequently, we removed the leaves and maintained the units in a greenhouse covered with shade cloth and ground beaten for 15 days. One day before the final transplanting, we prepared the seedling with a simple scraping the rhizome with a knife for the elimination of excedent roots and removal of necrosed parts. Finally, we weighed the rhizomes to separate the treatments used and the "refuse" of each cultivar. In the treatment of rhizomes without "ceva", the seedlings were also prepared, but they were harvested one day before planting, at which time all the leaves were removed, leaving only the seedling with the rhizome.

In the conventional system, we collected the experimental units for rhizome propagation with "ceva" performing the removal of the sprout with the rhizome of the cultivar of each treatment in the Terra Santa farm. The period of rest occurred under shading on field conditions and the soil surface. One day before the final transplanting, the seedlings were prepared through the elimination of leaves and excedent roots. All rhizomes were immersed for approximately 15 minutes in a solution with liquid carbofuran at 1%. This procedure was also applied to the treatments of propagation by rhizome without "ceva". In both cases, the collection of the sprout with rhizome was to the agroecological process [10].

We analyzed the following indexes: LP → leveling point (kg/ha); IR → interest rate of the period from planting to harvest (%); OC → opportunity cost (R\$); and TNI → total net income (R\$). To obtain the indexes mentioned above, we measured the variables: total operating revenue (TOR); total operating cost (TOC); and total operational profit (TOP).

The total operational cost (TOC) of the conventional system was obtained in commercial areas of banana production in the region, according to [15]. The total operational cost of the agroecological system was achieved in areas of banana production in the region, according to [12]. The total operating cost in the conventional exploration activity (TOCc) was R\$ 18,786.30 and in the agroecological system (TOCa) was R\$ 8,703.48.

We included the following items as standard costs for both kinds of propagation: (i) inputs for plant nutrition (bovine manure, urea, fertilizer formulation 4-14-8, and potassium chloride); (ii) electric power consumption; (iii) irrigation system; (iv) labor force; (v) mechanized activities (tillage, brush cutting, and harvesting); and (vi) costs for the acquisition of seedlings. The miscellaneous items cost (business compensation, office supplies, and prices in the logistics of each area studied) were considered as the sum of 10% all items of each kind of propagation.

The costs assigned only to the conventional propagation were: (i) the labor and mechanized activity adopted in the application of agrochemicals; (ii) the inputs for phytosanitary control of plants with the use of agrochemicals (Furadan liquid and granulate, Opera insecticide, Talstar, and Roundup herbicide); and (iii) inputs for plant nutrition with the use of ammonium sulphate, potassium sulphate, magnesium sulphate, zinc sulphate, copper sulphate, manganese sulphate, boric acid, and Comol fertilizer.

The total gross revenue (TGR) for a given treatment (ti) was obtained by the ratio between the productivity per area obtained by each treatment (prodt.ti) and the average price² of banana per kg sold (Eq. 01). That is,

(² The average selling price of 1 kg of banana produced at the farm Terra Santa, municipality of Quixeré-CE, on 11-18-2015 = R\$ 1.10)

$$TGR = Prodt. ti \times R\$1,10 \quad (\text{Eq. 01})$$

We obtained the total operating profit (TOP) per treatment using the difference between the total gross revenue for each treatment (TGR) and the total operating cost per treatment (TOCt) (Eq. 02). That is,

$$TOPti = TGR - TOCti \quad (\text{Eq. 02})$$

We estimated the opportunity cost per treatment (OC) by the simulation of the bonus that the cost of stable capital would provide if applied in another activity (interest - in the case of financial application - or

profitability of the alternative activity). For other items of stable capital (buildings, machines, equipment, etc.) the opportunity cost was obtained as the annual interest that reflects the alternative use.

As the chosen interest rate for this calculation should be equal to the rate of return of the best alternative application, we used the Selic rate. This index is considered the basic interest rate of the economy, which value reflects the average profitability of productive activities of the national economy.

During the period from Mar/2012 to Mar/2013 (the period of the research in the agroecological system) and Sep/2013 to Sep/2014 (period of the conventional system), the projection of interest was respectively 0.63% and 0.82% per month, and 7.54% and 9.86% per annum [16]. Thus, we considered the opportunity cost separated for the agroecological system (OCa) and conventional system (OCc).

As the outlay of resources is in installment during the productive cycle, the interest accounted for half of the total value of the cost for the two situations in studies (OCa and OCc) multiplied by the annual interest rate for the first cycle divided by twelve months and by the interval between planting and harvesting of the first cycle divided by the sum of the days of the months that comprised the period.

The total interest rate of the period by treatment, the interval between planting and harvesting of each treatment was taken into account and added to the "ceva" period, in cases where the treatments underwent "ceva". In this way, the opportunity cost of capital (OC) was calculated as shown in Eqs. 03 and 04.

$$OCa = \frac{OCti}{2} \times \frac{\text{annual crop interest rate for agroecological model}}{12} \times \frac{\text{interval from planting to harvest} + \text{period of "ceva" or not}}{\text{sum of the days of each month of the interval}} \quad (\text{Eq. 03})$$

$$OCc = \frac{OCti}{2} \times \frac{\text{annual crop interest rate for conventional model}}{12} \times \frac{\text{interval from planting to harvest} + \text{period of "ceva" or not}}{\text{sum of the days of each month of the interval}} \quad (\text{Eq. 04})$$

At the end of the analysis inferences, the total net income of each treatment (TNI) was calculated by subtracting the total operating profit per treatment (TOPti) and the opportunity cost per treatment (OCti). Instantaneously, such calculation differentiates, quantitatively and qualitatively, which treatments exceeded the bonus that the cost of stable capital provides if it were applied in another financial activity. The formula is shown in Eq. 05.

$$TNI = TOPti - OCti \quad (\text{Eq. 05})$$

(² The average selling price of 1 kg of banana produced at the farm Terra Santa, municipality of Quixeré-CE, on 11-18-2015 = R\$ 1.10)

Finally, the data were tested to the ANOVA assumptions by the residue test and submitted to analysis of variance through the F test and the hierarchical grouping analysis using the single linkage method of the Euclidean distances of the multivariate statistic [13], [9]. In the univariate statistic, the means were compared by treatments and by unfolding of factors that had significance [13]. We show only the possibilities that best

explain the results of the analyzed. The statistical test was carried out in the software STATISTICA 13® [1].

III. RESULTS AND DISCUSSION

Our data met all assumptions for parametric analysis. Therefore, we applied standard tests without transformation of data.

The hierarchical grouping split three independent groups: (TNI) the total net income; (OC and IR) the

opportunity cost with the interest rate for the period from planting to harvest; and (LP) the leveling point. The variable LP has the highest degree of independence from the other ones (low correlation), TNI has intermediate autonomy from LP and the subgroup (OC and IR), while the variables OC and IR showed the highest degree of dependence (high correlation) (Figure 1).

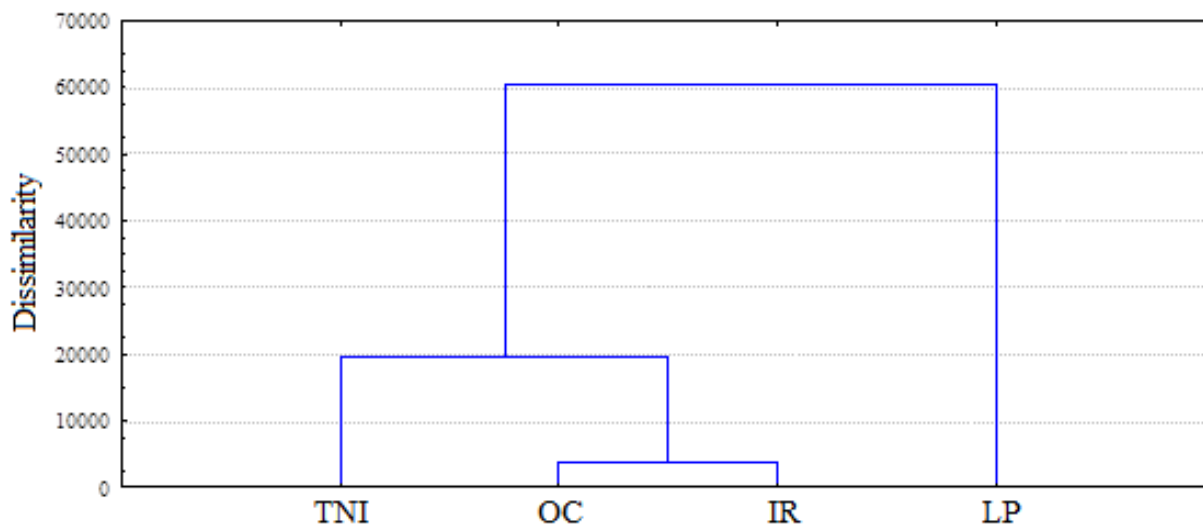


Fig.1: Dendrogram of the distance matrix for the LP, IR, OC, and TNI variables evaluated by the single linkage method of Euclidean distances carried out in the study of the banana tree economy in the semi-arid region of northeastern Brazil. 2015.

At 1% of probability, we obtained the following results. The method of propagation 1 (MP1) affected the leveling point (LP) significantly. The cultivar (C), MP1, the interaction between cultivar and method of propagation 2 (C x MP2), and the interaction among cultivar, method 1, and method 2 (C x MP1 x MP2) affected the of the interest rate (IR). The cultivar, MP1,

interaction C x MP1, and the interaction C x M1P x MP2 influenced the opportunity cost (OC) (Table 1).

The total net income (TNI) was affected only by MP1 and the interaction C x MP2 at 5% of probability. Similarly, the IR was influenced by the interaction C x MP1 only at 5% of probability (Table 1).

Table.1: Results of the analysis of variance by the F test for the financial characteristics of the banana fruit production (*Musa sp.*) of experiments carried out in the semi-arid region of northeastern Brazil. 2017¹.

Source of variation	df ²	LP (kg/ha)	IR (%)	OC (R\$)	TNI (R\$)
Cultivar (C)	1	1.000 ^{ns}	0.007**	0.002**	0.372 ^{ns}
Method of propagation 1 (MP1)	1	0.000**	0.000**	0.000**	0.012*
Method of propagation 2 (MP2)	1	1.000 ^{ns}	0.131 ^{ns}	0.157 ^{ns}	0.199 ^{ns}
C x MP1	1	1.000 ^{ns}	0.019*	0.003**	0.865 ^{ns}
C x MP2	1	1.000 ^{ns}	0.001**	0.197 ^{ns}	0.049*
MP1 x MP2	1	1.000 ^{ns}	0.905 ^{ns}	0.545 ^{ns}	0.758 ^{ns}
C x (MP1xMP2)	1	1.000 ^{ns}	0.000**	0.000**	0.095 ^{ns}
Average		12,495.36	8,553	620.74	2,706.66

¹ns = non-significant; * P < 0.05; ** P < 0.01; ²df = degree of freedom; LP = leveling point; IR = interest rate of the period from planting to harvest; OC = opportunity cost; TNI = total net income.

These results suggest that the application of the economic resources in the agricultural production of banana crops comprises the best investment among the ones evaluated. The average net income (R\$ 2,706.66)

generated resources four-fold higher than what he would obtain with the remuneration of capital in the financial application (R\$ 620.74). Also, the banana production provides social benefits, since this activity avoids the

rural exodus giving opportunities to keep the population in the field, with employment, income, and a better chance in food production [7], [2].

The method of propagation 1 yielded the most representative leveling points, clearly stating the superiority of agroecological management (7,912.26 kg/ha) against the conventional system (17,078.45 kg/ha). Only 46% of the production in the conventional

experiment was required to pay all the costs of the agroecological one. Conventional agriculture produced the highest leveling point (17,078.45 kg/ha). Intermediate leveling points were obtained for the other variables (12,495.36 kg/ha), where agroecological management accounted for 63% of their average values (table 2).

Table.2: Mean values for LP, IR, OC, and TNI according to the factors studied in the experiment developed in the semi-arid region of northeastern Brazil. 2017¹.

	df	LP ² (kg/ha)	IR (%)	OC (R\$)	TNI (R\$)
Pacovan cultivar	1	12,495.36 ^B	8.62% ^B	R\$ 626.87 ^B	R\$ 3,110.25 ^B
Dwarf Prata cultivar	1	12,495.36 ^B	8.49% ^C	R\$ 614.61 ^C	R\$ 2,303.08 ^B
Agroecological system	1	7,912.26 ^C	7.25% ^D	R\$ 315.32 ^D	R\$ 1,502.74 ^C
Convencional system	1	17,078.45 ^A	9.86% ^A	R\$ 926.17 ^A	R\$ 3,910.59 ^A
Propagation without "ceva"	1	12,495.36 ^B	8.59% ^C	R\$ 623.36 ^B	R\$ 2,121.53 ^B
Propagation with "ceva"	1	12,495.36 ^B	8.52% ^C	R\$ 618.13 ^{BC}	R\$ 3,291.79 ^B

¹In each column, averages with the same letter do not differ from each other by the F test; ²df = degree of freedom; LP = leveling point; IR = interest rate of the period from planting to harvest; OC = opportunity cost; TNI = total net income.

On average, the interest rate obtained in the financial market (banking application) with the financial resource applied in the costing of the plants of the cultivar Pacovan (8.62%) outperformed the interest obtained with the Dwarf Prata cultivar (8.49%) by 0.13%. Such difference brought Pacovan a slight disadvantage compared to Dwarf Prata because the interest rate was affected by its delay in harvest, which delayed the production of revenues, thus raising the cost of capital invested. Both propagation types (with and without "ceva") showed statistically similar means, and these are considered regular compared to the extreme values of interest rates obtained in the test (table 2).

The interest of the cultivar variation source was higher than the recommended in other studies, where values range around 6% per year (the real rate paid by the savings account) with practically no risk [19], [15]. However, the total net income of the Pacovan cultivar (R\$ 3,110.25) and Dwarf Prata cultivar (R\$ 2,302.76) were similar to the values in other studies, which were R\$ 3,216.00 ha⁻¹ [4] and R\$ 2,809.89 ha⁻¹ (Santana et al., 2004) [19], [15], [4], respectively.

The interest rate of agroecological management (7.25%) was 2.61% lower than the conventional system (9.86%). However, this surplus of 2.61% was purely coincidental due to the two experiments were carried out in different periods (the agroecological occurred in the 2012/2013 fiscal year, while the conventional in the 2013/2014 fiscal year). In this case, the inter-period rate surplus was caused solely by the Brazilian economic policy. Therefore, the discussions of the mean values

obtained for propagation method 1 and its double and triple interactions (C x MP1, MP1 x MP2, and C x MP1 x MP2) are unnecessary for analysis of the results (table 2).

As the result of cluster analysis showed a correlation between the opportunity cost (OC) and the interest rate (IR), we also discarded the discussion of the mean values obtained for propagation method 1 and its double and triple interactions (C x MP1 and C x MP1 x MP2) (Table 2).

In this case, the opportunity costs of the cultivars were R\$ 614.37 and R\$ 626.87 for Dwarf Prata and Pacovan, respectively (Table 2), which indicate a disadvantage of R\$ 12.50 of Pacovan relative to Dwarf Prata cultivar. Thus, the Pacovan cultivar has a more significant expectation of success in the use of the resources of costing in the financial application. However, recent research, developed under the same conditions, obtained an opportunity cost of R\$ 689.76 [6]. This value exceeded R\$ 69.14 the mean value of OC in our experiment, which reinforces that the choice of the application of the costing resource in the banana plantation for Brazilian semi-arid conditions was the best option among those evaluated.

The total net income (TNI) under the method of propagation 1, the agroecological management provided the lowest value (R\$ 1,502.74), while the highest value was obtained in the conventional system (R\$ 3,910.53). The average values in conventional management were 2.6 folds higher than the average value of the agroecological management. The remaining sources of variation were statistically similar (Table 2).

Even with the interest rate surplus between the two periods of experiments (2.61%), there was no advantage to obtain the net income in the agroecological system, supporting the independence between the TNI and the other variables analyzed (table 2).

We obtained similar or better than [20] for all variables, except the agroecological management (R\$ 1,502.74). This author propagated Dwarf banana in the conventional system, with the best results ranging R\$ 1,976.60. The total net income of all treatments evaluated,

only 16.67% of the results were unsatisfactory (value of agroecological management).

Unfolding of cultivars within each kind of propagation, the highest interest rate of the Pacovan cultivar occurred when we propagated them by rhizome without "ceva" (8.74%). This effect, however, was utterly overcome since it provided one of the best total net incomes (R\$ 3,444.37) (table 3).

Table.3: Mean values for the unfolding of cultivars within the banana propagation by rhizome with and without "ceva" for the variables IR and TNI of the experiment carried out in the semi-arid region of northeastern Brazil. 2017¹.

Cultivar	df ²	IR		TNI	
		Without "ceva"	With "ceva"	Without "ceva"	With "ceva"
Pacovan	1	8.74% ^{Aa}	8.50% ^{Ab}	R\$ 3,444.37 ^{Aa}	R\$ 2,776.13 ^{Bb}
Dwarf Prata	1	8.44% ^{Ba}	8.53% ^{Aa}	R\$ 798.70 ^{Bb}	R\$ 3,807.46 ^{Aa}

¹In each column, and to each group of two consecutive columns, averages with the same letter do not differ from each other by the F test; ²df = degree of freedom; IR = interest rate of the period from planting to harvest; TNI = total net income.

Inversely, the unfolding of the Dwarf Prata cultivar on the propagation by rhizome without "ceva" showed the lowest interest rate (8.44%), confirming that this cultivar had the best results. However, their propagation with "ceva" (8.53%) was statistically similar to the propagation of Pacovan with "ceva" (8.50%). Thus, that the total net income of Dwarf Prata propagated without "ceva" provided the worst result (R\$ 798,70), with the profit of R\$ 2,776.13. Conversely, the yield of the Dwarf Prata propagated with "ceva" (R\$ 3,807.46) was statistically similar to the best profit option (propagation of the Pacovan without "ceva") and superior to the other options (table 3).

Thus, the best options of net income (TNI) of banana propagation in northeastern Brazilian was the conventional management, with the use of Pacovan cultivar propagated without "ceva" or the Dwarf Prata with "ceva" [10]. The second option was the use of the Pacovan cultivar propagated by rhizome with "ceva", while the less recommended option was the use of Dwarf Prata rhizome without "ceva" (Tables 2 and 3).

IV. CONCLUSIONS

Based on the indexes obtained from the economic analysis, we can conclude that:

- The application of financial resources in banana production was the best investment among the evaluated ones since it exceeded by more than four times what would be obtained with the remuneration of the capital in the financial application;
- The best options of net economic income for banana propagation in the Brazilian semi-arid region were the

- conventional management with the use of Pacovan cultivar propagated by rhizome without "ceva" or Dwarf Prata cultivar propagated by rhizome with "ceva";
- The worst option of net economic income was the use of the Dwarf Prata cultivar propagated by rhizome without "ceva".

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Design of Electric Vehicle

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Abstract— The aim of this thesis work 'Design of electric vehicle including different power train components' is to design an energy model of electric vehicle including different power train components with the application of a design and simulation tool, which in this thesis work would be MATLAB Simulink software. With this design and simulation, we expect to find the energy consumption by a vehicle by virtue of different types of forces acting on vehicle when subjected to different standard driving cycles. This work also includes a survey of different vehicles which runs on electric propulsion either only or in assisted mode in the present market.

Keywords— Design, Simulation, Electric Vehicles, Dynamics, Electrochemical cell, Vehicle Energy Modelling, MATAB, Simulink, Driving Cycles, State of Charge, Energy, Voltage, Power, Lithium Ion Batteries, Aerodynamic Drag, C-Rate.

I. INTRODUCTION

The nature of the fossil fuel, as the name indicate, 'Fossil',

which takes millions of years to get replenished in abundance. Natural phenomenon such as volcanic aerosol and anthropogenic economic activities has been seen as significant contributors to temperature rise over past years, apparently leading to temperature rise leading to glacier meltdown. (1) (2). The rate of consumption of the fuel is just making its way higher than the rate of productions, which inevitably will reach on a point where it will be absolutely exhausted with no more fossil fuels to satire the demand. Imagine life with mobile phones, but without any electricity to charge it, seems like dark ages, not a pretty picture to imagine. Other prominent concern related to the exhaustible use of fossil fuel is environmental issues. Impact of carbon di oxide gas (CO₂) on the environment is not new to be known. It has been first theorized by noble prize laureate Svante Arrhenius back in 1896. However, the emission of the CO₂ can be divided majorly into two causes: Natural Phenomena and Anthropogenic.

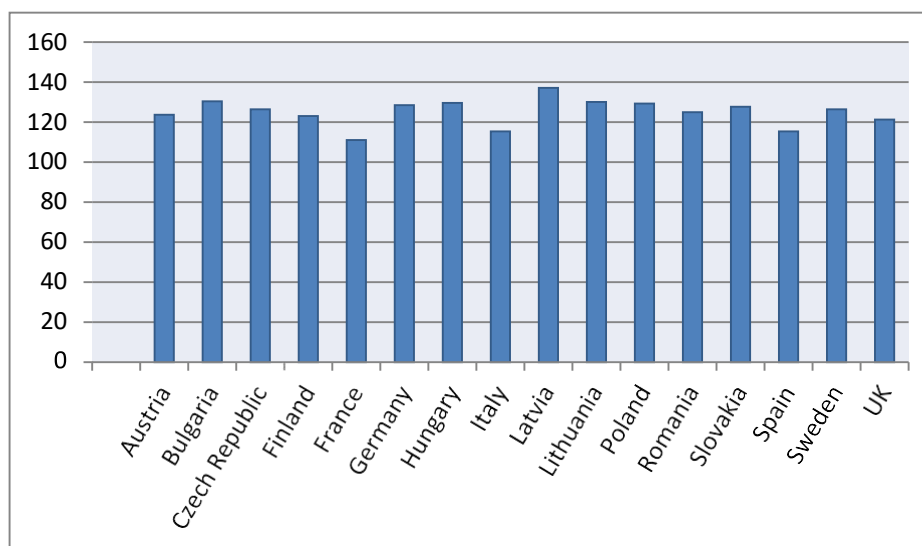


Fig.1: CO₂ emission in 2015

The problems just do not persist with the exhaustible nature of the hydrocarbons and environment. 'Oil' in this contemporary world scenario is not just an energy resource but also heavily influence the international politics and policies of nations. Different war conflicts and wars are waged to acquire the oil. New family of storage devices advanced electronic drives, fabrication of sophisticated

semiconductor materials, fabrication material, ultra-capacitors have played their major part in bringing back the trend of EVs with much more economy introduced in it. (1)With the current trend and peer pressure from the perspective of Environment, limited resource, and political interventions, vigorous researches are done through which lead to the advancement of existing technology. Intense

research and development is being carried out in order to develop new concepts, low cost, more reliability of hybrid power trains. As it can be seen as future of transportation, almost all major automobile manufacturers from all across the world are jumped into the market of EV, HEV and

FCEV . ‘Prius’ from Toyota, to name few available models. This competition has led to the creation of such cars which are economically viable and are being used now. Although, there are a lot of scope in the improvement of storage technology, which will open new doors for EVs.

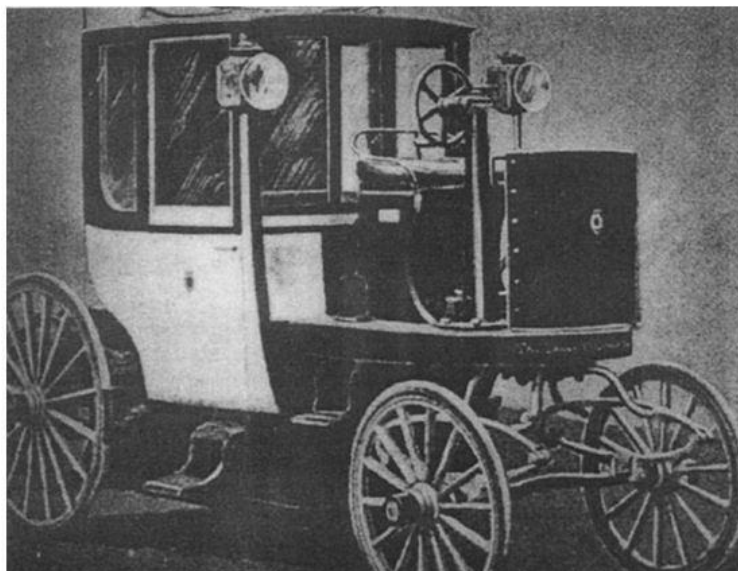
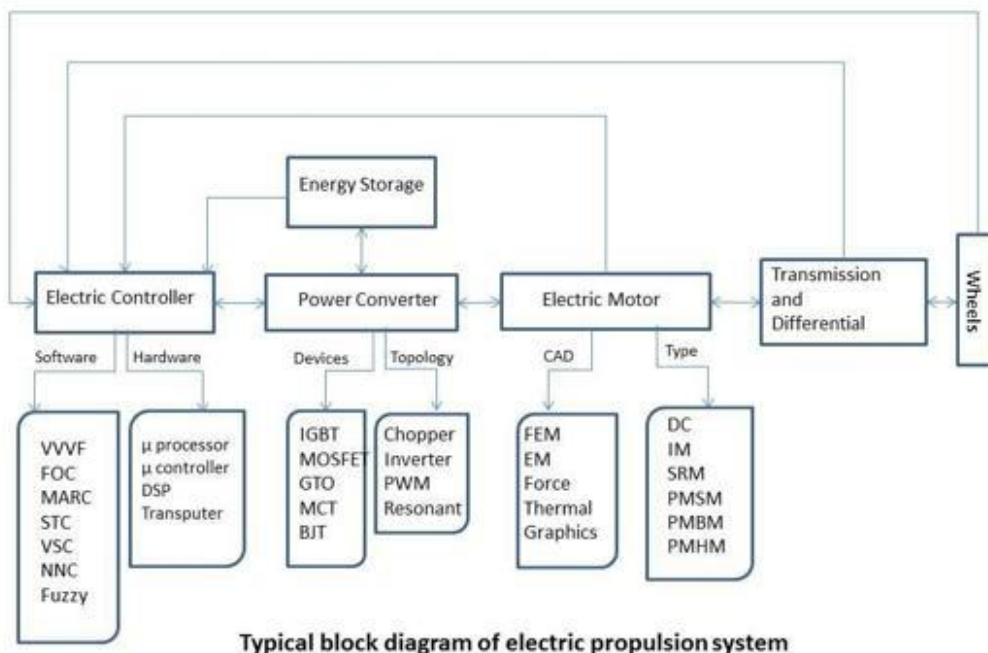


Fig.2: London electric cab company's taxi

Since BEV's is now being totally dependent of the electrical storage technology and will improve as storage and energy density will improve. Nowadays, Hybrid Electric vehicles are in trend. Hybrid vehicles. As per proposed by the Technical Committee 69 (Electric Road Vehicles), International Electro technical

Commission. "A hybrid road vehicle is one in which propulsion energy, during specified operational missions, is available from two or more kinds or types of energy stores, sources, or converter. Electric Propulsion



Typical block diagram of electric propulsion system

Fig.3: Representation of electric propulsion systems (4)

Electrical machines can be classified mainly into two

groups depending upon nature of electricity employed, DC

machine and AC machine. Both family of machines have their pros and cons, and found their application according to the load requirement. DC machines were incorporated in the 1980's decade due to its torque to load characteristics and controllability. In spite of such fine traits, DC machine are no longer being preferred due its size and maintenance requirement. Now a day, latest vehicles manufacturers are employing AC and brushless motors, including Induction Motors, Switched Reluctance Motor and Permanent Magnet Motors. This chapter aims to render a brief overview of electrical machines.

DC Machine: The electrical machine which uses the direct current as power input (motoring mode) and generating direct current (generation mode) are termed as DC machine. DC machines consists of two set of windings, on the rotor (rotating body mounted on shaft) and stator (stationary part which holds current carrying conductive wiring in order to cause the interaction between two field fluxes, resulting in torque generation producing necessary torque to overcome the inertia and friction. Simply put, force (F) experienced by any current carrying conductor of length (L) in the magnetic field density (B) is,

$$F = B \times I \times L \tag{1.1}$$

And when the current carrying conductor is in coil shape then, Torque (T) produced will be,

$$T = B \times I \times L \times \cos(\alpha) \tag{1.2}$$

α is angle between the coil plane and magnetic field (B).
(4)

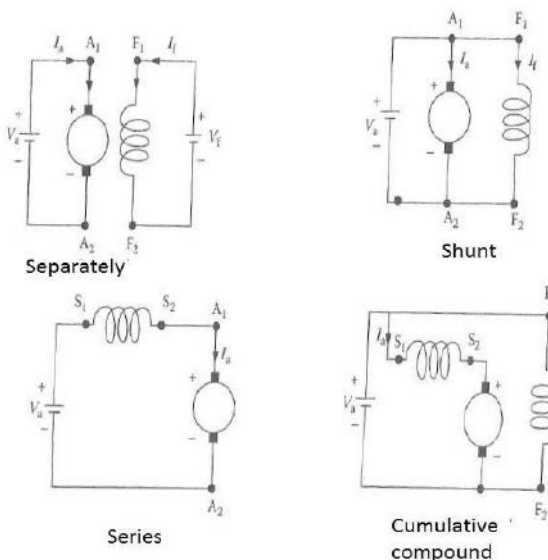
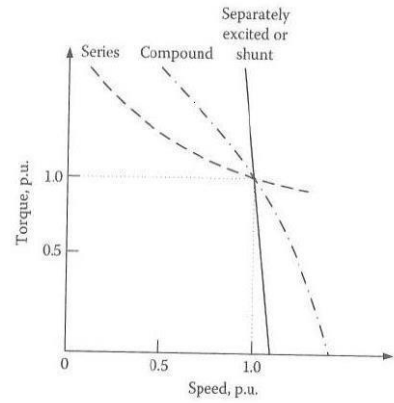


Fig.4: Different Schemes of stator field Winding

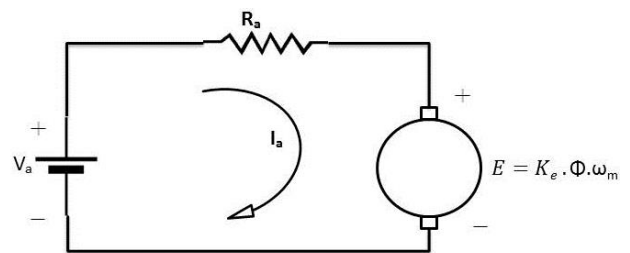


Torque vs. Speed Characteristics of different excitations

Fig.5: Torque vs Speed characteristics for DC machine

As it goes without saying all the topologies have its own advantage and drawbacks, and their application depends upon the load requirement as well. Typical torque- speed characteristics of the DC machines are mentioned as following.

In separately excited DC machine, it is easy to control field and armature voltage independently. Whereas, in shunt winding, which has same speed torque characteristics as separately excited machine, controlling is possible only when using inserting resistance in the circuit. However, it is an inefficient method due to the presence of the resistance in the circuit. But, if we replace the mentioned resistance in circuit by the power electronic devices (DC-DC converter) we can actively control production of proper armature and field voltage. (4)



Equivalent circuit of the armature circuit DC motor

Fig.6: Equivalent DC Armature circuit

Basic equations of DC machines are as follows;

$$V_a = E + R_a \cdot I_a \tag{1.3}$$

$$E = K_e \cdot \Phi \cdot \omega_m \tag{1.4}$$

$$T = K_e \cdot \Phi \cdot I_a \tag{1.5}$$

Where,

V_a = DC supply voltage (volts); ϕ = flux per pole (webers);

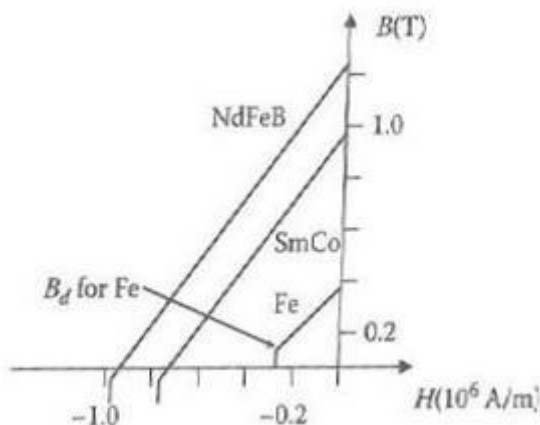
E = emf(volts),

T = torque (N m); R_a = armature resistance(ohms); I_a = armature current(amps);

ω_m = armature speed (rad/s); K_e = constant.

The PM machines now a days are being preferred in the hybrid and electrical vehicles by the manufacturers since it has significant advantages over the conventional machines such as IM and DC machine, or Synchronous machines. Since, we already know that using excitation winding in machine always comes with the *excitation penalty* (8). The initial cost of the PM machines can be high but when we talk about the small motors for vehicular application, using of excitation winding can be complex and undergo losses. In addition to this, the field winding's current will lead to the deterioration of the winding which means increase of maintenance cost. Also, absence of excitation winding facilitates compact arrangement of the PM machines in the vehicle. On the other hand for the heavier machines excitation penalty is more economical as compared to the initial cost of PM machine. (8)

Discussion of PM machines is incomplete without discussing permanent magnets incorporated in PM machines. The main purpose of permanent magnet is to provide constant *mmf*, as a constant current source (8). The magnetic flux density remains constant as long as operating point is under the linear region, but as soon as operating point goes beyond, *knee-point* (B_d) of the characteristics, some of the characteristic is lost permanently. When the demagnetizing field is removed beyond the limit, new characteristic will exist but lesser than last characteristics. But most PMs are designed to withstand considerable magnitude of current (up to 2-4 times the rated current). Some of the permanent magnets are enlisted and discussed below;



Characteristics of discussed permanent magnets
 Fig.7: BH curve of permanent magnets

Simply put, PM synchronous motor is a synchronous motor which produces sinusoidal *mmf*, voltage and current provided by the permanent magnets. PMs used in PMSM motor ensure high flux density in air gap consequently increasing power density and torque to inertia ratio. Due to PMSM's fast response, high power density, and high efficiency it found its application in high performance

control application such as robotics and aerospace applications. The PMSM is fed from supply via power electronic converters with its smooth torque operation depends upon the shaping of current waveform. Field weakening mode is possible in PMSM by applying stator flux opposite to rotor flux. The speed is limited because of current rating, back-emf and maximum output of inverter. Although, PMSM and IM have good torque response but slip speed calculation makes IM more complex than that of PMSM. According to construction, PMSM has lower inertia due to absence of heavy rotor cage as in IM. Both IM and PMSM have limited field weakening range, a limitation.

PMSM has a higher temperature and load sensitivity which is the major drawback of PMSM, therefore, PMSMs are typically limited to low or medium power applications, however some of the high-power applications are employing PMSM.

PMSM has two main sections, rotor and stator, like in all rotating machines. Stator is incorporated with three phase sinusoidally distributed copper winding similar to AC machines winding. On the other hand, Rotor, does not have any winding but permanent magnets are settled over the rotor instead. The three phase balanced supply is provided to the stator winding which in turn establishes a rotating *mmf* of constant amplitude in the air gap. The stator current is regulated by the position feedback of rotor in order to maintain the frequency in synchronism to the rotor. The interaction of these stator and rotor fields results in the torque development on the rotor. (8)

The PMSMs can be classified on the position and shape of the magnets on/in rotor. Illustrative figure of the PMSM types are provided below;

- a) Face Mounted
- b) Inset
- c) Interior

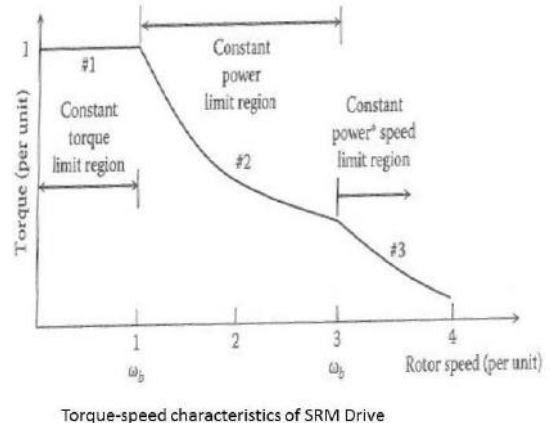


Fig.8:

Face mounted, and insets are also called surface-mount PMSMs. In inset the magnets are inside the rotor surface but exposed to air gap whereas in face mounted magnets

are protruding. The magnets are attached to rotor by the help of epoxy glue. It implies that the ability to perform surface- mount PMSM during operation depends upon the adhesiveness of epoxy glue. But these types of PMSMs are easier and simpler to construct. In contrast to them, in interior PMSM, magnets are actually buried inside the rotor, thus mechanical strength is higher as compared to the previous ones. However this technology is costly and complicated. (8)

II. VEHICLE DYNAMICS

Vehicle design’s fundamentals are a direct implementation of Newton’s second law of motion, which relates force and acceleration. The acceleration of vehicle is caused by the fact of presence of non-zero resultant force. This force to move the vehicle forward comes from the propulsion unit overcoming the resisting force imposed by gravity, and air and tire resistance. The road and aerodynamic condition along with power available from traction unit determines the acceleration and speed of the vehicle. In this chapter we will get into basic governing factors affecting the design of the vehicle focusing on electric.

The force from the propulsion unit is known as the tractive force. Once the force required is known, energy and power consumption can be calculated.

Centre of Gravity

According to newton’s second law of motion,

$$\sum F_i = m \times a; \tag{4.1}$$

Where, F_i = net force, m = mass, a = acceleration.
 As a complex conjunction of subsystems, there exist different individual masses at several points of contact of the vehicle with reference to outside world leading to be a bit complex task to analyze and calculate forces at each point of mass’ contacts. Thus, in order to simplify this problem, we consider one location where all these points will merge and net force due to gravity can be realized. This location is known as *Centre of gravity* (COG) of the vehicle. For the calculation purpose, we shall consider vehicle to be a particle mass concentrated at the COG.

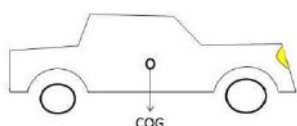


Fig.9: Center of Gravity

The motion of particle is defined by *acceleration* and *velocity* characteristics. let x , be the distance travelled by the particle and v be the velocity and a be the acceleration of the particle then the mathematical relation in these quantities are as follows,

$$\vec{v} = \vec{dx}/dt \tag{4.2}$$

$$\vec{a} = d\vec{v}/dt \tag{4.3}$$

The input power P for the force F , to the particle mass is,

$$P = \vec{F} \cdot \vec{v} = |\vec{F}| |\vec{v}| \cos\theta \tag{4.4}$$

Where, θ is angle between F and v .

Torque T on the rigid body rotating about a fixed axis,

$$T = J \alpha; \tag{4.5}$$

Where, J = polar moment of inertia of the rigid body

α = angular acceleration (rad/ s^2)

$$\text{Also, } \alpha = d \omega /dt \tag{4.6}$$

$$\omega = d\theta/dt \tag{4.7}$$

Where, ω = angular speed (rad / sec)

θ = angular displacement.

The relation between power input and torque input is important and is given below,

$$P = T \times \omega \tag{4.8}$$

Vehicle kinetics

The propulsion unit generates and exerts the *traction force* to the wheels to provide motion to the vehicle. In order to move vehicle, tractive force must overcome the opposing force acting on the vehicle. This opposing force is known as *road load force*, $F_{RL} = F_{GRAV} + F_{ROLL} + F_{DRAG}$; (4.9)

Where, F_{gxT} = Gravitational force,

F_{ROLL} = Rolling resistance,

F_{AD} = Aerodynamic drag force,

xT is tangential direction on the roadway.

We will discuss these terms and, their cause and effect on the vehicle motion.

Force due to gravity

The force on vehicle due to gravity is a function of slope of the road, the mathematical relation is given as follows, $F_{gxT} = m g \sin \beta$;

Where,

m = mass of the vehicle,

g = acceleration due to gravity,

β = slope angle (grade angle) with respect to horizon.

III. MODELLING AND SIMULATION

In this chapter we will discuss and present the *Simulink* modelling of the electric vehicle with different powertrain.

For modelling of simulation vehicle MATLAB and *Simulink*TM (*Simscape*) from MATLAB is being used, due to its wide presence and easy to understand modelling technique. The model being discussed below consists of

three major components: Power Sources, Electromechanical device and loads by the virtue of vehicle motion in an open environment. The modelling does have assumptions in order to keep work easy and not complicated to understand for a layman. Due to assumptions, the accuracy of the model is affected, but it will provide base to idea being discussed in this thesis work.

The following assumptions are being taken under consideration

- Vehicle is moving with certain velocity according to standard drive cycle.
- Vehicle’s operation weather is constant at all instants during simulation.
- Batteries initially have finite state of charge.
- Using predefined standard drive cycles to assess the results.

With the start of the simulation, we will define some inputs in the *MATLAB Editor*. These values are being considered in accordance to *Nissan Leaf*. This model also allows us to observe range and power it can be taken out of any other vehicle model, once all the parameters are known. Following is the screenshot of the MATLAB editor, with the details mention as the comment in the editor itself due as it is convenient.

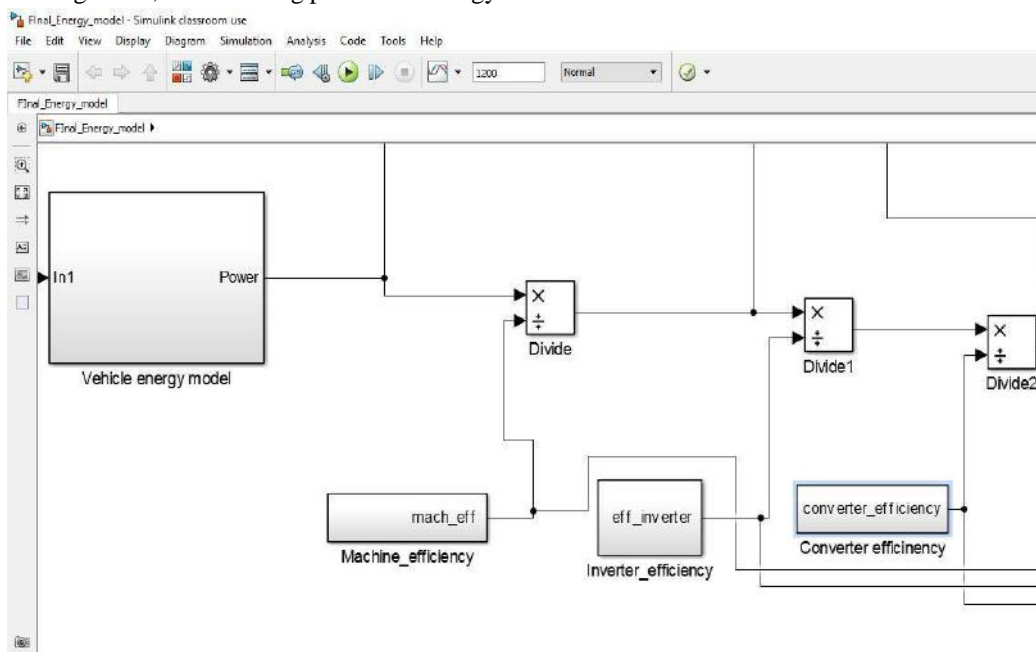
The study of the model is in accordance to variation in *velocity-time* profile (drive cycles) and *slope/s*. During drive cycles, the vehicle undergoes transiency due to start, stop, acceleration, braking. Thus, with drawing power and energy

from the battery packs in order to overcome the resistance offered by the vehicle. In addition to it, different power electronic converters such as DC/DC bidirectional inverter and DC/AC converters are used in series with electric machine. All these above mentioned converter components come with their own efficiencies. Due to these efficiencies, extra energies have to be extracted from the batteries in addition to required energy to overcome vehicle road load. These efficiencies are also being modelled in this chapter. Overall energy model of the electric vehicle:

With respect to following screenshot given below, the energy consumption of the vehicle from each of the individual energy consumption mentioned previous in the chapter is being added in order to give a output in the terms of the power required by the vehicle to complete different driving cycles our vehicle would be subjected to. Please note that this power consumption is just the result of the vehicle dynamics and not include *auxiliary* power consumptions, such as heating, air conditioning, and other amenities.

Efficiency Modelling:

This section of current chapter will bring some light on the modelling of different components incorporated in the drive train. These components facilitate power flow from the source, i.e. Electro-chemical batteries to the load, i.e. due to vehicle dynamics and auxiliary power consumptions.



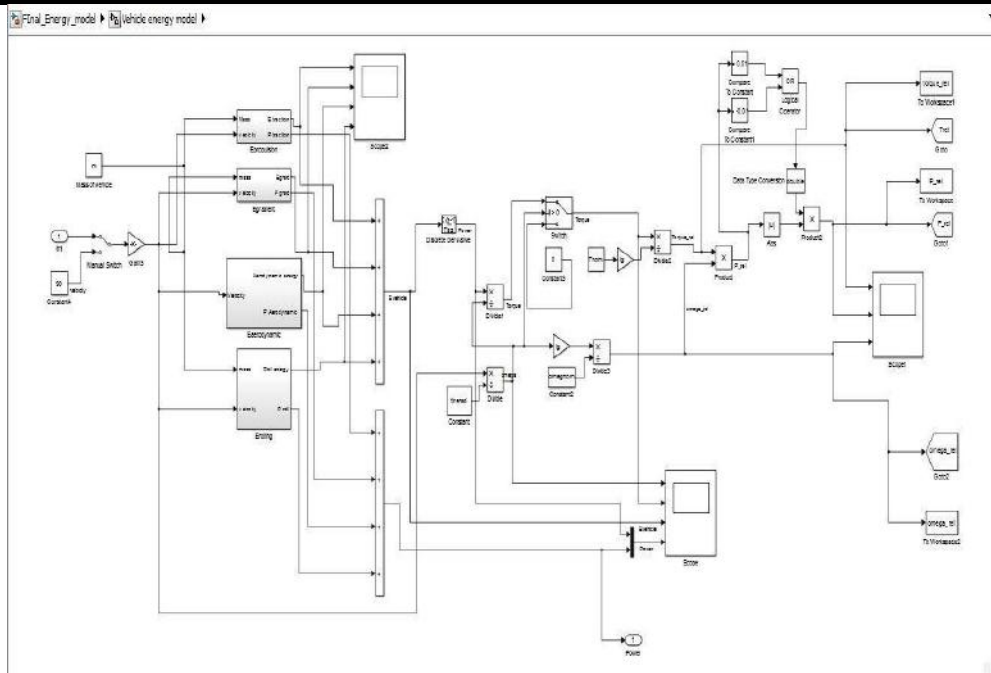


Fig.11: Model to estimate aggregate energy required

Machine Efficiency

Machines are electromechanical device, which are meant to provide interface between mechanical and electrical parameters. Mechanical input can be torque, force, speed and the output can be current, power, and vice versa. Ideally

machines have no losses, but in real case, there are different power losses due to different factors such as mechanical and electrical. Thus this loss can be measured by the mathematical relation in between machine’s output over input. (37)

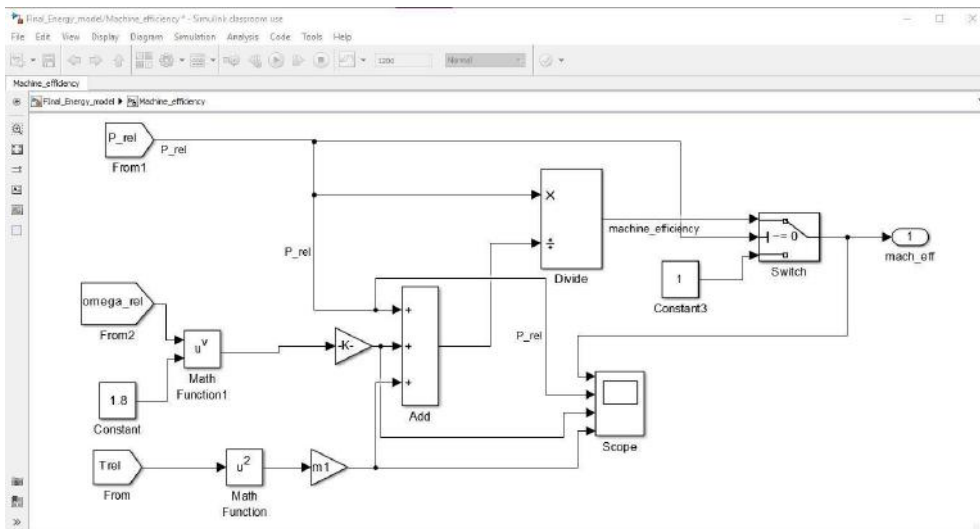


Fig.12: Machine's efficiency model

Inverter Efficiency:

One of two primary types of power electronic device’s application used in this model is inverter. Inverters are the devices which are responsible for conversion of direct current supply to three phase currents or vice versa by the means of intelligent switching of power electronic devices. There are different topologies and different scheme of switching schemes of inverters. Topologies and switching schemes are vast and requires whole

discussion over that, thus we are limiting the work to calculate the efficiency of the inverters being used, in general. Since, this modelling is to demonstrate energy consumption and comparison for different parametric changes in the vehicle loads, therefore, I am using a general mathematical relation for efficiency being mentioned during lectures. It greatly simplifies the model itself and easy to understand. (37)

$$\eta_{inverter} = \frac{P_{rel}}{i_1 * P_{rel} + i_2}$$

Where,
 η_{inve} = Efficiency of inverter,

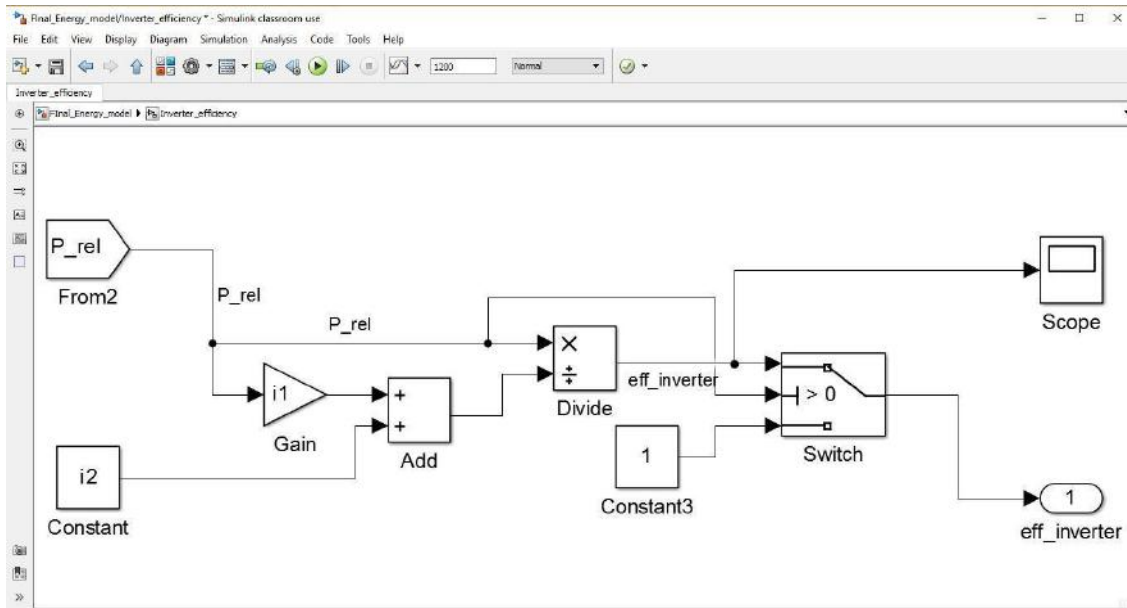


Fig.13: Inverter's efficiency model

Converter efficiency:

Converter or DC/DC converter is a device which alters the voltage level into different output. Usually rated voltage of electrical machine is different from that of battery terminal voltage. Also, ideal battery source experiences drop of voltage, depending on different parameters such as Battery's State of Health (SOH), lifetime, SOC, etc. (37)These effects have already been discussed during previous chapters in this work.

The mathematical model used for the *Simulink* model is as follows,

Where, = efficiency of DC/DC converter

$C_1 = 1.02$ (empirical value)

$C_2 = 0.005$ (empirical value) (37)

$$\eta_{converter} = \frac{P_{rel}}{c_1 * P_{rel} + c_2}$$

(6.4)

Once we get the efficiency from each component as above, we can calculate the actual energy (current) withdrawn from the battery source and thus we can know the actual SOC of the vehicle model.

SIMSCAPE (Battery and controlled current source)

In this chapter, a model has been worked out which includes the electrochemical battery source block from the *Simpowersystem*. We can choose any battery predefined in the block, such as Lead Acid, Ni-based batteries, Lithium-ion batteries (38). In this model, I have considered Lithium-ion battery model (used in Chevrolet Leaf), due to its scope in modern applications in terms of energy density, lifetime and flat profile of discharge. The *controlled current source* block is being used here to account the variation of load. This is being controlled by the current input. In this case, our input current is the result of the varying power requirement by the vehicle during different driving cycles. The screenshot of the *Simscape* model is mentioned down below,

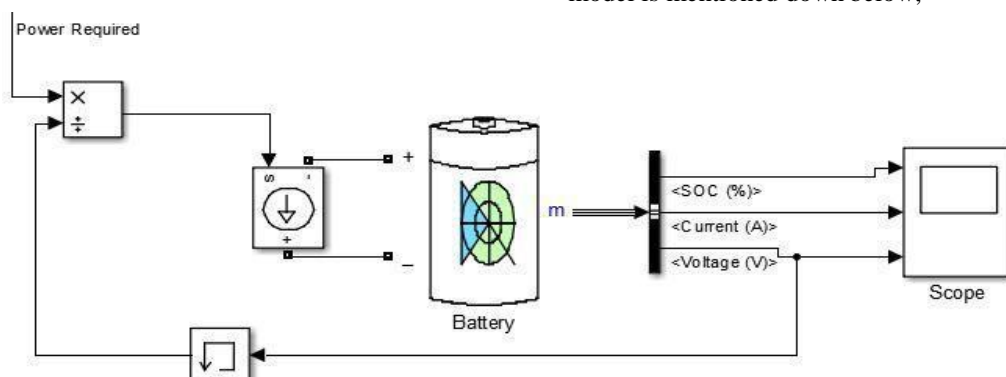


Fig.14: SIMSCAPE battery and Controlled Current source block

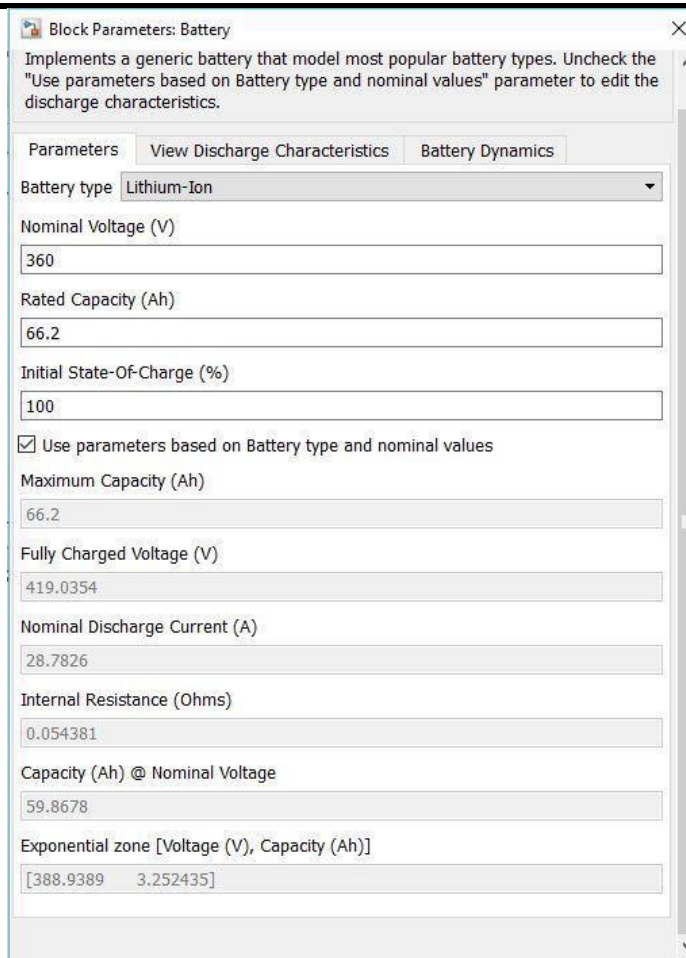


Fig.15: Battery parameters in accordance to light electric vehicle (Leaf)

Observations

In this section we will observe, energy consumed by the vehicle, State of Charge (SOC) remaining, and their comparison. With these observations we can observe how energy requirement varies with different profile of driving cycle along with the slope variation. We can also observe depletion of the battery during the standard and custom driving cycles, in the terms of SOC remaining at the end of

each driving cycle.

IV. TOTAL ENERGY CONSUMED

The scope’s graphs shown below are the total energy consumed by the vehicle model during the different driving cycles. We can notice different curves in graphs, they belong to different subjected slopes on the vehicle.

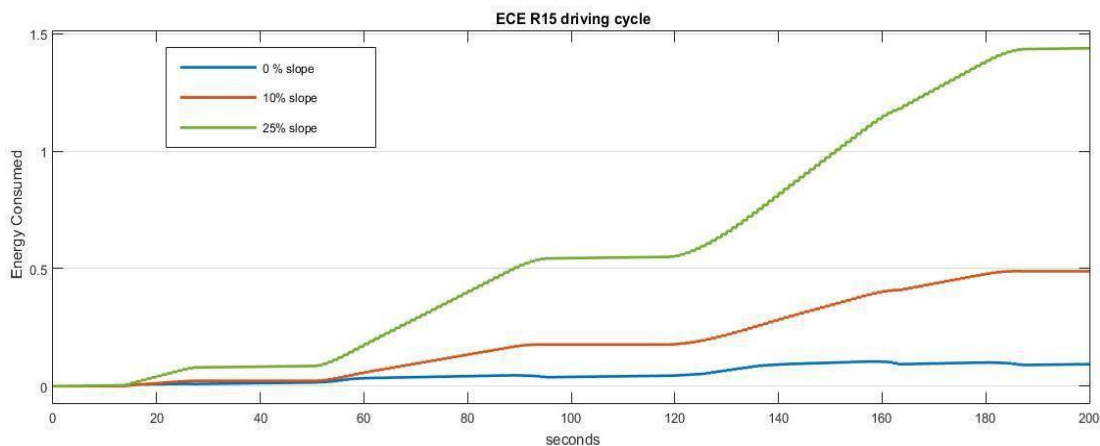


Fig.16: Energy consumed during ECE R15

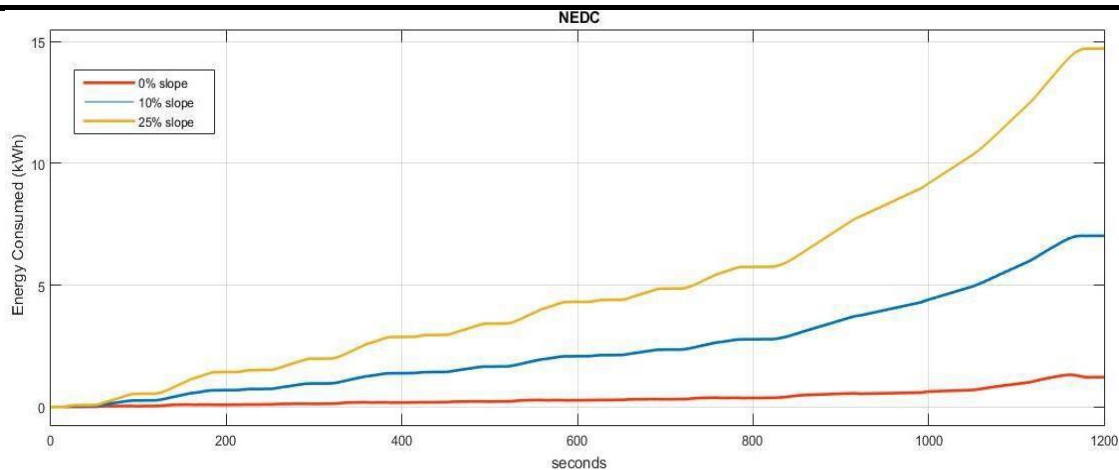


Fig.17: Energy consumed during EUDC

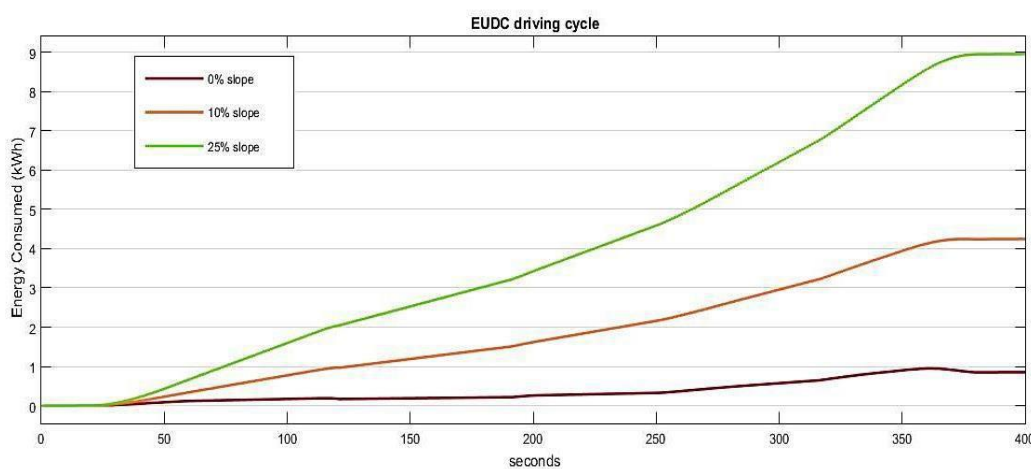


Fig.18: Energy consumed during

State of Charges (SOCs) for different drive cycle for different slopes

In this section we can see, SOC's left after each standard driving cycle and custom cycle. Each graph contains three different curves, which represents as different slopes. We can observe with the help of these graphs, we can conclude that slopes and velocity profile plays a major role in the variation of SOC of the electrochemical source.

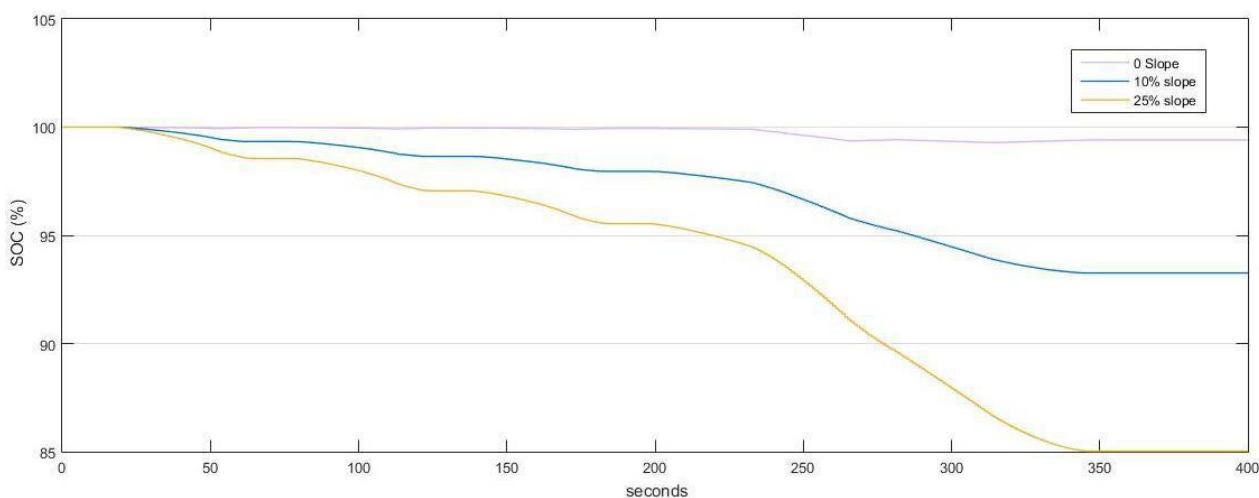


Fig.19: SOC's for SFUDS Driving Cycle

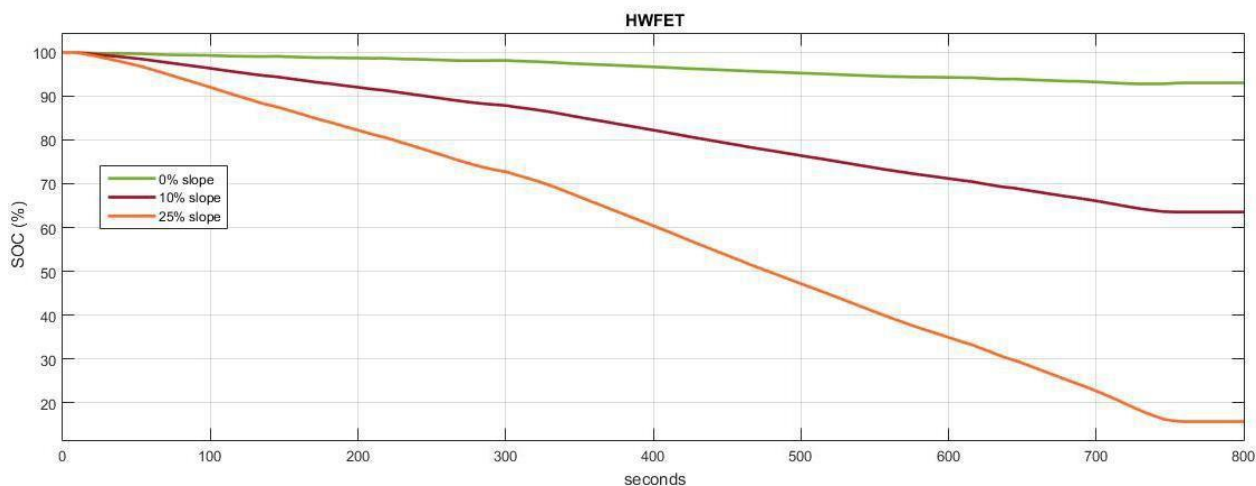


Fig.20: SOC's for HWFET Driving Cycle

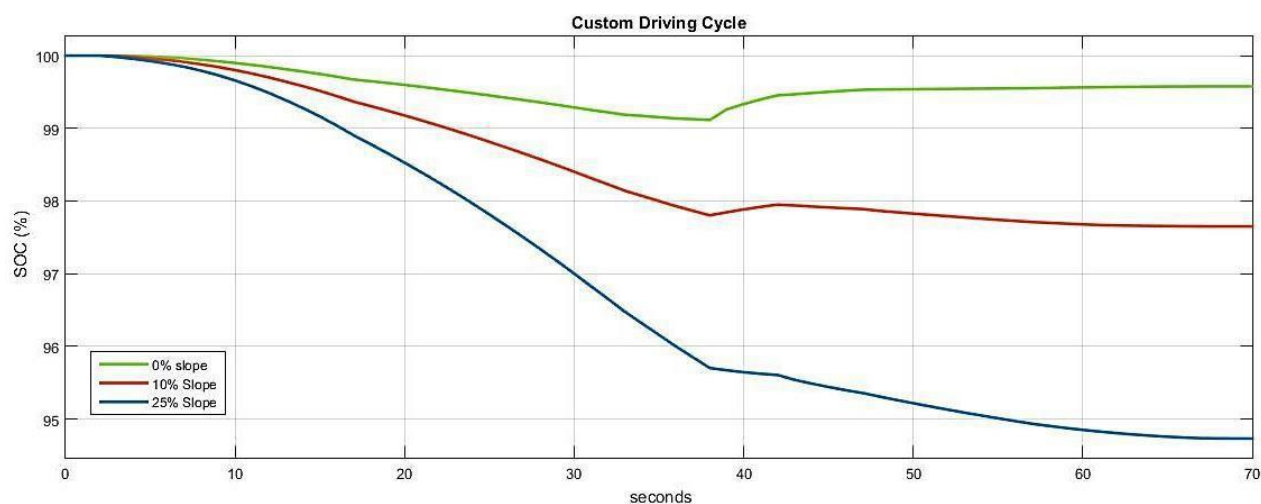


Fig.21: SOC at different slopes for Custom Driving Cycle

Table.4: Power and SOC at the end of driving cycles

Driving Cycle	Distance	Avg. Speed	Avg. Power (kW)	Time(s)	Max. Power	Slope pu	Auxiliary (kWh)	Final SOC (%)
NEDC	11.84	35.53	2.689	1200	26.06	0	0	96.64
NEDC	11.84	35.53	3.689	1200	26.06	0	1	69.64
NEDC	11.84	35.53	44.12	1200	143.43	0.25	1	40.80
NEDC	11.84	35.53	21.8	1200	71.73	0.1	1	73.58
ECE 15	1.12	20.27	12.51	200	24.20	0.1	1	97.61
ECE 15	1.12	20.27	1.686	200	6.17	0	1	99.87
ECE 15	1.12	20.27	25.89	200	54.22	0.25	1	94.66
EUDC	7.37	66.04	7.695	400	26.06	0	1	97.19
EUDC	7.37	66.04	38.21	400	71.73	0.1	1	83.60
EUDC	7.37	66.04	80.6	400	143.43	0.25	1	63.40

Table.5: Power and SOC at the end of driving cycles

Driving Cycle	Distance	Avg. Speed	Avg. Power (kW)	Time(s)	Max. Power	Slope	Auxiliary (kWh)	Final SOC (%)
Artemis(Urban)	4.46	16.06	1.68	1000	22.16	0	1	99.43
Artemis(Urban)	4.46	16.06	10	1000	41.74	0.1	1	90.30
Artemis(Urban)	4.46	16.06	21.19	1000	71.05	0.25	1	77.90
Artemis(Rural)	16.02	55.5	5.12	1100	30.93	0	1	95.30
Artemis(Rural)	16.02	55.5	31.58	1100	76.16	0.1	1	63.01
Artemis(Rural)	16.02	55.5	67.41	1100	143.36	0.25	1	14.60
SUFD	3.08	27.72	2.47	400	14.75	0	1	99.41
SUFD	3.08	27.72	16.70	400	45.55	0.1	1	93.30
SUFD	3.08	27.72	34.82	400	102.42	0.25	1	85.00
HWFET	16.52	74.36	9.20	800	18.80	0	1	93.00
HWFET	16.52	74.36	42.25	800	52.75	0.1	1	63.50
HWFET	16.52	74.36	89.86	800	110.71	0.25	1	15.60
Custom	1.07	54.92	6.808	70	33.38	0	1	99.58
Custom	1.07	54.92	32.68	70	74.58	0.1	1	97.60
Custom	1.07	54.92	68.87	70	145.49	0.25	1	94.73

V. CONCLUSION

In this design and analysis work, I have covered introductory information of Electric Vehicles, with market survey. In addition to it, one can find sufficient information of the resistive forces acting on the vehicle while subject to different driving conditions, which in this work is being represented by standard and custom driving cycles.

The model created in this work is quite simple to understand and gives a fine idea of different forces acting on the vehicle while in motion, and against the slope (gravitational pull). When going through observations obtained via simulations at different slope and at different driving cycles, we can see that battery's state of charge depends on speed, acceleration, deceleration and slope on which vehicle is subjected. The variations of slope although is quite prominent and also plays a significant role in determining the SOC of battery, therefore range of the vehicle.

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Environmental Education Perception Index (IPEA)¹ headed for sustainable development: A study in Elementary Schools in the city of Guajará-Mirim, Rondônia (Brazil)

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¹ The translator kept the Portuguese nomenclature IPEA (Índice de Percepção da Educação Ambiental)

Abstract— Goal: To analyze in the framework of elementary State schools located in Guajará-Mirim, the environmental education practice in reference of the National Curriculum Parameters for Education in Brazil which may bring new elements allowing to infer on the prospects for the future generations of a region highly committed to the environmental policy instituted in the State of Rondônia (Brazil) along its trajectory. **Method:** It has been used a construction method of Environmental Education Perception Index (IPEA) which has followed the logic of factorial analysis. **Results:** In general, the IPEA (Teachers) submitted a result considered "good". About the students, the result was troubling due to 75% of the of the schools studied submitted results considered only "regular". The average IPEA of formal public education at the fundamental level was considered "regular" at the IPEA of 0.597. **Final Considerations:** It does not notice an educational coherence for what is the strongest point in Guajará-Mirim: environmental preservation. It was possible to observe that the Guajaramirense society is experiencing a moment of institutional crisis, of values, ethics and behavior which reflects directly on the citizens' attitudes that do not correspond to the status of a region with a strong environmental policy.

Keywords— IPEA. Environmental Policy. Environmental Education.

I. INTRODUCTION

There are new proposals for solving the environmental challenges facing the planet today. Environmental problems, according to Dias (2004), are individual and collective responsibility. The author emphasizes that at the end of the day, we must have done something for improving and maintaining environmental quality.

In Brazil, environmental education has been taken for quite a while into consideration among the speeches and discussions in matters of proposing institutional action in search of the planet's balance. For Moraes (2012) there is a consensus in the educational community that environmental education is fundamental to achieve the ideal of a sustainable society.

The city Guajará-Mirim located in the State of Rondonia holds the title of "The Green City". This title had been granted by the Biosphere Environmental Institute in May 2009 in the city of Rio de Janeiro due to the recognition of the significant number of legally protected areas that comprise approximately 92% of the city Guajará-Mirim which are distributed by Conservation Units of Nature (CU's) and Indigenous Lands (IL's).

It is important to highlight the following questions: how is the environmental education practice at the schools in Guajará-Mirim? What is its relationship

with the sustainable development based on the perspective observed among the student staff, faculty and professionals with technical degree of the schools?

The general goal of this work was to analyze the environmental education practice in the context of the basic education of the State schools in Guajará-Mirim in reference of the National Curricular Parameters for Education in Brazil which may bring new elements allowing to infer on the prospects for the future generations of a region highly committed to the environmental policy instituted in the State of Rondonia along its trajectory.

II. THE NATIONAL CURRICULUM PARAMETERS AND ENVIRONMENTAL EDUCATION: THE BASES OF BRAZILIAN FORMAL EDUCATION

The National Curriculum Parameters for Education in Brazil are a set of documents. In the year of 1997 have been implemented throughout the national territory as a reference for renewal and re-elaboration of the curricular proposal. (BRASIL, 1997a).

The National Curriculum Parameters for Education in Brazil are structured in specific documents at each stage of school education: Childhood Education, Primary Education and Secondary Education, addressing the contents of the different areas of knowledge. In other words, from elementary to middle school the students must study Portuguese language, mathematics, the physical and natural world, social and political reality, emphasizing the Brazilian situation (BRASIL, 1997a, p.14)

In the year of 1997 the National Curriculum Parameters for Education in Brazil (PCNs)² were approved by the National Education Council after two years of discussions. The PCNs are a subsidy to support the school during the development of its educational project inserting procedures, attitudes and values in the school community, as well as the need to deal with some urgent national issues of national scope, called cross-cutting³ themes: environment, ethics, cultural plurality, sexual orientation, work and consumption, with the possibility of schools and/or communities electing others of importance relevant to their reality. (BRASIL / MEC / SECAD, 2007).

The PCN, "*The option for working with the environment theme brings the need to acquire knowledge and information on the part of the school so we can*

² The translator kept the Portuguese nomenclature PCNs (Parâmetros Curriculares Nacionais).

³ According to UNESCO, either transversal themes or cross-cutting themes are correct.

develop a suitable work with students" (Brasil, 1997, p. 35 b).

The official documents point out that, "by the nature of environmental issue, acquisition of information on the subject is a necessity for all". It must not affirm teachers should "know everything""to develop" projects but they should be willing to learn about the subject for better sharing the knowledge with their students.

The education is seen as an indispensable element which helps transformation of environmental consciousness. At school the environmental content must be integrated into the curriculum through cross-cutting themes, because they will be treated in different areas of knowledge, so to permeate the entire educational practice and, at the same time, create a global and comprehensive vision of the environmental issue. (TOMAZELLO, 2001)

The Department of Education of Brazil⁴, through the National Curriculum Parameters (PCN), seeks to bring the schools closer to reality surrounding the proposal of work with cross-cutting themes in education which should be incorporated into school practice to avoid extracurricular and disarticulated treatment. In this way, the inclusion of environmental education in the school curriculum, proposed by PCNs encircling the environment theme implies an educational innovation process (BRASIL, 1998).

Schools are invited to find a solution to the environmental crisis through activities directed to environmental education. They can follow the National Curriculum Parameters (PCN) - Environmental Health referring to the first four grades of fundamental education, which aims to assist the teacher while their work. It seeks to share in the daily effort to make children able to have the knowledge they need to grow as fully recognized citizens and aware of their role in our society (BRASIL, 1997b).

It is necessary for the whole school community take responsibility about environment issues and take over objectives that will be accomplished in different kinds of actions which may involve everyone where each person will have a special role to play. (BRASIL, 1997b).

III. PROPOSAL for AN ANALYTICAL MODEL

The parameters used during the research corresponded to the perception evaluation based on teachers' environmental attitudes of the studied schools; the practices and experiences developed by teachers inside the classrooms with regard to environmental education; and the young elementary school students' perception of each involved school in this research and about how they recognize that the environmental

education practices are being achieved among these chosen schools, capable of generating the Environmental Education Perception Index (IPEA).

For this purpose, factorial analysis had been used as a mechanism to build the performance indexes for each parameter studied. Factorial analysis is a generic name given to a class of multivariate statistical methods whose main purpose is to define the underlying structure in a data array.

In general terms, factorial analysis addresses the problem of analyzing the structure of interrelationships (correlations) among many variables defining a set of common latent dimensions, called factor. With factorial analysis, the researcher can first identify the separate dimensions of the structure and then ascertains the degree where each variable is explained by each dimension. Once these dimensions and the explanation of each variable are determined, the two main operations of factorial analysis - summary and data reduction - can be achieved.

The factorial analysis gets latent dimensions. They describe the data in a much smaller number of concepts than the original individual variables. Data reduction can be achieved by calculating scores for each latent dimension and substituting the original variables for them (HAIR et al., 2005, p.91). For more information see the works of SANTANA (2005a; 2005b; 2006; 2007) and Cavalcante (2011).

For analysis of such parameters, 4 (four) State schools in Guajará-Mirim were aleatory selected: Paulo Saldanha, Durvalina Estilben de Oliveira, Alkindar Brasil de Arouca and Almirante Tamandaré.

Tables 1, 2, 3 and 4 illustrate each of these State schools investigated as a form of better understand the reality of this study.

⁴ The Portuguese nomenclature is MEC (Ministério da Educação)

Table.1: General characterization of Paulo Saldanha School.

Historical	PAULO SALDANHA State School
1-School Creation Law	Law Decree No. 317 of 24/02/1956.
2-Management Competence	Elementary and Middle School.
3-Overall, how many students are enrolled in the school?	652 students.
4-Of this total, how many are enrolled in elementary school?	476 students.
5-In general, what is the quantity of teachers linked to the school?	Twenty-three teachers.
6-Of this total, how many are crowded in elementary school?	Seventeen teachers.

Source: Search data.

Table.2: General characterization of Durvalina School.

Historical	DURVALINA ESTILBEN DE OLIVEIRA State School
1-School Creation Law	Law Decree No. 2,862 of 12/02/1986.
2-Management Competence	State Elementary School.
3-Overall, how many students are enrolled in the school?	404 students.
4-Of this total, how many are enrolled in elementary school?	404 students.
5-In general, what is the quantity of teachers linked to the school?	Twenty-three teachers.
6-Of this total, how many are crowded in elementary school?	Twenty-three teachers.

Table.3: General characterization of Alkindar School

Historical	State School in Brazil
1-School Creation Law	Law Decree No. 385 in 10/08/1980.
2-Management Competence	Elementary and Middle School.
3-Overall, how many students are enrolled in the school?	846 students.
4-Of this total, how many are enrolled in elementary school?	619 students.
5-In general, what is the quantity of teachers linked to the school?	Twenty-three teachers.
6-Of this total, how many are crowded in elementary school?	Twenty-two teachers.

Table.4: General characterization of Admiral Tamandaré School.

Historical	School State Admiral Tamandaré
1-School Creation Law	Law Decree No. 493 of 26/12/1966.
2-Management Competence	State Elementary School.
3-Overall, how many students are enrolled in the school?	303 students.
4-of this total, how many are enrolled in elementary school	303 students.
5-In general, what is the quantity of teachers linked to the school?	Fourteen teachers.
6-of this total, how many are crowded in elementary school?	Fourteen teachers.

IV. METHOD: CONSTRUCTION METHOD OF ENVIRONMENTAL EDUCATION PERCEPTION INDEX (IPEA)

The method used in this study followed the logic of factorial analysis, which can be seen in the matrix form as in Dillon; Goldstein (1984):

$$X = \alpha F + \epsilon \quad (1)$$

Then

X is the p -dimensional vector transposed from observable variables, denoted by $X = (x_1, x_2, \dots, x_p)$;

F is the q -dimensional vector transposed from non-observable variables or latent variables called common factors, denoted by $F = (f_1, f_2, \dots, f_q)$, where $q < p$;

ϵ is the p -dimensional vector transposed from random variables or unique factors, denoted by $\epsilon = (\epsilon_1, \epsilon_2, \dots, \epsilon_p)$;

α is the array (p, q) of unknown constants, called factorials loads.

According to Gama *et al.* (2007); Santana (2007), in the factorial analysis model it is assumed that specific factors are orthogonal, among themselves, with all common factors. Normally, $E(\epsilon) = E(F) = 0$ and $Cov(\epsilon, F) = 0$.

According to the authors, the initial structure used to determine the array of factorials loads, in general, may not provide a significant pattern of variable loads, so it is not definitive. This initial structure can be done by several methods of rotation of the factors, as Dillon; Goldstein (1984); Johnson; Wichern (1988). It was used the VARIMAX method of orthogonal rotation of the factors for this study.

The VARIMAX method is a process where the reference axes of the factors are rotated around the source until some other position is reached. The objective is to redistribute the variance of the first factors to others and to achieve a simpler and more theoretically significant factorial (REIS, 2001; HAIR *et al.*, 2005; SANTANA, 2005b, GAMA *et al.*, 2007; SANTANA, 2007).

The choice of factors was carried out through the technique of latent root. So, the array of factorials loads, which measures the correlation between the common factors and observable variables, is determined by means of the correlation matrix, as Dillon; Goldstein (1984).

For determining environmental education perception index (IPEA) it was used the matrix of factorials scores estimated by the orthogonal base factorial rotation process, as pointed out by Santana (2006). The factorial score puts each observation in the gap of the common factors. For each factor f_j , the i -th factor score extracted factorial score is defined by F_{ij} ,

expressed as follows (DILLON; GOLDSTEIN, 1984; SPSS, 1997):

$$F_{ij} = b_1 x_{i1} + b_2 x_{i2} + \dots + b_p x_{ip} \quad (2)$$

Then:

b_i are the estimated regression coefficients for the n Common factorials scores;

x_{ij} are the n Observations of p Observable variables.

$$i = 1, 2, \dots, N.$$

$$j = 1, 2, \dots, p.$$

To reach the equation that is the perception index, Gama *et al.* (2007); Santana (2007), show the sequence evolution of the formulas from the previous equation. It turns out that even if the variable F_{ij} is not observable it can be estimated through the factorial analysis techniques, using the matrix of observations of the vector x of observable variables. In factorial notation, equation 2 becomes:

$$F_{(n,q)} = X_{(n,q)} b_{(p,q)} \quad (3)$$

In Equation 3, F is the matrix of the estimated regression from the n Factorials scores and it can be affected by both the magnitude and the measurement units of the variables x . To work around this kind of problem, replace the variable x by the standard variable w , given the ratio of the deviation around the average and the standard deviation of x , as follows:

$$\frac{x_i - \bar{x}}{S_x}$$

With these values, Equation 3 is modified making equation 4 possible, then:

$$F_{(n,q)} = W_{(n,q)} \beta_{(p,q)} \quad (4)$$

Based on equation 4, the beta weights matrix (β) with q standardized regression coefficients, replaces b , given that the variables are standardized on both sides of the equation. Pre-multiplying both sides of equation 4 by the value $\frac{1}{n} w'$, in which n is the number of observations and W is the transposed matrix of w' , it makes it possible to reach the following equation:

$$\frac{1}{n} w'_{(p,n)} F_{(n,q)} = \frac{1}{n} w'_{(p,n)} W_{(n,p)} \beta_{(p,q)} = R_{(p,p)} \beta_{(p,q)} \quad (5)$$

The Matrix $\frac{1}{n} w' w$, therefore is the matrix of intercorrelated variables or correlation matrix among the observations of the matrix x , designated by R . The Matrix $\frac{1}{k} w' F$ It represents the correlation between the factorials scores and the factors themselves, denoted by Λ . With this, rewriting the equation 5, one must:

$$\Lambda_{(p,q)} = R_{(p,p)} \beta_{(p,q)} \quad (6)$$

If the matrix R is non-singular, one can pre-multiply both sides of equation 6 by the inverse of R, obtaining:

$$\beta = R^{-1}A(7)$$

Substituting the β vector into equation 4, we obtain the factorial score associated with each observation, as follows:

$$F_{(n,q)} = W_{(n,p)} R_{(p,p)}^{-1} A_{(p,q)}(8)$$

The main formula of the perception index is reached where the IP is defined as a linear combination of these factorials scores and the proportion of the variance explained by each factor in relation to the common variance. The mathematical expression is represented by the following formula:

$$IP_i = \sum_{j=1}^q \left(\frac{\lambda_j}{\sum \lambda_j} FP_{ij} \right)(9)$$

Then:

$i = 1, 2, \dots, n$.

$\lambda =$ is the variance explained by each factor;

$\sum \lambda =$ is the total sum of the variance explained by the set of common factors.

The factorial score was standardized (FP) to obtain positive values from the original scores and allow the hierarchies of the cities as the values of the performance index are located between zero and one. The formula that allows this tiering can be seen by the following equation:

$$FP_i = \left(\frac{F_i - F_{\min}}{F_{\max} - F_{\min}} \right)$$

It can be seen that F_{\min} And F_{\max} are the maximum and minimum values observed for the factorial scores associated with the parameters observed in the Guajar-Mirim schools. It is based on this understanding that it was possible to calculate the perception index adopted in this study.

4.1 Tests of adequacy of the factorial method to the data mass

According to Gama et al. (2007); Santana (2007), the two main tests with the objective of assessing the adequacy of the method to the mass relate, first to Bartlett's sphericity test, which has the property to evaluate the general significance of the correlation matrix, that is, test the null hypothesis that the correlation matrix is an identity matrix. In addition to the Bartlett test, the Kaiser-Meyer-Olkin (KMO) test is also widely used and is based on the principle that the inverse of the correlation matrix approaches the diagonal matrix in which case it seeks to compare the correlations between the observable variables. The two methods were used by this research as techniques of gauging the adequacy of the method to the raised database.

According to Dillon; Goldstein (1984); Reis (2001); Mingoti (2005); Gama et al. (2007); Santana (2007) the mathematical formulas of these tests can be seen by the following equations:

$$KMO = \frac{\sum_i \sum_j r_{ij}^2}{\sum_i \sum_j r_{ij}^2 + \sum_i \sum_j a_{ij}^2}(10)$$

Like this

$r_{ij} =$ is the correlation coefficient of the sample between the variables x_i and x_j ;

$a_{ij} =$ It is the partial correlation coefficient between the same variables which is, at the same time, an estimation of correlates between factors, eliminating the effect of other variables.

According to Hair *et al.* (2005), the a_{ij} should assume values close to zero, since it is assumed that the factors are orthogonal to each other. So according to this same author, values of this test below 0.50 are unacceptable.

The Bartlett test of sphericity tests the null hypothesis that the variables are independent against the alternative hypothesis that the variables are correlated with each other. That is, $H_0: R = 1$ or $H_0: \lambda_1 = \lambda_2 = \dots = \lambda_p$, which allows us to arrive at the following mathematical formula:

$$X^2 = - \left[n - 1 - \frac{1}{6}(2p + 5) \right] \cdot \sum_{j=1}^p \ln \lambda$$

(11)

Then

$|R| =$ is the determinant of the sample correlation matrix;

$\lambda =$ is the variance explained by each factor;

$n =$ is the number of observations;

$p =$ is the number of variables;

The statistic has an asymptotic distribution of χ^2 with $[0,5p(p - 1)]$ degrees of freedom. The Bartlett test is the most common method applied to test the homogeneity of variances (ZAR, 1996).

4.2 Analysis Tool

The SPSS programming (version 17) enabled the application of mathematical knowledge and allowed the construction of the index of perception based on each parameter analyzed. This statistical program (statistical package SPSS software, version 17.0) is widely applied for data analysis in the social sciences which made possible the factorial analysis of the data and the generation of performance indexes subsidized the discussions and the main conclusions of this work.

As indexes generated by this tool follow a perspective of how much "greater, better" then there was the need to reverse, since for some of them this relation

indicated exactly the opposite. Without this method the statistic could indicate an unrealistic situation. The following data used in this study: deforestation, illiteracy rate, Gini index, percentage of the population with incomes less than 1/2 and 1/4 minimum wages, percentage of children with incomes less than 1/2 and 1/4 minimum wages, unemployment rate and child labor rates.

4.3 Scale levels

The classification used by the research to express the results achieved by the schools in Guajará-Mirim is described in Table 5.

Table.5: Analysis scale adopted by the research.

Scale	Description	Color
0,801 – 1,000	Great	Blue
0,601 – 0,800	Good	Green
0,401 – 0,600	Regular	Yellow
0,201 – 0,400	Bad	Brown
0,000 – 0,200	Terrible	Red

Source: Own Elaboration.

V. RESULTS AND DISCUSSION

According to Chart 1, the IPEA - Teachers had a result considered "good" by the scale adopted in this study. The highest indices occurred in descending order in the Durvalina schools (0.706), followed by the Tamandaré (0.690), Paulo Saldanha (0.630) and Alkindar (0.611) schools.

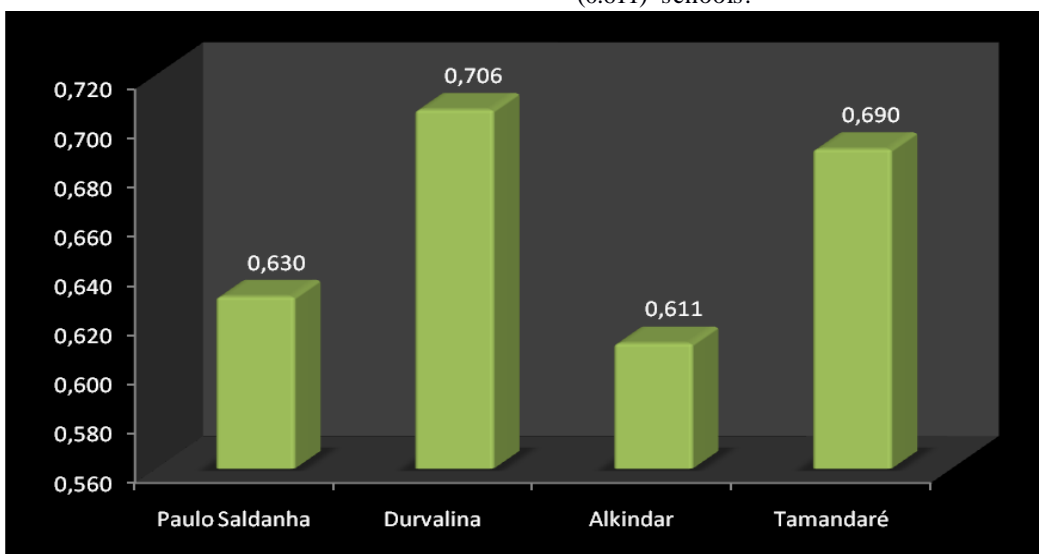


Chart 1: IPEA – Parameter: Teachers

Source: Own Elaboration

From the point of view of staff (administrative and managerial part), the Durvalina, Tamandaré and Paulo Saldanha schools had a "good" performance, while the Arouca Alkindar Brasil school had "regular" result. (Chart 2).



Chart 2: IPEA – Parameter: School

Source: Own Elaboration

Regarding the students, the result was somewhat worrisome because 75% of the schools studied had results considered just "regular". In this category appears the Paulo Saldanha School (0.535), followed by the Durvalina School (0.532) and Alkindar School (0.459). The Tamandaré School was the only one classified as "good" (Chart 3).

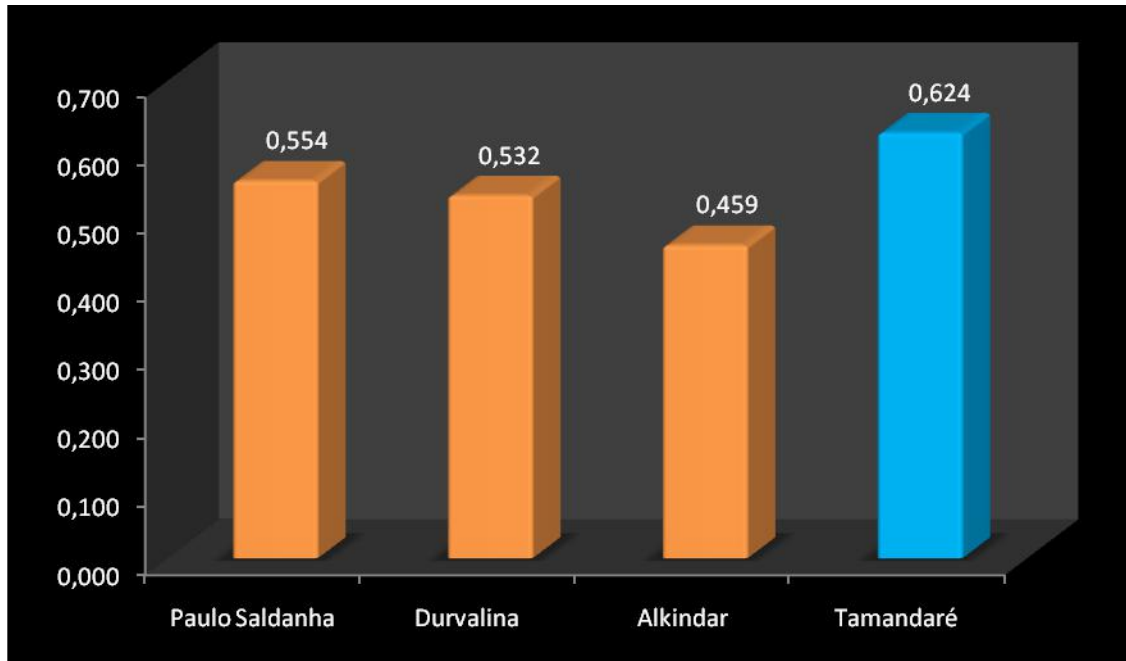


Chart 3: IPEA – Parameter: Students

Source: Own Elaboration

Considering the average of the results found for each of the analyzed parameters, i.e. teachers, school (staff) and students, it reaches the environmental education perception index (IPEA) in elementary school for each of the schools studied. On this wise, it was possible to verify that the Tamandaré and Durvalina Schools were the ones with the best performances among all those surveyed, reaching rates of 0.644 and 0.626, respectively. On the other hand, the Paulo Saldanha and Alkindar Schools were classified as "regular" when they reached 0.595 and 0.522, respectively (Chart 4).

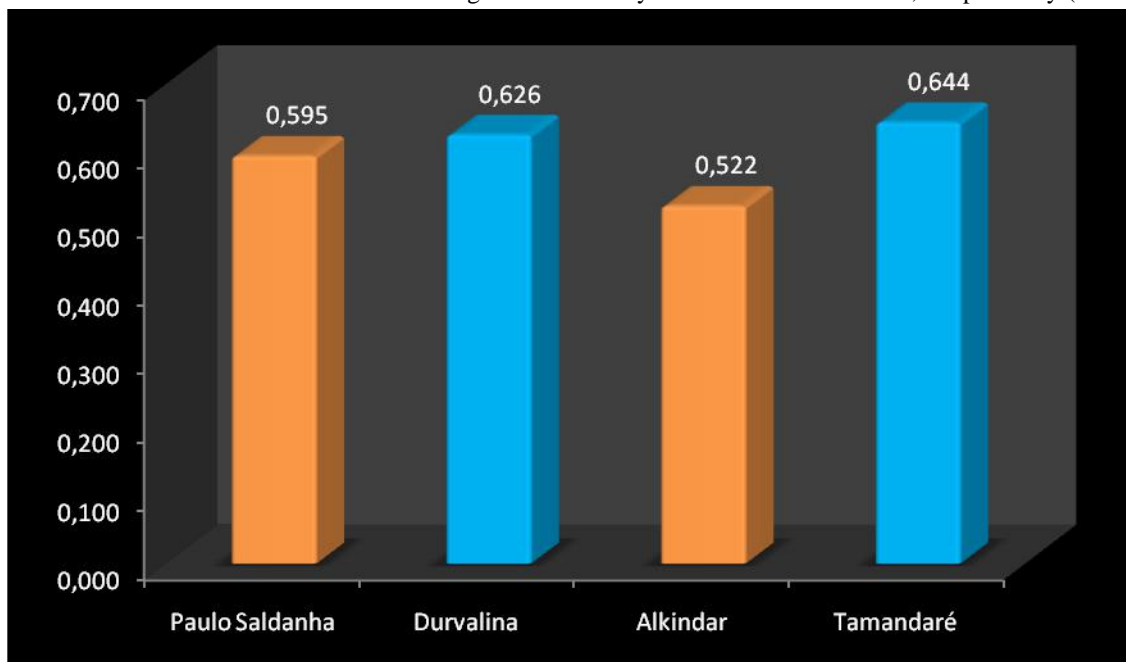


Chart 4: IPEA – Elementary School of studied schools

Source: Own Elaboration

By making the general average among all the schools studied, it is understood that the average IPEA of formal public education at the fundamental level in Guajará-Mirim is considered "regular" once reached the IPEA of 0.597 (Chart 5).

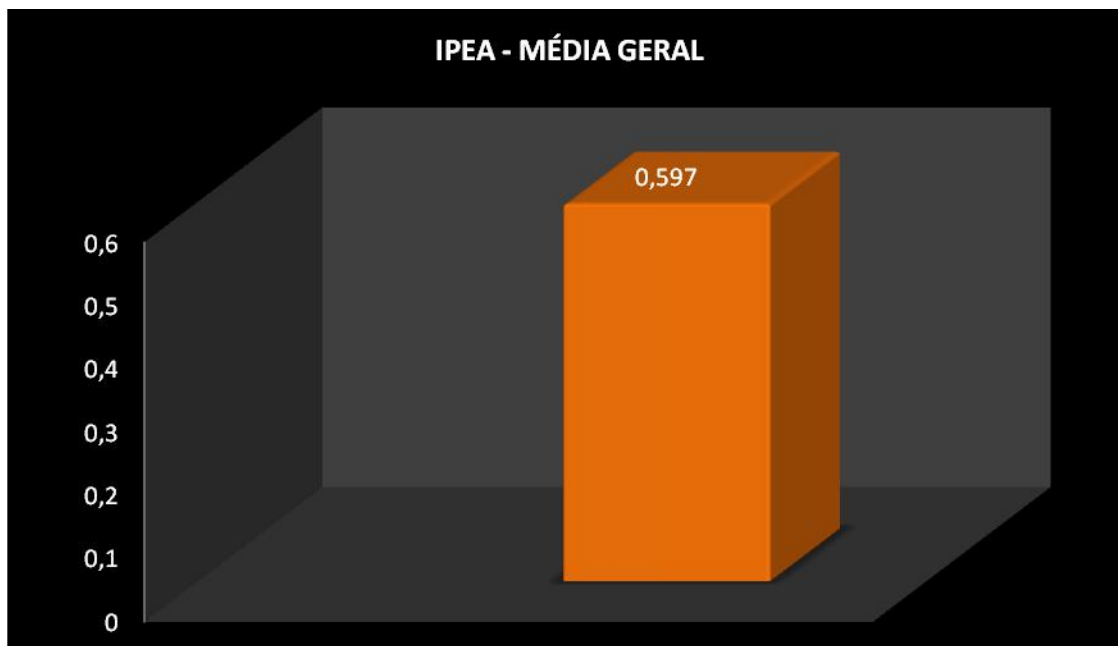


Chart 5: IPEA in Guajará-Mirim

Source: Own Elaboration

There is a distorted vision in Guajará-Mirim in what concerns the perception about the local reality, especially in virtue of 92,06% from its territory is Legally Protected Areas - ALPs⁵ as can be seen in Tables 6 and 7. Although environmental education is being discussed in all schools studied the points analyzed allow us to conclude that this practice needs attention, because the schools considered "good" are closer to the "regular" scale.

Table.6: Conservation Units in Guajará-Mirim – Rondônia (Brazil).

Conservation Units in the municipality	Administrative Sphere	Area (ha)	% of the area in the municipality ⁶	Area in the municipality (ha)	% of the area of the municipality occupied by Conservation Units
PARNA de Pacaás Novos	Federal	764.801	20,04	153.266	6,17
PARNA da Serra da Cutia	Federal	283.611	100	283.611	11,41
RESEX Barreiro das Antas	Federal	107.234	100	107.234	4,31
RESEX do Rio Cautário	Federal	73.817	100	73.817	2,97
RESEX Rio Ouro Preto	Federal	204.583	73,45	150.266	6,05
Parque Estadual de Guajará-Mirim	State	207.148	2,33	4.827	0,19
REBIO estadual Rio Ouro Preto	State	46.838	100	46.838	1,88
REBIO Estadual	State	22.540	100	22.540	0,91

⁵ The translator kept the Portuguese nomenclature ALPs (Areas Legalmente Protegidas).

⁶ The translator chose using Municipality instead of County.

do Traçadal						
Resex Rio Pacaás Novos	State	342.904	100	342.904	13,80	
Rio Cautário						
Resex Estadual	State	146.400	47,5	69.540	2,80	
% OF THE MUNICIPALITY AREA OCCUPIED BY CUs					50,49	

Source: Cavalcante *et. al.* (2014).

Table.7: Indigenous Lands in Guajará-Mirim – Rondônia (Brazil).

IL in the municipality	Percentage of the municipality area occupied by IL
IL Ig. Lage	2,30
IL Rio Negro Ocaia	4,17
IL Pacaás Novas	11,43
IL Uru-eu-wau-wau	18,32
IL Sagarana	0,75
IL Rio Guaporé	4,60
% OF THE MUNICIPALITY AREA OCCUPIED BY ILS	41,57

Source: Cavalcante *et. al.* (2014).

There is a gap between the reality of a region where 92.06% of its territory is consisted of conservation units, indigenous lands and educational practice within this approach. I.e. there is no educational coherence for what is strongest in the municipality: environmental preservation.

Guajará-Mirim holds one of the world's largest indices in terms of legally protected areas. The educational practices do not go beyond what is customarily done in any other region of Brazil, i.e., it is notorious that perception of the elementary school students about environmental education practices in state public schools in the region, except Tamandaré School, a performance considered only "regular."

It's important to acknowledge the weakness about environmental education practices in the studied schools but these schools cannot be considered as the main responsible for their inadequacy. This fact is noticeable when you look at the answers for the question "do you know what Nature Conservation Units and Indigenous Lands is?" 42.86% of Tamandaré School, 18.18% of Durvalina School and 15.38% of Paulo

Saldanha School answered, "I know a little about it" and/or "I fully know".

For those who answered, "I know a little" and/or "I know nothing about it" had reached the highest percentage in Alkindar School (80.00%) followed by Paulo Saldanha School (79.93%), Durvalina School (72.73%), and Tamandaré School (28.58%). Who answered "more or less" the result pointed to 28.57% for Tamandaré School, 20.00% for Alkindar School, 9.09% for Durvalina School and 7.69% for Paulo Saldanha School (Chart 6).

To the question "Do you know most of the part of Guajará-Mirim is Nature Conservation Units and Indigenous Lands?" From Alkindar School, 40.00% answered "I do not know" and/or "I know a little about it" followed by the Durvalina School (27.27%) and Paulo Saldanha School (23.07%).

For those who answered, "I fully know" and/or "I know little" the highest percentages were found in schools in decreasing order: Tamandaré (85.71%), Durvalina (45.45%), Paulo Saldanha, 46%) and Alkindar (20.00%). (Chart 7)



Chart 6: Perception about "What is Nature Conservation Units and Indigenous Lands? "

Source: Own Elaboration



Chart 7: Perception on the issue "Do you know most of the part of Guajará-Mirim is Nature Conservation Units and Indigenous Lands?"

Source: Own Elaboration

It is necessary to analyze the entire local context and notice the Guajaramirenses society is experiencing a moment of institutional crisis, of values, of ethics and of behavior. Citizens' attitudes fronting environmental practices do not correspond to the legal status of a place with a strong environmental policy.

The citizens do not care for their own garbage which is thrown in the streets, the bones of slaughtered animals can also be seen in some parts of the city. At the end all the garbage is put in open dumps without any attention. The streets are bumpy and give the impression of carelessness. The deforestation keeps repeating every year and the act of burning the leaves, trees and garbage

(high point in August and September) became part of the culture. So, how do we think environmental education where all the facts point to a society in crisis? That is the biggest challenge.

The environmental education cross-cutting must be analyzed and make it work not only with Sciences and Geography subjects. In this case showed a low transverse power in the studied schools. In addition, it is worth highlighting another aspect considered important here and that needs to be better studied: training of teachers.

Brazil has been advancing in relation to interdisciplinary vision as a basic training to work with complex themes such as the environment. Some

postgraduate programs of higher institutions throughout the country are responsible for the professional formation which become capable to work with this matter.

VI FINAL CONSIDERATIONS

There is a gap between the reality of a region with approximately 92% of its territory consisting of Conservation Units and Indigenous Lands and the educational practice. There is no educational coherence for what is strongest in the city: environmental preservation.

It is necessary to analyze the entire local context. It was noticed the *Guajaramirense* society experiences moment of institutional crisis, of values, of ethics and of behavior. Citizens' attitudes fronting environmental practices do not correspond to the legal status of a place with a strong environmental policy.

It became clear the low connection between the real and the practice, where the real is the strength of environmental policy in this part of Rondônia (Brazil). Perhaps, in this case, the inexhaustibility thought of natural resources works as wall which hinder the thought of scarcity.

As it written before, Brazil has been advancing in relation to interdisciplinary vision as a basic training to work with complex themes such as the environment. Due to most of the teachers are graduated in Pedagogy, it makes the disciplinary training of teachers still a general rule for those who work with environmental education in the public schools in Guajará-Mirim.

It is concluded the local scenario imposes risks to the environmental awareness of future generations by demonstrating inadequacies to fulfill its role institution as social transformer setting itself up as a limiting of sustainable development.

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Optimal H Infinity Controller Applied to a Stewart Platform

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Abstract— In recent years there has been great interest in studying parallel manipulators, mainly applied in flight simulators, with six degrees of freedom. The interest in parallel kinematic structures is motivated by its high stiffness and excellent positioning capability in relation to serial kinematic structures. This work presents the kinematic and dynamic modeling, design, development and identification of the parameters of motion platform with six degrees of freedom, electrically powered, for studies of flight simulators, is known as a Stewart Platform. It also presents the design of an H infinity controller with output feedback. The actuator model was obtained by a step voltage input to the engines and measuring its displacement by the encoders coupled, in each of the respective axes of the motors. Knowing the relation of motion transmission mechanism between the motor shaft and each actuator is obtained by the displacement rod from the rotation of motor which are measured by the corresponding encoder. The kinematics and dynamics platform's data compose the whole systems models simulations that are applied in the Stewart platform to validate the model and show the effectiveness of control techniques in which was applied to control the position and orientation of the platform were performed. An inertial sensor Xsens MTi-G measurement of the Euler angles of the platform was performed. The result obtained by the controller was satisfactory and illustrate the performance and robustness of the proposed methodology.

Keywords— Stewart Platform, Flight Simulator, H infinity Controller, Position Controller, Orientation Controller.

I. INTRODUCTION

Parallel structures have emerged in the '60s associated with flight simulators and, from the late '80s; parallel manipulators with rigid actuators have been used as the basis for simulations with various degrees of freedom. Stewart proposed a parallel structure with six degrees of freedom drawn from the adaptation of a flight simulator to a structure known since 1947 as Gough platform used to build a machine to test tires [1]. This structure became known as Stewart Platform [2].

Attitude and position control of Stewart platforms are real complex problems in several areas of study. The reference model for this mechanism can be split in two categories, hydraulic or electromechanical actuators [3, 4, 15]. For hydraulic actuators, depending on the load on the platform, it is necessary to model the system taking into account the dynamic characteristics of the hydraulic system and the platform. In the case of electromechanical actuators, where it has a gear ratio for conversion of angular velocity of the motor to linear velocity of the spindle. This transmission ratio plus friction can cause an inertial decoupling where the main dynamics can be considered only that of the actuator [18].

So, the main purpose of this paper is to present the platform that was developed for studies in control systems for flight simulators at the Laboratory of Airspace Control of the Engineering School of São Carlos of the University of São Paulo (Figure 1).



Fig. 1: Stewart Platform

II. KINEMATIC MODELLING

The inverse kinematics of the parallel robot is to determine which length values to actuators that satisfy a known position and orientation of the end-effector. Compared with serial robots inverse kinematics which presents greater complexity than the direct kinematics, inverse kinematics in parallel robots is less complex than the direct kinematics. The inverse kinematics is used to generate trajectories [5, 16, 17]. However, a mathematical model that describes the six degrees of freedom of the end of the manipulator must describe the position and orientation of the same relative to some fixed reference.

This way the inverse kinematics begins to be defined from the rotation in X, Y and Z axes, which take the reference of the moving part of the platform (B) in the frame of its fixed base (A). These rotations are determined by Euler angles ϕ , θ and ψ , where each of them is represented by the matrix (1), (2) and (3) respectively.

$$R(x, \phi) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\phi) & -\sin(\phi) \\ 0 & \sin(\phi) & \cos(\phi) \end{bmatrix} \quad (1)$$

$$R(y, \theta) = \begin{bmatrix} \cos(\theta) & 0 & \sin(\theta) \\ 0 & 1 & 0 \\ -\sin(\theta) & 0 & \cos(\theta) \end{bmatrix} \quad (2)$$

$$R(z, \psi) = \begin{bmatrix} \cos(\psi) & -\sin(\psi) & 0 \\ \sin(\psi) & \cos(\psi) & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad (3)$$

In the design of a position and attitude control system of the movable platform that is located at the top base from the Stewart platform, becomes necessary to know the inverse kinematics of this mechanism [6]. The inverse kinematics uses the position and attitude of the movable platform with respect to the fixed platform to obtain the lengths of the actuators and can be addressed using tensor modeling [7] or modeling based on linear algebra [8, 14]. The modeling using linear algebra is presented in this paper.

The positions of the joints that connects the platforms to the actuators are defined in two coordinate systems [5]. A system with origin in the center of the fixed platform A and axis x_A pointing between joints 1 and 2 of the fixed platform, axis z_A perpendicular to the plane of the fixed platform pointing up and axis y_A completing the right-hand rule. The other system has the origin in the center of the movable platform B and axis x_B pointing between joints 1 and 2 of the movable platform, axis z_B perpendicular to the plane of the movable platform pointing upward and axis y_B completing the right-hand rule. The Figure 2 shows the definitions of the two coordinate systems.

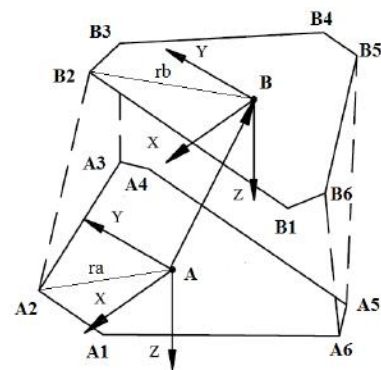


Fig. 2: Coordinate systems

The positions of the joints of the fixed and movable platforms coordinate systems centered at A_i and B_i respectively are expressed by Eqs. (4), (5), (6) and (7) as follows:

$$\{A_i\}^A = \{ra \cos(\lambda a_i) \quad ra \sin(\lambda a_i) \quad 0\}^T \quad (4)$$

$$= \{A_{i1} \quad A_{i2} \quad 0\}^T,$$

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

$$\{B_i\}^B = \{rb \cos(\lambda b_i) \quad rb \sin(\lambda b_i) \quad 0\}^T \quad (5)$$

$$= \{B_{i1} \quad B_{i2} \quad 0\}^T$$

$$\lambda a_i = 60^\circ i - \lambda a, \quad \lambda b_i = 60^\circ(i - 1) + \lambda b, \quad (6)$$

$$i = 1, 3, 5$$

$$\lambda b_i = 60^\circ(i - 1) + \lambda b, \quad \lambda a_i = 60^\circ i - \lambda a, \quad (7)$$

$$i = 2, 4, 6$$

where ra and rb are the radii of the circles centered at the center of the platform and contain the positions of the joints of the fixed and movable bases, respectively, and λa and λb are directors angles that help to define the positions of the joints of the fixed and movable platforms, respectively.

The vector representing the actuator in the fixed platform coordinate system $\{D_i\}^A$ is obtained using the Equation (8).

$$\{D_i\}^A = \{B_i\}^A - \{A_i\}^A \quad (8)$$

The vector representing the position of the joints of the movable platform in the fixed coordinate system is defined in Eq. (9)

$$\{B_i\}^A = \{B\}^A + [T^{BA}] \times \{B_i\}^B = \begin{Bmatrix} x \\ y \\ z \end{Bmatrix} + \begin{Bmatrix} u_i \\ v_i \\ w_i \end{Bmatrix} \quad (9)$$

where $\{B\}^A$ is the vector that represents the position of the center of the movable platform in the coordinate system of the fixed platform and $[T^{BA}]$ is the transformation matrix of the movable coordinate system to the fixed coordinate system.

Using a sequence of three rotations, it is possible to obtain the transformation matrix $[T^{BA}]$. First, a rotation is applied around the axis x_B until axis y_B becomes parallel to the plane formed by x_A and y_A , and the rotation angle ϕ is called roll angle. Then, a rotation is applied around y_B until x_B is parallel to the plane formed by x_A and y_B , being the pitch angle θ . Finally, a rotation around z_B is applied until x_B is parallel to x_A , and this angle of rotation is the yaw angle ψ . The resulting matrix of the three rotations is shown in Equation (10). Where c is the cosine and s is the sine function.

$$R_B^A = \begin{bmatrix} c\psi c\theta & c\psi s\theta c\phi - s\psi c\phi & c\psi s\theta s\phi + s\psi s\phi \\ s\psi c\theta & s\psi s\theta c\phi + c\psi c\phi & s\psi s\theta s\phi - c\psi s\phi \\ -s\theta & c\theta s\phi & c\theta c\phi \end{bmatrix} \quad (10)$$

Finally, the vector representing the i -th actuator $\{D_i\}$ is obtained using information about the geometry of the Stewart Platform and defined the position and attitude of the movable platform. The module of this vector $|D_i|$ is equal to the length of the actuator it represents.

III. ACTUATOR MODEL

For the movable platform remains in the desired position and attitude relative to the fixed platform, it is necessary to control the lengths of the actuators by Inverse Kinematics. However all six electromechanical actuators were tested and mathematically modeled to represent the system dynamics.

These actuators consist of electric motors with gear transmissions for the ball screw. The motor is actuated by an electrical signal direct current with amplitude of up to 12 volts, through a power supply, and changes its direction of rotation by reversing the signal. To power the engine, a drive speed control brushed motors RoboClaw 2 is used, this drive receives a signal of 0 to 2 volt and converts it to an analog signal of -12 volts to 12 volts. An encoder of 1250 points per revolution was installed in the axis of rotation with the function to measure the revolutions number engines.

The acquisition system used for processing and transmission the data was dSPACE that sends 0 to 2 volts signal to the engine speed controller card and that receive the position signal of the encoders, which will be feedback in control loop. The dSPACE works with real-time interface, where the controller is fully programmable in block diagrams in Simulink.

The first test was used for the varying length of the actuator in relation to the number of engine revolutions. In this test, the engines were powered to increase the length of the actuators to some random positions along their courses, were then measured the number of rotations of the motor and the stroke length of the actuators. The Equations (11), (12), (13), (14), (15) and (16) show the Equations of the straight obtained for actuator 1 to actuator 6, respectively [19].

$$y_{c1} = 0,00081315P + 7,8485 \quad (11)$$

$$y_{c2} = 0,00081329P + 11,6446 \quad (12)$$

$$y_{c3} = 0,00081225P + 9,8059 \quad (13)$$

$$y_{c4} = 0,00081201P + 11,1418 \quad (14)$$

$$y_{c5} = 0,00081207P + 9,7201 \quad (15)$$

$$y_{c6} = 0,00081252P + 9,4454 \quad (16)$$

where y_c is the length of stroke of the actuators in millimeters and P is the number of rotations of the motor measured in the encoder points.

The dynamics characteristics actuator's response was obtained in the second experiment, for greater reliability, the tests were performed three times and made the average of these results. In this test were applied step inputs voltage to the motor of the electromechanical actuator and the variation of the stroke of the actuator was obtained by reading the encoder, together with Equations (11) (12) (13) (14) (15) and (16). The Figure 3 represents the variations of the length of stroke of the actuator 1, when applied signals 4, -4, 6, -6, 8, -8, 10, -10, 12, -12 of volts. This procedure was repeated in the same way for all the actuators of the Stewart Platform. It can be seen that the actuators lengths increases with positive signals whilst their lengths decrease with negative signals while the voltage signal is applied and stopping only at the limits of course.

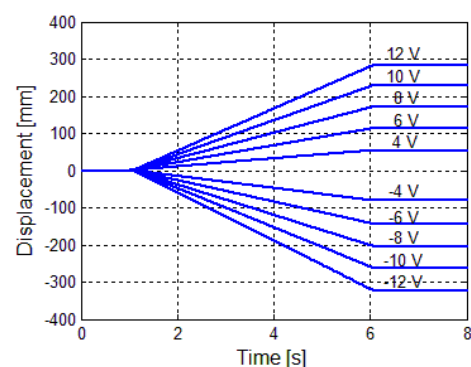


Fig. 3: Stroke length variations of the actuator 1

During the experiment was observed that the actuators, although having the similar physical properties and be of the same manufacturer, showed different responses to the same voltage signal applied. Therefore it was necessary identification and modeling for each of the six electromechanical actuators. The Figure 4 shows the variations in the length found for a step input signal 12V

applied to the actuators 1 to 6, respectively. It can also be observed that the actuators behavior with relations to the negative voltages and the positive voltage are not symmetrical, and also as occurred for positive voltages, the actuators showed different responses to each other for the same input. The Figure 5 shows the variation of length of all the actuators to the voltage -12V.

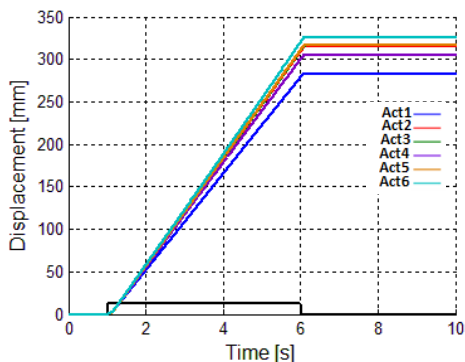


Fig. 4: Lengths variations for a step input 12V

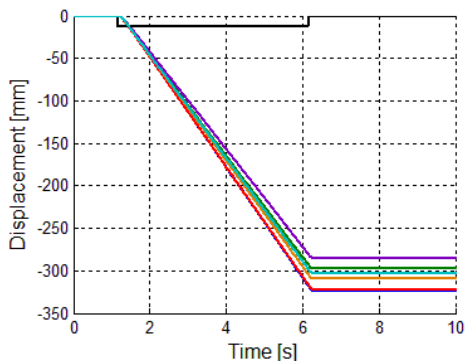


Fig. 5: Lengths variations for a step input -12V

Short information to the dynamic response of the actuators can be obtained using the length actuators variation to the step input, but using the responses of velocities forward and return actuators as shown in Figure 6 it can be observed that the velocity shows a stable response to a step input in all voltage levels analyzed. So we worked with the velocity to survey the dynamics of actuators.

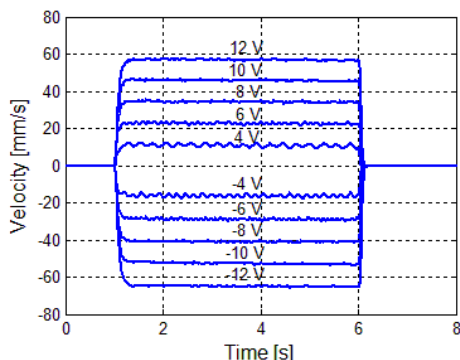


Fig. 6. Velocities of the actuator 1

The actuators has different speeds, a problem that causes each actuator must be treated independently. The Figure 7

shows the forward speed of 6 actuators tested where you can see the difference in behavior of each of the actuators. Negative voltages were also applied in order to check the recoil velocity of the actuators. The Figure 8 shows the speed of the six actuators for voltage -12V, also is possible to observe that the actuators behave differently between the advance and retreat of the actuators lengths.

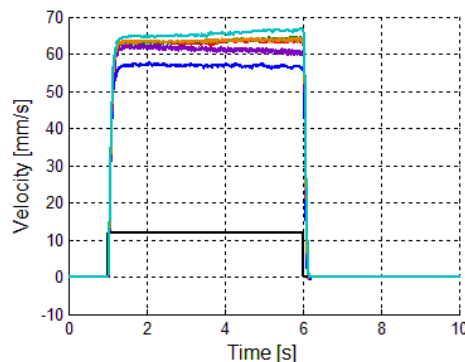


Fig. 7: Velocities of the six actuators for 12V

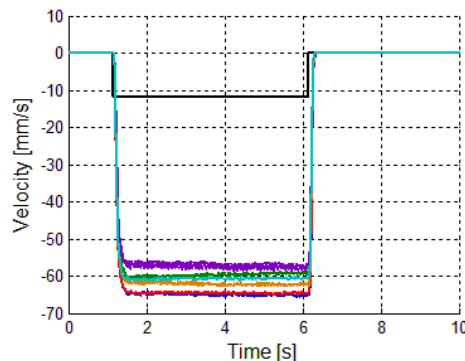


Fig. 8: Velocities of the six actuators for -12V

Based on the velocity response in the application step of inputs 4, -4, 6, -6, 8, -8, 10, -10, 12, -12 volts, shown in Figures 6, it was observed that the system displays a response without overshoot, but has a noise characteristic oscillation system. It can be argued that this response is typical of a system of first order but at least responding to noise regime. Where as the model of a complex formed by electric motor and mechanical parts of an actuator can be approximated by a second order dynamic system, so it was decided to use as a simplified model for the transfer function of the velocity of the electromechanical actuator by signal voltage, a system of second order, as shown by Equation (17).

$$\frac{Y(s)}{U(s)} = \frac{k}{(s + a)^2} \quad (17)$$

where k is the gain, is the double pole of the second order system, and $\frac{Y(s)}{U(s)}$ is the Laplace transform of the stroke speed and the voltage signal, respectively.

The characteristics of the system Equation 17 can be obtained by comparing the response velocity of actuator

stroke with the characteristics of the response of a second order system to a step input [9, 10].

Because of the presence of noise on the response velocity of the actuators courses, were used average values, taken from three tests conducted for all levels of input signals, as shown in Table 1.

In this experiment it was observed that the actuators have dead zone (Dz), as shown in Table 2. In other words, this voltage range does not change the stroke length actuators. This characteristic makes instead of using the value of the entry step in the calculations of Equations (17) and (18), we use the effective value of the step input, which is the difference between the value of the step input and dead zone.

Table.1: Mean Velocity of actuators

Mean of velocities of actuators in a regime (mm/s)						
Volts	Act 1	Act 2	Act 3	Act 4	Act 5	Act 6
4V	11,4	17,3	15,2	11,4	16,3	17,8
6V	23,0	29,0	27,6	24,4	28,5	29,9
8V	34,6	40,8	39,8	37,3	40,4	42,0
10V	45,9	52,2	52,0	49,6	52,1	54,0
12V	57,1	63,5	63,5	61,5	63,6	65,4
-4V	- 16,4	- 17,6	- 14,7	- 12,8	- 14,9	-15,2
-6V	- 28,9	- 29,5	- 26,5	- 25,1	- 27,0	- 26,8
-8V	- 40,9	- 41,2	- 37,8	- 36,8	- 38,9	- 38,3
-10V	- 53,1	- 52,8	- 49,0	- 47,5	- 50,8	- 49,9
-12V	- 65,2	- 64,7	- 59,7	- 57,5	- 62,2	- 60,8

Table.2: Values of dead zone

	Act1	Act2	Act3	Act4	Act 5	Act 6
Dz+	1,98V	0,97V	1,45V	2,12V	1,19V	0,99V
Dz -	-1,27V	-0,99V	-1,3V	-1,56V	-1,45V	-1,31V

As the stroke length of the actuator is the integral of the velocity of course, the stroke length transfer function of the effective voltage signal can be represented by Equation (18), where X(s) is defined as the change in length actuator stroke.

$$\frac{X(s)}{U(s)} = \frac{1}{s} \times \frac{k}{(s+a)^2} \tag{18}$$

$$= \frac{A_0}{s} + \frac{A_1}{(s+a)} + \frac{A_2}{(s+a)^2}$$

where A₀, A₁ and A₂ can be obtained using the partial fraction expansion theorem of Heaviside, shown in Equations (19), (20) and (21). The advantage of using a partial fraction expansion is that the individual terms, which result from this expansion in the form of partial fractions, are very simple functions [10].

$$A_0 = \frac{k}{a^2} \tag{19}$$

$$A_1 = -\frac{k}{a^2} \tag{20}$$

$$A_2 = -\frac{k}{a} \tag{21}$$

Applying the inverse transform Laplace into Equation (18), the stroke length of the actuator has the answer in Equation (22). Replacing terms of Equations (19), (20) and (21) into Equation (22) are obtained the Equations (23) and (24).

$$r(t) = A_0 + A_1 e^{-at} + A_2 t e^{-at} \tag{22}$$

$$r(t) = \frac{k}{a^2} - \frac{k}{a^2} e^{-at} - \frac{k}{a} t e^{-at} \tag{23}$$

$$r(t) = \frac{k}{a^2} (1 - e^{-at} - at e^{-at}) \tag{24}$$

In order to identify the k and a terms the following procedure was used: first identified the time of application of a step voltage input to the stroke speed reaches 60% of its value regime. These values can be substituted in Equation (24) and then the resulting Equation (25) is obtained.

$$0,6 = 1 - e^{-at_{60\%}} - at_{60\%} e^{-at_{60\%}} \tag{25}$$

However, Equation (25) does not present direct solution to obtain the value of a, so it was necessary to use numerical methods for the identification of the parameter. Equation (25) was rewritten in the form of Equation (26), to then create a function F that depends on the a.

$$\frac{e^{-at_{60\%}} + at_{60\%} e^{-at_{60\%}}}{F} = 0,4 \tag{26}$$

Then we used the linearization of the function F by Taylor polynomial shown in Equation (27).

$$F(a) = F(a_0) + \frac{dF(a_0)}{da} (a - a_0) \tag{27}$$

An iterative method in which the value of the a initialized as shown in Equation (28) is then calculated value of the function F and its derived using Equation (26), was used to calculate a new value of a using the Equation (29). This procedure was used so that the function F have lower error than 0.001 for the current value of a.

$$a = \frac{\ln(0,4)}{t_{60\%}} \tag{28}$$

$$a = \frac{F(a)}{dF} + a_0 - \frac{F(a)}{dF} \tag{29}$$

Identified the value of the parameter a, it was necessary to identify the value of k, using it for the Equation (24). Therefore, to find the value of k was used in Equation (30) which is the value in a regime the velocity of the actuator stroke. The values obtained for k and each actuator are shown in the Table 3.

$$Vr = \frac{k}{a^2} \tag{30}$$

Table.3: Values of k and a

	Act1	Act 2	Act 3	Act 4	Act 5	Act 6
k	7137	7345	7269	6928	6360	8513
a	34,23	34,93	34,55	33,35	32,28	34,32

Thus we obtain the transfer functions that represent the dynamics of each actuator, shown in Equations (31), (32), (33), (34), (35) and (36).

$$R = \frac{7137}{s(s + 34,23)^2} = \frac{7137}{s^3 + 68,46s^2 + 1171s} \quad (31)$$

$$R = \frac{7345}{s(s + 34,93)^2} = \frac{7345}{s^3 + 69,86s^2 + 1220s} \quad (32)$$

$$R = \frac{7269}{s(s + 34,55)^2} = \frac{7269}{s^3 + 69,1s^2 + 1194s} \quad (33)$$

$$R = \frac{6928}{s(s + 33,35)^2} = \frac{6928}{s^3 + 66,7s^2 + 1112s} \quad (34)$$

$$R = \frac{6360}{s(s + 32,28)^2} = \frac{6360}{s^3 + 64,56s^2 + 1042s} \quad (35)$$

$$R = \frac{8513}{s(s + 34,32)^2} = \frac{8513}{s^3 + 68,64s^2 + 1178s} \quad (36)$$

IV. H INFINITY CONTROL

To Real systems are subject to different types of disturbances. Uncertainties in the mathematical model of the system can be modeled as a disturbance in the nominal model. These uncertainties have different origins, it can be highlighted: the existence of errors in the values of model parameters or the values of the parameters are unknown, the parameters in linear model may vary due to nonlinearities or variation of the operating point; associated errors measuring instruments and the structure of the model at high frequencies is not known, resulting that the sum of all uncertainties can overcome the personal gain of the plants.

The problem of H infinity control was first formulated by G. Zames. H infinity refers in the space to the transfer function own and stable. The design of H infinity control is designed in the frequency domain in the context of optimizing the space of transfer functions given objective function in terms of the standard H infinity. The H infinity norm of a transfer function is defined as shown in the Equation (37) [11].

$$\|G(jw)\|_{\infty} = \sup_w |G(jw)| \quad (37)$$

The design of H infinity control considers the worst case operation and involves the minimization of the peak of the matrix transfer function in the scalar case this would minimize peak of the transfer function in the frequency domain and in multiple inputs and outputs case would be to minimize the maximum singular value represented by this norm.

The term H is the Hardy space where the space of functions with complex matrices, name space due to the mathematical Hardy. And the infinite term comes from the use of the infinity norm and the infinity symbol limit of Hp norm when p tends to infinity. Figure 9 shows the standard block representation where P (s) is the increased transfer function.

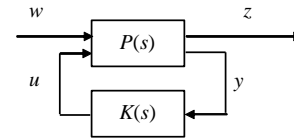


Fig. 9: Standard block representation

From the diagram above, results in:

$$\begin{bmatrix} z \\ y \end{bmatrix} = P \begin{bmatrix} w \\ u \end{bmatrix} = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} \begin{bmatrix} w \\ u \end{bmatrix}, u = Ky \quad (38)$$

Then the transfer function between the external input w and regulated output z. Substituting u in the Equation y

$$y = P_{21}w + P_{22}Ky \quad (39)$$

$$y = (I - P_{22}K)^{-1}P_{21}w \quad (40)$$

And, we can write:

$$u = Ky = K(I - P_{22}K)^{-1}P_{21}w \quad (41)$$

Finally, replacing u in the Equation z it result at

$$z = P_{11}w + P_{12}K(I - P_{22}K)^{-1}P_{21}w \quad (42)$$

$$= [P_{11} + P_{12}K(I - P_{22}K)^{-1}P_{21}]w$$

$$z = T_{zw}w, T_{zw} = P_{11} + P_{12}K(I - P_{22}K)^{-1}P_{21} \quad (43)$$

The augmented plant in the form of state space is of the form

$$\dot{x} = Ax + B_1w + B_2u \quad (44)$$

$$z = C_1x + D_{11}w + D_{12}u \quad (45)$$

$$y = C_2x + D_{21}w + D_{22}u \quad (46)$$

A. Weighting Functions

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 10. The weighting functions W₁, W₂ and W₃ 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 γ > 0.

$$\|T_{zw}\|_{\infty} = \left\| \begin{bmatrix} W_1 S \\ W_2 K S \\ W_3 T \end{bmatrix} \right\|_{\infty} \quad (47)$$

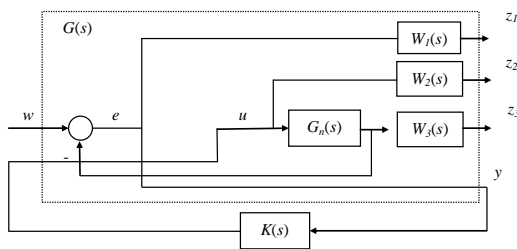


Fig. 10: Augmented plant

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 $C = KS$.

B. Synthesis Controller

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 (48).

$$P(s) = \begin{bmatrix} A & B_1 & B_2 \\ C_1 & D_{11} & D_{12} \\ C_2 & D_{21} & D_{22} \end{bmatrix} \quad (48)$$

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

$$\begin{bmatrix} \dot{x} \\ z \\ y \end{bmatrix} = \begin{bmatrix} A & B_1 & B_2 \\ C_1 & 0 & D_{12} \\ C_2 & D_{21} & 0 \end{bmatrix} \begin{bmatrix} x \\ w \\ u \end{bmatrix} \quad (49)$$

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:

$$A^T X + XA + C_1^T C_1 + X(\gamma^{-2} B_1 B_1^T - B_2 B_2^T) X = 0 \quad (50)$$

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

$$Y A^T + AY + B_1 B_1^T + Y(\gamma^{-2} C_1^T C_1 - C_2^T C_2) Y = 0 \quad (51)$$

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

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:

$$\begin{bmatrix} \dot{x}_c \\ u \end{bmatrix} = \begin{bmatrix} A_c & B_c \\ C_c & 0 \end{bmatrix} \begin{bmatrix} x_c \\ y \end{bmatrix} \quad (52)$$

and

$$A_c = A + \gamma^{-2} B_1 B_1^T X_\infty + B_2 F_\infty + Z_\infty L_\infty C_2 \quad (53)$$

$$B_c = -Z_\infty L_\infty \quad (54)$$

$$C_c = F_\infty = -B_2^T X_\infty \quad (55)$$

$$L_\infty = -Y_\infty C_2^T \quad (56)$$

$$Z_\infty = (I - \gamma^{-2} X_\infty Y_\infty)^{-1} \quad (57)$$

V. RESULT EXPERIMENTAL AND DISCUSSION

An input step of 15° in angle ϕ was applied, representing the movement of roll in the Stewart Platform. The Figure 11 shows the movement of all actuators, stabilizing at the required position. The Figure 12 shows the control action to move the platform to the desired orientation, to provide increased stroke length of the actuator is possible to observe what happened cutting the signal voltage of 12V, set by the saturator. The Figure 13 shows that the error tended to zero.

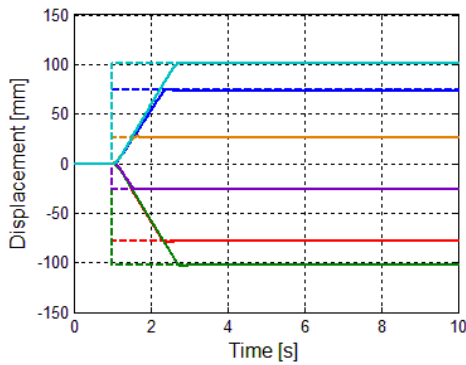


Fig. 11: Responses for 15° in ϕ

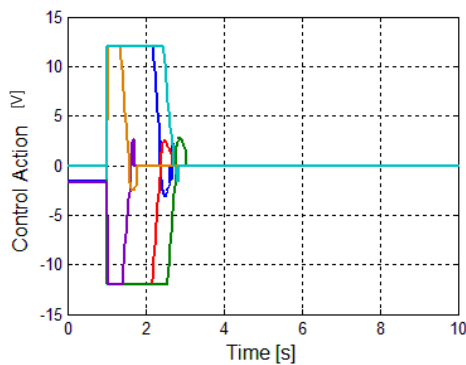


Fig. 12: Control Actions for 15° in ϕ

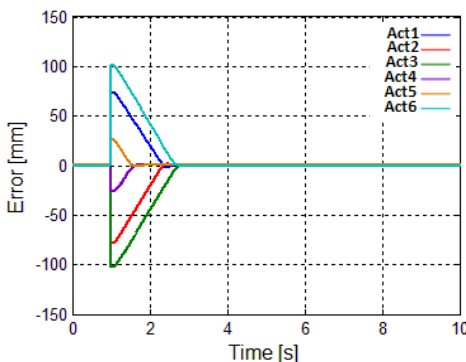


Fig. 13: Error for 15° in ϕ

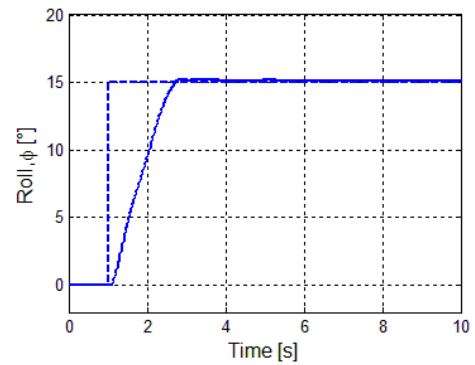


Fig. 14: Input step for 15° in roll

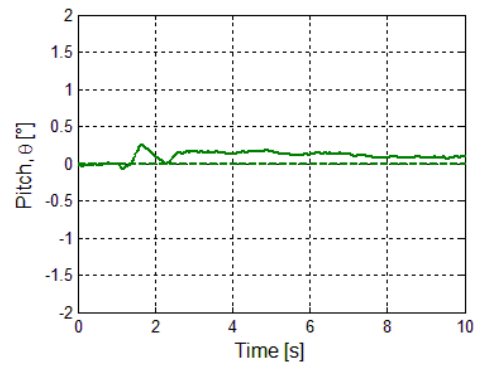


Fig. 15: Pitch for 15° in roll

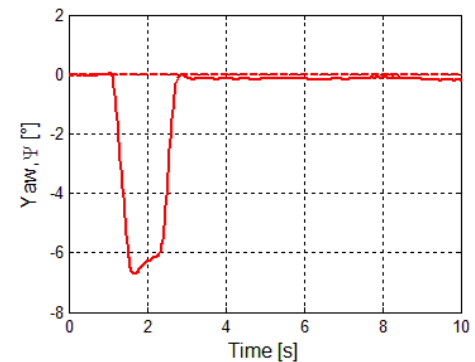


Fig. 16: Yaw for 15° in roll

The Figure 14 shows the angle ϕ for reading the input step 15°. You can see that the controller could converge to the desired orientation. The Figure 15 shows the reading of the angle θ remains near zero degrees, and the Figure 16 shows the reading angle ψ with a variation in the beginning of the step input, and thereafter tended to zero, as desired.

VI. CONCLUSION

For all this, it can be concluded that the methodology used for the identification of parameters and modeling the actuators showed good accuracy, introducing a mathematical model with the characteristics design of the next actual platform.

The experimental results show that the H infinity controller with output feedback can work well at different working conditions, being effective for the control of position and orientation of the actual model of the Stewart Platform. Small errors in result of yaw were observed during experiments to control orientation may be assigned by the existing clearances in the joints, the constructive differences of actuators, plus the error of inaccuracy of the sensor.

ACKNOWLEDGEMENTS

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Analysis of histological frequency and pediatric cancer in Rondônia, Western Amazonia (Brazil)

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Abstract— Objective: Describe the histological and cancer frequency in children and adolescents attended at the Hospital de Base Dr. Ary Pinheiro and the Hospital de Barretos / Rondônia, Western Amazonia, in the years 2014 and 2015. **Method:** This is a descriptive, quantitative and transverse study. We used a structured instrument containing a series of variables, such as gender, age, histological types, more frequent neoplasms, lymphomas, leukemias, among others. We asked The Comitê de Ética em Pesquisa em Seres Humanos (Research Ethics Committee) to dispense the Informed Consent Form because the study did not require intervention on the patient or collection of biological material, and no possibility of constraints on patients and their relatives. **Results:** From 75 cases, 32 (42.7%) were female and 43 (57.3%) were male. Regarding the distribution of patients according to the age group, 21 (28.0%) were younger than 4 years, 12 (16.0%), 5 to 9 years, 17 (22.6%) from 10 to 14 and 25 (33.4%) from 15 to 19. The most frequent histological types by gender were leukemias of myeloproliferative diseases and myelodysplastic diseases with 30% and 50% new cases in the period, followed by lymphomas and reticuloendothelial neoplasms with 16.65% and 20, 0% of the histological types in the period. Leukemia in the hematopoietic and reticuloendothelial system (C42) is the most frequent cancer in both, female and male gender, with 47.5% of cancers in the biennium. The second group

of cancers in children from 0 to 19 years old and location of the primary tumor is the encephalon carcinoma (C71), with 11.25% of the new cases. **Conclusions:** The results presented with their proper nuances are in agreement with the data of studies carried out in Brazil and in other countries.

Keywords—Childhood cancer. Pediatric cancer. Neoplasms. Rondônia. Western Amazonia.

I. INTRODUCTION

Pediatric cancer is a major public health concern. According to the National Cancer Institute (INCA) (2014), pediatric cancer is the second leading cause of proportional mortality in the age group 1 to 19 years old. It is studied and classified by the International Classification of Childhood Cancer (ICCC). Currently, it uses the ICCC with the new morphological classifications proposed in ICD-O3 [2].

Childhood and adolescent cancer (children and adolescents aged from 0 to 19 years old) is a set of diseases that has its own characteristics, mainly in relation to histopathology and clinical behavior. It is considered a rare disease, corresponding between 1% and 3% of all malignant tumors in most populations. Faced with these challenges, it is necessary that it be studied separately from those that affect adults.

This group of neoplasms presents, mostly short periods of latency, are more aggressive, grow rapidly, but

respond better to treatment and are considered of good prognosis. The classifications used for this disease group are based on morphology, unlike those used for tumors in adults [3]. For didactic purposes, we adopted in this paper the recognition of the distinction according to age, childhood cancer (children aged 0 to 14) and adolescent cancer (15-19 years old).

Among childhood and adolescent cancers, leukemia is the most common in majority populations (25% to 35%). In developed countries, lymphomas are the third most common type of cancer. In developing countries, this type corresponds to the second place, leaving behind only the leukemias. CNS tumors occur mainly in children younger than 15 years, with a peak at the age of 10.

It is estimated that this group, being the most frequent solid tumor in the pediatric age range, represents about 8% to 15% of pediatric neoplasms. Embryonal tumors together with retinoblastoma, neuroblastoma and Wilms tumor account for approximately 20% of all childhood and adolescent tumors and will rarely occur in other age groups. Carcinomas represent less than 5% of childhood tumors, being the most frequent type in adults [3] and [4].

For the study the following guiding question was raised: is there a high and significant frequency of cancer in children and adolescents attended at the Hospital de Base Dr. Ary Pinheiro and Hospital de Barretos / Rondônia, in the Western Amazon?

Thus, the present study aimed to describe the histological and cancer frequency in children and adolescents attended at the Hospital of Base Dr. Ary Pinheiro and Hospital of Barretos / Rondônia, in Western Amazon, in the years 2014 and 2015.

II. METHODS

The methodological design followed the characteristics of a documentary, transversal and descriptive study, based on the raw data produced in the sector, similar to that recommended by Paraguassú-Chaves [4]. The primary data were organized by the Hospital Nucleus of Epidemiology (NHE) of the Hospital de Base Dr. Ary Pinheiro from the medical diagnoses in the hospital mentioned above and the Hospital de Barretos in Rondônia, "Barretinho", in the period of 2014 and 2015.

Thus, a structured instrument was used to collect data containing variables related to gender, age, marital status, schooling, skin color, occupation, city of origin, cities of other states, place of birth, origin the first treatment, findings and medical approach, treatment received, histological types, the most frequent neoplasms, lymphomas and leukemias, among others.

These data were inserted into the statistical platforms, revised, (re) classified, (re) interpreted, (re) analyzed and correlated according to analytical and descriptive methods, using frequency distribution and proportional percentages in statistical representations.

We asked The Comitê de Ética em Pesquisa em Seres Humanos (Research Ethics Committee) to dispense the Informed Consent Form because the study did not require intervention on the patient or collection of biological material, and no possibility of constraints on patients and their relatives.

III. RESULTS

In the years 2014 and 2015, 75 new cases of childhood and adolescent cancer were diagnosed. Of these, 32 (42.7%) in females and 43 (57.3%) in males, predominating the age range of 15-19 with 33.33%.

Table.1: Distribution of cancer in children, by age range and gender, between 2014 and 2015 in Rondônia / Brazil-2018.

Variables	Female		Male		Total	
	af	rf	af	rf	af	rf
00 - 04	7	21.9	14	32.56	21	28
05 - 09	5	15.6	7	16.28	12	16
10 - 14	6	18.75	11	25.58	17	22.67
15 - 19	14	43.75	11	25.58	25	33.33
Total	32	100.0	43	100.0	75	100.0

Source: RHC / NHE / HBAP / RO / 2014

af: absolute frequency; rf: relative frequency

The most frequent histological types between 2014 and 2015 by gender were leukemias of myeloproliferative diseases and myelodysplastic diseases with 29 (41.4%) cases, being highlighted the

male gender with 20 (50%) among the 11 histological types presented in table 02.

It was found that lymphomas and reticuloendothelial neoplasms occupy the second position

with 13 (18.6 %) cases throughout the biennium studied. In addition, tumors of the central nervous system (CNS) with 5 (7.1%) cases, followed by bone and kidney tumors. Renal tumors were more frequent in the female gender with 3 cases, whereas the male

gender remains the carcinomas and other malignant epithelial neoplasms with 4 (10%) of the new cases.

In addition, other major histological types are malignant neoplasms and unspecified (4, 3%), as shown in Table 2.

Table.2: Distribution of the most frequent types of cancer in the age range 0-19 years, depending on the gender, between 2014 and 2015, Rondônia / Brazil.

Histological Type	Female		Male		Total	
	n	%	n	%	n	%
Leukemias, myeloproliferative diseases and myelodysplastic diseases	9	30,0	20	50,0	29	41,4
Reticuloendothelial lymphomas and neoplasms	5	16,6	8	20,0	13	18,6
CNS and miscellany of intracranial and intraspinal neoplasms	4	13,33	1	2,5	5	7,1
Malignant bone tumors	2	6,66	3	7,5	5	7,1
Renal tumors	3	10,0	1	2,5	4	5,8
Carcinomas and other epithelial malignancies	1	3,33	4	10,0	5	7,1
Tumors of the sympathetic nervous system	1	3,33	1	2,5	2	2,9
Soft-tissue sarcomas	1	3,33	1	2,5	2	2,9
Neoplasms of germ cells, trophoblastic and other gonadal	1	3,33	0	0,0	1	1,4
Retinoblastoma	1	3,33	0	0,0	1	1,4
Other malignant and unspecified neoplasms	2	6,66	1	2,5	3	4,3
TOTAL	30	100,0	40	100,0	70	100,0

Source: RHC / NHE / HBAP / RO / 2014

For the current research was considered the International Classification of Diseases ICD-10, in view of all records of the database used to be classified for medical diagnosis. Thus, the leukemia of the hematopoietic and reticuloendothelial system classified by ICD 10 as (C42) is the most frequent cancer in both genders with 38 (47.5%), being almost 3 times more in the male gender with 28 cases.

The second more common group of cancers in children between 0 and 19 in both genders are

the encephalon carcinoma (C71) with 9 cases, and secondary and unspecified malignant neoplasm of lymph nodes (C77) with 9 cases.

Also among the cancers recorded by ICD-10 are the malignant neoplasm of bone and articular cartilage of other and unspecified sites (C41), followed by malignant neoplasm of thyroid gland (C73) and other cancer with rust 1 to 3 cases as shown in table 3.

Table.3: Distribution of the most frequent histological types at the age of 0 to 19 years, according to the gender, between 2014 and 2015, Rondônia / Brazil.

Location of primary tumor	ICD-10	Female		Male		Total	
		af *	rf *	af *	rf *	af *	rf *
Hematopoietic and reticuloendothelial system	C42	10	37	28	52,9	38	47,5
Brain	C71	5	18,6	4	7,5	9	11,25
Lymph nodes (lymph nodes)	C77	2	7,4	7	13,2	9	11,25

Kidney	C64	2	7.4	1	1, 9	3	3.75
Placenta	C58	2	7.4	0	0.0	2	2.5
bone and articular cartilage of other and unspecified sites	C41	2	7.4	3	5.7	5	6.25
Connective tissue, subcutaneous tissue and other soft tissues	C49	1	3.7	2	3.7	3	3.75
Thyroid gland	C73	1	3.7	3	5.7	4	5
bone and articular cartilage of limbs	C40	1	3.7	1	1.8	2	2.5
Skin	C44	0	0.0	3	5.7	3	3.75
thymus	C37	0	0.0	1	1, 9	1	1.25
Eyes and attachments	C69	1	3.7	0	0.0	1	1.25
TOTAL		27	100.0	53	100.0	80	100.0

Source: RHC / NHE / HBAP / RO / 2014

* af: absolute frequency; * rf: relative frequency

Acute myeloid leukemias are the histological types more relevant in the retrospective period revised with absolute frequency of 18 cases and relative frequency of 18.4%, distributed by gender.

Next comes the Lymphoblastic Leukemia of Precursor Cells, with an absolute frequency of 20 cases and a relative frequency of 15.3%, distributed in both genders, a greater tendency is observed in the male gender in this histological type. Among all lymphomas, the malignant lymphoma, NOS or diffuse is the first place in this histological class with an absolute frequency of 18 cases and a relative frequency of 13.9%.

Hodgkin's Lymphoma Mixed Cellularity rank second among the most frequent histological types in the biennium 2014-2015 and with greater incidence in the male gender. Chronic lymphocytic leukemias are the third place among the most frequent types with absolute frequency of 10 cases and relative frequency of 7.7%.

Other histological types are the plasmocyte tumors -973 and chronic myeloid leukemia, matched by the same absolute frequency in both genders in the biennium, followed by Burkitt cell leukemia with 05 cases in total.

Table.4: Proportional distribution of lymphomas and leukemias, by gender, according to the histological type - ICD-03 between the years 2014 -2015, Rondônia / Brazil.

Lymphomas and Leukemias	Female		Male		Total	
	fa	fr	fa	fr	fa	fr
Acute Myeloid Leukemia, NOS	8	17.1	16	19.2	24	18.4
Lymphoblastic Leukemia of Precursor Cells, NOS	5	10	15	18	20	15.3
Malignant Lymphoma, NOS or Diffuse (959)	10	21.3	8	9.7	18	13.9
Hodgkin's Lymphoma Mixed Cellularity or Lymphocytic Depravity	4	8.5	9	10.9	13	10
Chronic Lymphocytic Leukemia of B Cell / Lymphocytic Lymphoma	4	8.5	6	7.2	10	7.7
Hodgkin's Lymphoma, Nodular Sclerosis	0	0.0	2	2.4	2	1.5
Large B-cell Lymphomas or Burkitt's Lymphoma (968)	1	2.2	3	3.7	4	3.1
Small B-Cell Lymphoma	1	2.2	2	2.4	3	2, 4
Mature B-cell Lymphoma	1	2.2	0	0.0	1	0.8
Tumors of Plasmocytes (973)	2	4.3	6	7.2	8	6.1
Leukemia NOS (980)	0	0.0	1	1.2	1	0.8
Acute Leukemia, NOS	0	0.0	0	0.0	0	0.0
Lymphoid Leukemia, NOS (982)	0	0.0	2	2.4	2	1.5
Burkitt's Cell Leukemia	2	4.3	3	3.7	5	3.9
Acute Myeloid Leukemia Type M6	1	2.2	0	0.0	1	0.8
Chronic Myeloid Leukemia, NOS	4	8.5	4	4.8	8	6, 1

Acute Monocytic Leukemia	1	2.2	0	0.0	1	0.8
Acute Myeloid Leukemia with Multiline Dysplasia	0	0.0	2	2.4	2	1.5
Acute Leukemia, Biphenotypic	0	0.0	0	0.0	0	0.0
Lymphoblastic Leukemia of Precursor Cells Type B	0	0.0	2	2.4	2	1.5
Myeloid Leukemia, NOS	2	4.3	0	0.0	2	1.5
Leukemia Cell Type	0	0.0	1	1.2	1	0.8
Acute Myeloid Leukemia T	0	0.0	1	1.2	1	0.8
Acute Myeloid Leukemia with Abnormality	1	2.2	0	0.0	1	0.8
Total	47	100	83	100	130	100

Source: RHC / NHE / HBAP / RO / 2014

IV. DISCUSSION

The studies published in important international journals such as Epidemiology of childhood cancer "Cancer Treat Rev", Cancer Incidence and Survival among Children and Adolescents "Bethesda: National Cancer Institute"; and Cancer incidence among children and adolescents in the United States "Pediatrics", report a higher incidence of cancer in general in males. On the other hand, there was no statistically significant difference in relation to this variable in the study in Rondônia. As described in the literature, there was a higher frequency in males with 43 cases.

The most frequent histological types were leukemias of myeloproliferative diseases and myelodysplastic diseases, with a total frequency of 41.4% of new cases in the biennium studied.

The reticuloendothelial lymphomas and neoplasms were the most common histologic types representing 18.8%, followed by CNS tumors and a miscellany of intracranial and intraspinal neoplasms, malignant bone tumors, carcinomas with 7.1% of new cases respectively during the studied period. These findings corroborate those found by Paraguassú-Chaves et al. (2017).

However, when the results are compared to the national study of the RCBP and other states and other regions of Brazil, they may appear in order of frequency with small variations. That is shown by some studies like the Clinical-Demographic Profile of the Patients Served at the Attended in the Oncology Service of the Hospital de Clínicas de Porto Alegre (Da Luz, 2011) and Cancer incidence among children and adolescents in Brazil: first report of 14 population-based cancer registries (De Camargo et al. 2010).

In the present study leukemia in the hematopoietic and reticuloendothelial system (C42), is the most frequent neoplasm in both, female gender with 37%, and the male, with 52.9 % of cancers in the biennium.

In the same place of the research, the studies of Paraguassú-Chaves et al. (2015a), for the year 2013, had

already found the similar results without statistically difference. Kaatsch [7] in Epidemiology of Childhood Cancer, had already pointed that leukemias are the most common pediatric cancer type in the world and correspond to 34.1% of all childhood cancers until the age of 15, followed by CNS tumors (22.6%) and lymphomas (11.5%).

"Cancer incidence among children and adolescents in Brazil: first report of 14 population based cancer registries", a national study that collected 14 population-based cancer registries (RCBP), showed that Goiânia, Manaus, and Curitiba were the three capitals of Brazil with the largest population incidence rates for leukemia (De Camargo, 2010).

The study "Pediatric cancer: analysis of a hospital registry", indicates that in studies performed in hospital services in the states of Santa Catarina and Rio Grande do Sul, show a incidence of 36.6% and 26.9%, respectively, for leukemia (Silva, Pires and Nassar, 2002).

Among all childhood malignancies, leukemias are the most frequently diagnosed and are responsible, in most populations, for 25% to 35% of all pediatric malignancies according to Parkin et al. (1998).

In most countries, this type of neoplasia most frequently affects children under the age of five. Acute lymphocytic leukemia (ALL) is the most common of the leukemias, corresponding to 75% - 80% of all leukemias in white populations in North America, Oceania and Europe [10]. In the same regions, acute non-lymphocytic leukemia (ANLL) represents 15% to 17% of cases. Not common in childhood, chronic myeloid leukemia (CML) rarely exceeds the proportion of 4% [11]. In the study in Goiânia, from 1989 to 1996, these frequencies were 66% for ALL, 20% for ANLL and 1.4% for CML [12].

The second group of cancers in children between 0 and 19 years old and the location of the primary tumor in the biennium is the encephalon carcinoma (C71), with 11,25 % of new cases. For the 2 years of study in Rondônia, the lymph nodes (C77) best represent the second group of cancers with 11.25 %

and with relative frequency more representative in the masculine gender, 13.2 %.

In Brazil, lymphomas appear as the second most frequent neoplasm in childhood [6]. In the present study, it was also the second most frequent neoplasm, and is second only to leukemias. This corroborates the findings of Paraguassú-Chaves [3].

Lymphomas and leukemias distributed by gender, according to the 10 most frequent histological types, present a similar distribution in the studied period. Precursor cell lymphoblastic leukemia, NOS, is the most frequent leukemia. Shortly after, comes the leukemia from plasma cells (973), the acute myeloid leukemia, NOS, malignant lymphoma, NOS or Diffuse (959), leukemia NOS (980), Hodgkin's lymphoma mixed or lymphocytic depletion and leukemia chronic myeloid, NOS. These results are in agreement with those found in the Paraguassú-Chaves study [3].

The study "Cancer Incidence and Survival among Children and Adolescents: United States SEER Program 1975-1995" [13] and the study "Epidemiology of childhood cancer" [7] are similar to the present study, but they specify the frequencies of leukemias and lymphomas with more detail in some variables.

Leukemias are more frequent from 1 to 9 years old [13]. For the ALL subgroup, there is a peak between 2 and 3 years, which occurred in 66% of the cases analyzed in their study. Already in the studies of Kaatsch [7], lymphoma is practically non-existent in children under one year old, rare in children 1 to 4 years old, with higher frequencies in the following age ranges.

The study "Paediatric cancer in low-income and middle-income countries", shows that lymphomas were the second most frequent neoplasm, followed by retinoblastoma and CNS tumors [14].

Central nervous system (CNS) tumors represent the second most common diagnostic group in childhood, corresponding to 19% - 27% of neoplasms. Similar data were observed in Goiânia, with prevalence of 18.3% [12].

Lymphomas, following tumors of the central nervous system (CNS), are the third type of neoplasia of higher incidence in developed countries, covering 7% to 18% of cases of childhood neoplasia [10].

In developing countries, they generally rank second in incidence rates, as confirmed by the study recently conducted in Goiânia, which correspond to 18.3% of diagnosed childhood tumors [12]. However, there is great variability of lymphomas in histological terms when different regions are compared.

Approximately 45% of all lymphomas in children are represented by Hodgkin's lymphoma [15] and their incidence is usually more pronounced in populations with lower socioeconomic status, such as in Kuwait, Brazil and Costa Rica [9]. In Goiânia, for example, 44%

of the aforementioned lymphomas were Hodgkin's [10,16].

The research "The Childhood Cancer: Epidemiological Profile of Patients Referred to the Clinical Hospital of UFPR Pediatric Oncology Unit," by Hadas, Gaete and, Pianovski [17], corroborate with essential part of the findings in this study. In addition, the results found in the research are in accordance with the projection presented by Paraguassú-Chaves et al. (2015b).

V. FINAL CONSIDERATIONS

Therefore, the presented results with their due nuances are in agreement with the data of studies realized in Brazil and in other developed countries. In addition, it is recognized that more rigorous evaluation of these data may allow the identification of population groups at greater risk or with a worse prognosis. Thus, this study should serve as a basis for the systematization of data essential for the planning, execution and evaluation of actions to promote, prevent, control and treat childhood and adolescent cancer in Rondônia, as well as to establish priorities.

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Analysis of Turbocharged Engine Driven by Pulses with Split Exhaust System and Distinct Discharge Valves

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Abstract— Much effort is now being made to reduce the emissions of internal combustion engines (ICE) to comply with increasingly stringent environmental regulations. In parallel with this objective several studies are conducted with the objective of making ICE increasingly energy efficient, thus reducing the consumption of fossil fuels. This article proposes to present a new concept that can work together with others to reduce the emissions and improve the efficiency of small engines that operate in partial loads. The results that will be presented were obtained from a computer simulation using AVL BOOST software for its practicality and for being an established industrial standard.

Keywords— Turbocharging, Internal combustion engine, Fuel economy.

I. INTRODUCTION

The use of a turbocharger in internal combustion engines boosts its volumetric efficiency and has been an option that is constantly used by the industry for passenger cars and heavy duty engines. However, the pressure generated by the turbine in the exhaust manifold increases the pumping work performed by the engine, thus reducing part of its energy potential. Another consequence of the use of turbocharged systems is the existence of the turbo lag that occurs due to the low volume of exhaust gases towards the turbine at low rotations, which in turn does not reach high enough revolutions to generate pressure gain in the compressor.

Turbocharged systems also have limitations in high rotations, when the turbine cannot give sufficient leakage to the exhaust gases. To solve this problem, the relief valve known as wastegate is used which releases the exhaust gases into the atmosphere and is controlled by a set-up spring to set the maximum admissible pressure in the intake manifold.

In order to overcome all of these limiting characteristics of turbocharged systems, increased back pressure,

increased pumping work and a narrow operating range, this study presents a possible modification in the exhaust system to benefit the system and increase its efficiency. The modification consists in using two exhaust ducts per cylinder, where one will direct the gases to the turbine and the other after the turbine, directly to the catalytic converter. This system used in conjunction with a varied valve control in the exhaust would allow greater control of the operating point of the turbine and would make it useful in all ranges of rotation. The gains in efficiency would be due to both the increase in power over wide ranges of rotation and the reduction of pumping work. In order to qualitatively evaluate the proposed system, simulations were performed in the AVL boost software in a standard engine provided by the software. The engine in question is a turbocharged 6-cylinder diesel engine. The performance was evaluated at a constant rotation of 2500 RPM.

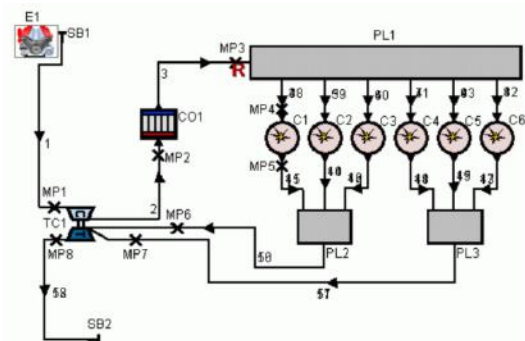


Fig. 1: AVL 6-cylinder diesel engine model.

II. METODOLOGY

In order to qualitatively evaluate the presented concepts, the OD model of the 6-cylinder engine (6c s) in the AVL boost was used as a basis. The standard simulation data were collected and used as base parameters to evaluate the performance of the proposed system. The same model was modified to evaluate the split flow exhaust system (6c vi). To further enhance turbine efficiency under this

condition a new cam profile was developed with the aim of directing a larger amount of exhaust gas to the turbine during the start of the exhaust process. This new cam profile ensures that 50% of the available energy in the exhaust gases is directed only to the turbine, then the relief valve to the atmosphere is opened to reduce pumping work.

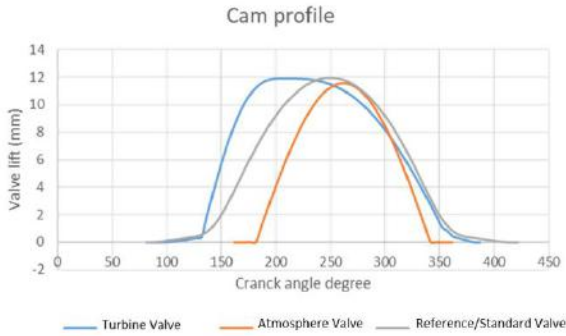


Fig. 2: Came profile

To add the new exhaust duct in the model it was necessary to restructure the exhaust system of the initial model, this was done using two exhaust valves with hydraulic diameters equal to half of the valve of the original model. The wall thickness and the lengths of the exhaust ducts were kept equal to those of the model presented by AVL. For reasons of simplification and because this was a qualitative evaluation, the loss of charge caused by the intercooler was maintained, as well as the models of heat release during the combustion process.

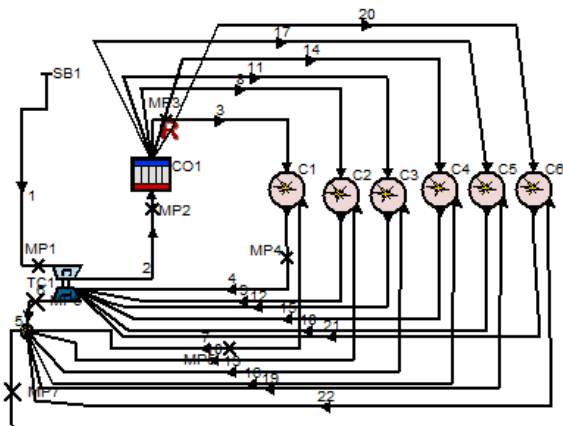


Fig. 3: Double relief valve system proposed

Multiple measurement points were used to obtain a better understanding of the exhausting process in this presented configuration. To increase the robustness of the process, several interactions were required by the software to satisfy the system governance equations and maintain their coherent values.

III. RESULTS

The simulation presented several results that when evaluated were shown to be consistent with the expected. The presented model obtained a nominal power lower than the base model presented by the AVL boost, but the fraction of unburned fuel increased drastically, since the fuel mass injected per cycle was maintained as a static parameter in all simulations. This suggests that this model could operate with an injected fuel volume much lower than the base model and have a higher overall efficiency.

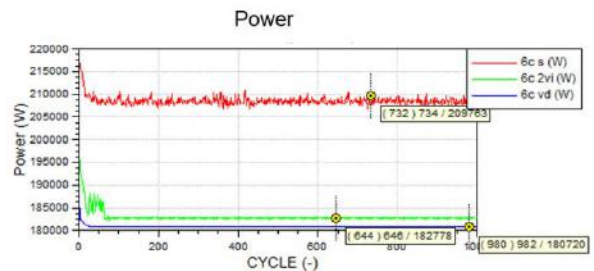


Fig. 3: Power of each model

Another relevant result to be highlighted was the enthalpy flux measured in the turbine, the camshaft model proposed by this study and divided flow, presented intermediate values to the other models, which makes it consistent with the expected and evidences that the proposed system can operate at multiple partial turbine operation points only by modifying the cam profile or the opening and closing phase of the cam.

Power at the turbine

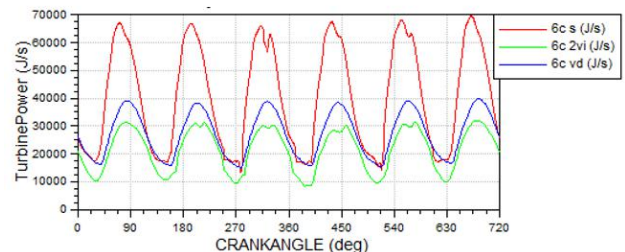


Fig. 4: Power at the turbine

IV. CONCLUSION

The preliminary results presented in this paper were satisfactory and consistent with that shown in the literature. This system should be studied in greater depth to have a broader understanding of its capabilities and applications.

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Analytical Calculation of the Drives of a Flight Simulator Platform with 2 Degrees of Freedom

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Abstract—With constant technological advances, flight simulation has increasingly resembled a real flight. The use of motion platforms together with a virtual simulation is what is most recent in this field, due to its global approach to a flight. However, these flight simulators generate a great added value, so that for trivial trainings and entertainment their use becomes impracticable. With this in mind, in this work was presented a low cost project of a new model of flight simulator containing both simulations, visual and motion. More specifically, this work aims to demonstrate an analytical method for calculating the drives of the designed simulator, so that it supports the loads of the structure and user, in addition to the dynamic torque required by the simulation platform. Furthermore, it was shown how to obtain the inertia of a complex structure as designed using SolidWorks software and also how to acquire magnitudes such as acceleration and angular velocities using Flight Simulator X and Link2FS Multi software. Finally, with the torque and power values required to perform the pitch and roll movements, a commercial selection of the motors was made for platform so that these drives would supply the demand of both torque and power.

Keywords—Analytical Calculation. Flight Simulation. Link2FS Multi. Power. Torque.

I. INTRODUCTION

Since the dawn of aviation, pilots training has been the subject of many studies seeing that they should achieve a high level of efficiency without risk being taken during the training phase. In military aviation, for example, pilot

skill was of paramount importance, as precision in combat maneuvers could ensure the success of the mission [1].

Flight simulators have been developed for more than a century, seeking to achieve the highest possible realism and safety for the user. Currently, flight simulators have been widely used for both professional training and entertainment. Generally, the use of a simulator is always superior to the use of real equipment in three aspects: safety, cost of equipment and experimental control [1][2][3].

According to Dourado [1], when used for training, the flight simulator should have a reduction in the time between land training and real flight due to mistakes made by beginners, the simulation must be safe, cost and pollution must also be smaller.

Many authors have discussed themes or subsystems related to the simulation of a flight, but few have discussed this as a whole, that is, from virtual simulation to simulation of aircraft movements. For example, Shahal treated only the influence of visual parameters such as brightness and contrast on the visual simulation of a fixed-base simulator, while Pool presented a cybernetic approach to evaluate the flight simulator's motion fidelity [4][5].

Due to that reason, the authors elaborated a project considering the required subsystems in order that a simulation with a global fidelity of a real flight can be acquired [6]. These subsystems are a view of the environment outside the cockpit of an airplane, a motion system which supports the movements done by an

aircraft, and the main controllers of an airplane, in this case the joystick, the rudder pedals and the accelerators. A flight simulator with 2 degrees of freedom (2DOF) containing both the visual and control simulation made by Flight Simulator X (FSX) software and controller replicas of an aircraft, as well as simulation of airplane movements, made through a motion platform composed of structural parts and electrical drives.

However, owing to the complexity of the platform and the calculations involved, in addition to all programmatic control, this work aims to present the final design of the flight simulator and the analytical procedure to calculate the power and torque of the electric motors of the simulator and also the computational method used to obtain the moment of inertia of the simulation platform. In addition, an effort has been done to select the appropriate commercial electric motors for each movement.

II. METHODS

2.1 Project of the Flight Simulation Platform

During the initial phase of the project several factors were defined in order to delimit the peripherals and drives to be used. The relevant factors for this project were the final cost, the interaction of the user with the simulator and, the most relevant, the fidelity of the simulation provided by the precision of the movements. For the platform modeling, SolidWorks 2016 software was used.

2.2 Determination of the Drive type

Before determining the type of drive to be used on the platform, the initial factors were again considered on the choosing. The main types of drives are hydraulic, pneumatic and electric. Pneumatic drives were the first to be discarded because they can achieve low power and torque, which would not match the demand of this project. The hydraulic drive would be the one that would present greater precision of the movements, besides high powers that could be reached, but the needed cost would be very high compared to the electric drives, for this reason the hydraulic drive was also discarded [7]. Amongst the electric drives, stand out the conventional motors AC and DC, besides the servomotors. Of these types of electric motors, the one that fit better was the AC motor, although this one needs an inverter of frequency for the control of the speed, would still be a cheaper option than the others. However, this motor has less control accuracy when compared to the servomotor, but by establishing a certain precision tolerance, the AC motor would comply with the demand.

2.3 Torque Analytical Calculation

The motion platform was designed to describe the pitch and roll movements of an aircraft, each movement being

described by an electric motor. Thus, the calculation procedure was done using the Euler equations of motion for the dynamic torque, where each component of the torque represents one of the movements of the aircraft. However, if this analytical method were not used, the computation could be done by systematic computation using a generic technique such as Euler-Newton [8].

So, the minimum torque required by the motors can be calculated as proposed, analytically, by equation 1:

$$M_{min} = M_{dynamic} + M_{static}$$

(1)

Where $M_{dynamic}$ can be calculated by Euler equations from 2 to 4[9]:

$$M_x = I_{xx}\alpha_x + \omega_y\omega_z(I_{zz} - I_{yy}) \quad (2)$$

$$M_y = I_{yy}\alpha_y + \omega_z\omega_x(I_{xx} - I_{zz}) \quad (3)$$

$$M_z = I_{zz}\alpha_z + \omega_x\omega_y(I_{yy} - I_{xx}) \quad (4)$$

Where I is the inertia for the part of the motion platform and α and ω are respectively the maximum angular acceleration and velocity described by the structure.

Using the parallel-axis theorem, also called the Steiner's theorem, the rotational inertia of a body with respect to an axis parallel to the center of mass axis can be calculated by equation 5 [10]:

$$I = I_o + Md^2 \quad (5)$$

Where I_o is the inertia about to the center of mass and d is the distance between the parallel axes.

However, this inertia calculation is usually done manually for bodies with simple geometry as shown by Abdulghany [10]. Therefore, to calculate the inertia of three-dimensional bodies and complexes, software is commonly used to this calculation and it express the result as an inertia tensor as shown in equation 6 [10]:

$$I = \begin{pmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{pmatrix} \quad (6)$$

Where the elements of the diagonal refer to the moments of inertia on the three orthogonal axes x , y and z .

In order to obtain this tensor a tool of the software SolidWorks 2016 was used, which shows the mass properties of the selected bodies in the project, so that inertia can be obtained for both pitch and roll.

The angular acceleration was obtained empirically using two programs, Flight Simulator X (FSX) and Link2FS Multi. A flight simulation was done using the FSX with Cessna 172 model as aircraft, one of the most used aircraft for pilot training. During the simulation,

forced maneuvers were made to simulate extreme flight situations, where critical accelerations would be imposed on the aircraft. Using the Link2FS Multi software, the critical accelerations imposed on the aircraft were collected and the maximum acceleration obtained was used for the calculation, as this would be the situation where a higher torque would be required. Then, the dynamic torque was calculated using the Euler equations.

As well as the minimum torque, the dynamic torque could have been computationally calculated according to the dynamic analysis done by Herrero [11] for a mechanism with 3DOF. But, as a simplification to calculate the static torque, the equation 5 [12] was used.

$$M_{static} = r \times F = \begin{vmatrix} i & j & k \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix} \quad (7)$$

Where r_x , r_y and r_z represent the orthogonal distances, according to the coordinate system, up to the axis of rotation and F_x , F_y e F_z represent the force vectors according to the coordinate system.

However, for this calculation both mass and distance were obtained using SolidWorks 2016 software to evaluate these quantities, where m would be the mass of the selected platform part added to an arbitrary mass given to the user which multiplied by gravity would promote the force weight would generate the static torque considering a r that would be the orthogonal distance from the center of mass to the axis of rotation of the motors. Then, the static torque was calculated, disregarding its sense since at times the torque would be favorable to the movement and now would be contrary. Finally, the minimum torque required for each of the motors can be calculated.

2.4 Power Analytical Calculation

The motors are commercially found according to their power and in their datasheet can be found the value of the nominal torque. The electric motor must supply both the required power and torque. Thus, the analytical power calculation was done using equation 8[13]:

$$P = M_{min} * \omega \quad (8)$$

Where M_{min} was previously calculated and ω is the maximum angular velocity achieved by the Cessna 172 aircraft during the simulated flight in FSX. As well as the angular acceleration, the maximum angular velocity was obtained using Link2FS Multi.

2.5 Selection of motors and gear units

The selection of suitable motors was consulted catalogs from one of the largest electric motor companies, the WEG [14]. In addition, catalogs of gears were also consulted, so that the drives meet the required torque[15].

Another necessity was that the drive presented irreversibility, something that only the AC motors are not able to guarantee, being thus in analyzing the reducers this factor was also considered for choice.

III. RESULTS

3.1 Flight Simulator Platform

Fig.1: Motion Flight Simulator Platform shows the isometric view of the finished and rendered project. The platform was designed in an attempt to obtain the maximum possible structural symmetry. As seen in Fig.1: Motion Flight Simulator Platform, the roll is described by the internal structure, the gear and motor assembly being located on a support in the outer ring, where movement would be imposed on the structure by a coupling. In the meantime, the pitch movement would be imposed on the structure as a whole by means of the gear and motor assembly arranged in one of the support tripods of the structure. The platform is designed to describe angles of maximum 40°, and in commercial flights the maximum pitch and roll values are 15°. In this way, the platform would attend both for pilot training and entertainment.

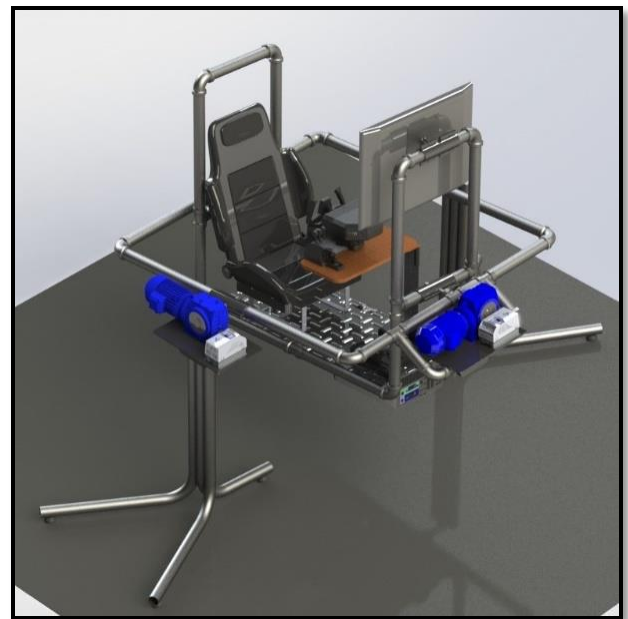


Fig.1: Motion Flight Simulator Platform

Fig.2: Other view of the Flight Simulator shows another view of the simulation platform, which can be seen interface devices with a replica of the joystick used in the Cessna 172 as well as accelerators, in addition to a 32 "TV for visual simulation.



Fig.2: Other view of the Flight Simulator

3.2 Torque Analytical Calculation

Fig.3: Internal Structure and its Mass Centers shows an image of the selected platform parts to obtain their mass properties, and with the inertial tensor calculated by the software, the inertia for the roll was obtained. The mass of the user was simulated by a thin plate positioned on the seat with a mass of 100kg.

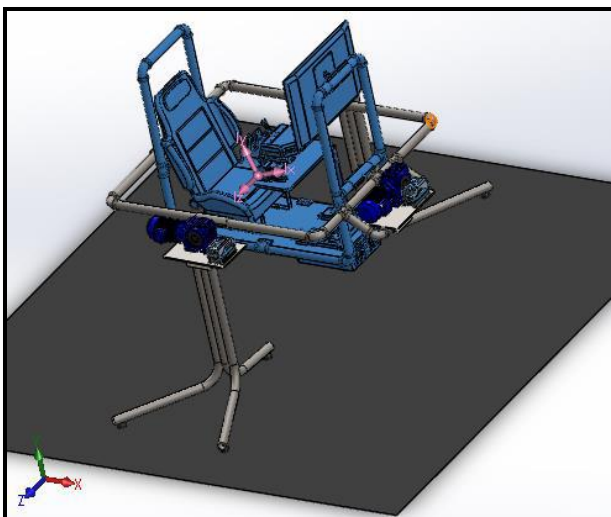


Fig.3: Internal Structure and its Mass Center

The relevant properties for the torque calculation are the distance from the center of mass to the center of rotation of the roll motor and the inertia of the structure relative to the axis of rotation. Equation 9 shows the inertia tensor of the selected bodies and shown in Fig. 3:

$$I = \begin{pmatrix} 51.55 & 5.25 & -0.59 \\ 5.25 & 73.27 & -0.47 \\ -0.59 & -0.47 & 106.95 \end{pmatrix} \quad (9)$$

The units of the inertias shown in equation 9 are in kg.m². Fig.3: Internal Structure and its Mass Centers shows that the dynamic torque for the roll is the M_x, so the inertia to be considered for the calculation should be the I_{xx} which is equal to 51.55 kg.m². The acceleration obtained using the software FSX and Link2FS was 0.5 rad/s². From this data can be calculated the dynamic torque using the equation 2 and considering that there is no initial velocity, because the motor would have interrupted cycles, that is, with each movement that was carried out, soon after if it was not necessary to continue the movement, the motor would stop the movement. In this way, the second part of equation 2 would be null. Thus, the dynamic torque obtained was 17.44 N.m.

The orthogonal distances from the center of mass to the axis of rotation were also obtained through the mass properties in order to calculate the static torque. Table.1: Mass Center from Internal Structure shows the data from the center of mass to the internal structure.

Table.1: Mass Center from Internal Structure

Mass Center (m)	
X	-0.08
Y	-0.13
Z	0.01

Therefore, the distance considered for the calculation of the torque was the distance in Z, since this is perpendicular both the force weight (F_y) and the axis X, already the distance r_y although it is orthogonal to the X axis at the same time is parallel the force weight, for this reason does not generate a static torque. Using equation 7, the static torque was calculated. The mass of the internal structure considering the mass of a user of 100 kg was 284 kg. The static torque for distance Z was 27.8604 N.m. Thus, using equation 1, the minimum torque for the motor running the roll was 45.3 N.m.

The same procedure was used to calculate static and dynamic torques for pitch motion. Equation 10 below shows the inertial tensor for the platform considering the internal and external structures.

$$I = \begin{pmatrix} 55.05 & 4.59 & 1.16 \\ 4.59 & 93.25 & -0.55 \\ 1.16 & -0.55 & 123.62 \end{pmatrix} \quad (10)$$

The coordinate axis was maintained for this calculation, so the pitch motion is executed around the Z axis. In this way, the inertia used to calculate the dynamic torque (M_z) was the I_{zz} which is equivalent to 123.62 kg.m². Using the equation 4 and the same consideration which was done for roll, the dynamic torque for the pitch was realized and this obtained a value of 61.81 N.m.

Another time, the displacement of the center of mass in relation to the axis of rotation was considered to calculate the static torque. Table.2: Mass Center from the Whole Motion Structure shows the values of the displacements of the center of mass on the axis of rotation about to the orthogonal axes.

Table.2: Mass Center from the Whole Motion Structure

Mass Center (m)	
X	-0.03
Y	-0.12
Z	0.01

From these values were made the same calculations as previously performed for the roll. But for the pitch we considered the distance r_x as this is orthogonal to the force weight and the Z axis. This time, the mass found for the whole structure was 305 kg. From these values, the static torque found was 89.76 N.m. Therefore, the minimum torque for pitch execution was 151.57 N.m.

3.3 Power Analytical Calculation

Once the pitch and roll torques have been determined, the power calculation becomes trivial. Using equation 6 and a maximum angular velocity for a structure of 0.42 rad/s, the powers for pitch and roll were respectively 63.66 W and 19.03 W.

Table.3: General Results for Torque and Powers shows the final results obtained for torque and power.

Table.3: General Results for Torque and Power

	Pitch	Roll
Torque (N.m)	151.57	45.3
Power (W)	63.66	19.03

3.4 Selection of motor and gear units

As seen in Table 3, the powers found were very low, but in other hand the required torque was very high. Therefore, it was proposed to use motors with low power with high reductions to withstand the torques at the output. Table.4: Reducer and its output properties shows the selected gear units and their respective output torques and powers. The values shown in the table refer to

reductions rates in 1 stage and motors with 1750 rpm of nominal speed.

Table.4: Reducer and its output properties

	Reduction	Power (hp)	Torque (N.m)
Pitch	1:80	0.65	208
Roll	1:60	0.40	96

For the selected reduction and to obtain these values of torque and output power, the electric motors required for pitch and roll were respectively 2 hp and 1 hp. According to the gearbox catalog of WEG-Cestari, MAGMA type gear units for pitch and roll were size 7 and 5 respectively.

IV. CONCLUSION

From the analysis of the results, it can be concluded that the flight simulation platform, despite having a high torque demand, at the same time showed a low power requirement due to the low displacement velocity. It may also be noted that as proposed, the analytical method of calculating dynamic quantities was very simple, even for a complex structure as projected.

Finally, it is possible to simply specify the torque and power calculation to specify commercial devices that would support with a certain safety factor the torque and power values found.

In future works, this article will be compared an another approach calculation which will be done using an assistance of software like Adams and Ansys.

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Determination of Resistance Parameters of Contaminated Compacted Tropical Soils in the State of Rio de Janeiro

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Abstract — Direct shear (DS) tests with controlled shear rates were performed in two soils from the Baixada Fluminense region, in the city of São João do Meriti – Rio de Janeiro, Brazil. The first soil characterized as Inorganic Clay of high plasticity (CH) was located in a hillside region. The second soil characterized as medium plasticity clay (CL) was located in a central region of the studied area with a slight slope. The soils in question are deposited on non-compacted soft soil with the addition of Municipal Solid Waste (MSW). Both samples of compacted soil were excavated at a depth of 1.0 m, and undisturbed samples were collected. In addition to the previously mentioned tests, oedometric tests and soil physical classification tests were carried out to evaluate geotechnical parameters. In both tests the shear rate of 0.043 mm / min was adopted. The tests presented coherent results with probabilistic accuracy greater than 95% inreliability compared to three tests with compacted tropical soils.

Keywords —direct shear (DS), clay, tension, friction angle, cohesion, liquid limit, plasticity limit, soil.

I. INTRODUCTION

During the last years, tests that determine soil resistance have been extensively studied in order to indicate the best test to be performed on each type of soil. Associated with this, projects of foundations of structures have been requiring more information about the soils studied.

In particular, tropical coastal regions, such as Rio de Janeiro State, with a large mountainous cluster and steep slopes, are most often exposed to static loads, motivated the study of more critical resistance parameters.

In general, the direct shear (DS) test has been more widely used, and the parameters obtained in the tests have been more frequently used in engineering projects [1].

The research has as main focus the study of tropical soils through particular geotechnical tests, especially the

directshear (DS) test.

The objective is the study of resistance parameters of a tropical compacted soil from the Rio de Janeiro state. Thus, a better understanding of the mechanism of rupture and movement of the slope is sought, as well as the evaluation of the criteria adopted. The experimental results were compared in order to investigate the differences between the parameters of shear strength of authors, DS tests, and others authors tests in different normal effective shear and failure criteria. It is also the basis of the research to describe methods, materials and laboratory tests that could assist in the determination of basic geotechnical parameters and resistance.

II. CONTEXTUALISATION

2.1 Compacted soil structure

According to Seed et al. [2] and Mitchell et al. [3] the soil is the result of rock degradation, transport, mineralogical composition, electric forces between particles and other forces that acted during the history of the soil and interaction between particle arrangements.

It is thus called, by clay soil, the soil with sufficient percentage of clay to govern the behavior of the soil as a whole. According to Marsal et al. [4] clay percentages greater or equal to 30% already influence in a determinant way in the properties of the materials.

The clay fraction is composed of particles smaller than two microns and is called the active component of the soil, while the silt, sand and gravel portion is often referred to as the inert component. This is due to the fact that the clay has physical-chemical phenomena these, not present in the granular fraction.

In clay soils, if the amount of water is increased, allowing the double layers to form, the predominant efforts will be repulsion. Thus, the particles tend to disperse, parallel to each other.

According to Seed et al. [2] another way of obtaining

dispersion is to print large shear stresses on the soil mass. According to the authors, the boundary region of two types of structure above is for clayey soils around the optimal moisture, for energy levels compatible with the Normal Proctor.

The compaction moisture is thus a factor of great importance in the formation of the soil structure, being dry molded soils of greater capacity of support than those molded with moisture.

However, soil structure is not only defined by compaction moisture, but also by the type of effort employed.

Casagrande and Hirschfeld [5] conducted compaction curve studies for soils compaction. The studied tropical compacted soil presented good parameters of energy levels.

Marsal et al. [4] used the terms open and occluded, to designate the occurrence of air and water, and their interactions with the solid phase.

In the occluded state, characteristic of compacted soils in the moist branch of the compaction curve, the air is present in bubbles, surrounded by the liquid phase, and therefore there is no continuity of the gas phase.

In the open state, common to compressed soils with below-optimal moistures, the gas is fully connected to the atmosphere.

Another item to be approached regarding soil structure is the presence of saprolite soils.

These soils are more easily destroyed by mechanical manipulation or action, due to the high heterogeneity of their characteristics.

Mori [6] states that saprolite soils, when excavated and compacted in the field, still maintain much of their structure intact, whereas in laboratory tests, the initial matrix destruction is quite intense.

That is, compacted saprolite soils have even more complex structures than those presented in homogeneous compacted soils.

According to genealogical origin of tropical soils of the region, the soils studied are a homogeneous lateritic soil.

2.2 Location

The experimental ground of study is in São João do Meriti, located in the Metropolitan Region of Rio de Janeiro (Brazil).

This experimental ground was established in 2010 to study the construction of landfills on layers of non-compacted soft soils with the addition of Municipal Solid Waste (MSW), a common environmental problem throughout the country. A comprehensive research project was started in 2017, under the supervision of Professor Claudio Fernando Mahler, from COPPE /UFRJ.

Figure 1 below shows the location:

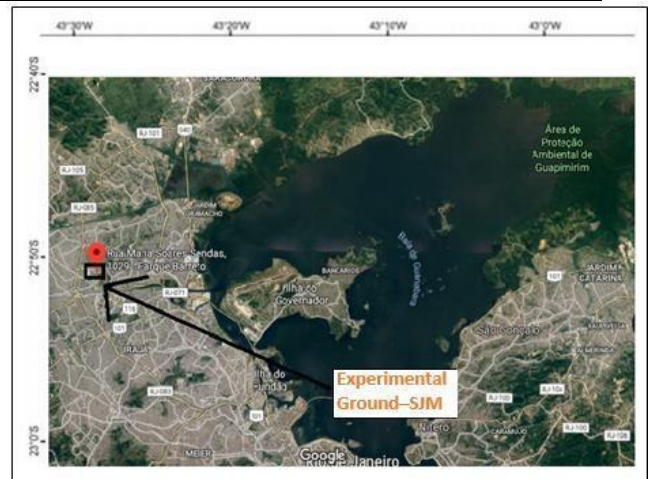


Fig. 1: Location of ground of study (Google Maps)

III. MATERIALS AND METHODS

3.1 Undisturbed block of soil

For the field removal of the undisturbed block 5 campaigns were carried out to collect the samples in block. First, it was necessary to excavate 1.0 m depth from an area of 1.0 m x 1.0 m. The excavation was performed manually. Subsequently it was molded to the selected size (30 cm x 30 cm x 30 cm) so that it could be packed in the vehicle used. For the correct mold were used string, knife, wire saw and steel cables. Although it was not always possible to cut the block at the desired location due to the presence of pebbles in the soil, it was generally sought to adopt the central plane as the base axis. During the molding, the ruler was used for the correct dimensioning of the block.

The block was packed with the smallest changes possible. For this purpose a layer of PVC film paper was used, followed by two layers of aluminum foil and one more of a canvas fabric.

Immediately after the procedure, step 3 was started, resin melting.

Step 4 was then followed: filling the external surface area of the fabric with a resin in the liquid state with the aid of a shell and then naming the block using label and pilot, which will be glued to the resin. Immediately after its solidification in ambient state the block is then laid in a wooden box with the desired dimensions and filled in the gaps with sawdust. This same block is then stored in a polypropylene box for better transportation, and then stored in the vehicle.

Figure 2 below shows the collect of undisturbed block of soil:



Fig. 2: Undisturbed block of soil

3.2 Soil Physical Classification

The test is initiated with a visual tact analysis in order to pre-identify the soil to be worked on.

In this work a careful analysis of the grains was made, in order to define how the soil sample would be chosen and, thus, from the current norms, to obtain data that allows its characterization and use by means of curves.

The materials and equipment used in this phase are: sieves, metal trays, mortar, clock, scales, greenhouse, beaker, dispersing apparatus, glass beakers, hydrometer, thermometer, mechanical stirrers, metal brushes, glass stick, replaceable metal propellers and cup with metal baffles, vacuum pump with registers, vacuum gauge and connections, capable of applying a vacuum of 8 kPa, funnel, flexible blade spatula, check height dropping shell, steel ball with 8 mm diameter, suitable containers, glass plates and porcelain capsule with 120 mm diameter.

Figure 3 below shows soil sifting:



Fig.3: Soil Sifting

3.3 Oedometric Test

The oedometric test followed the following steps:

- Molding of the specimen with the aid of a bevelled

- ring to reduce disturbances in the sample during cutting;
- Placement of the ring with the ground on the rigid cell which should contain a porous stone at its base to allow drainage of the water from the specimen;
- Assembly of top plate, which shall also contain a porous stone;
- Adjustment of the displacement meter for vertical displacement measurements;
- Application of vertical loads;

For this test the first loading stage was 0.031 (kg/cm²), with 8 loading stages which were applied to the sample. The loading variation was 0.031; 0.062; 0.125; 0.250; 0.500; 1,000; 2,000 and 4,000 (kg/cm²), and three stages of unloading 2,000; 1,000; 0.500 (kg/cm²). Each charging stage should last for 24 hours. During the execution of each loading stage, vertical compression measurements of the sample are made as a function of time, for the times of 0,0.1,0.25,0.50,1,2,4,8,15,30,60,120 and 240 minutes. With these data the density curves are constructed, that is, displacement versus time. With the aid of these curves, the coefficient of soil densification is determined by a process found in the literature, the Casagrande method (log t scale)

With the development of the consolidation process, the pore-pressures dissipate in the sample. With the values of deformation, at the end of each loading stage, a curve of the effective tension versus the deformation produced by the increase of this tension is constructed. This curve can be presented in several ways, such as vertical effective tension versus pre-consolidation coefficient.

Figure 4 below shows the test, while Figure 5 shows the sample from point 1 in a saturated state.



Fig. 4: Oedometric Test

Figure 7 below shows the granulometric (particle size distribution) curves of point 1 and point 2 with the respective material composition present in the soil. Figure 8 shows the Atterberg Limits of point 1 and point 2.



Fig 5: Sample of point 1 - Saturated state

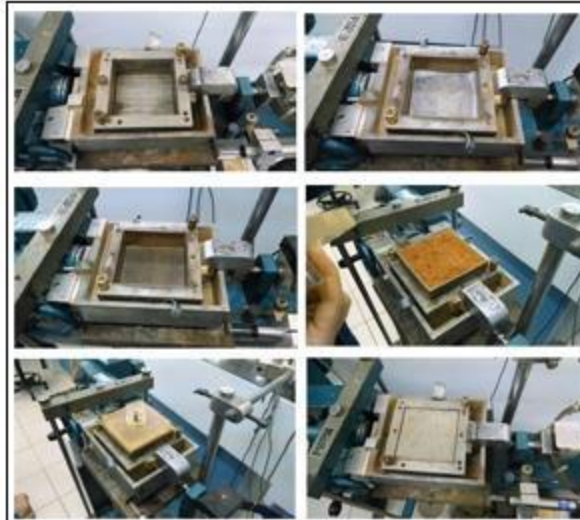


Fig. 6: Direct Shear molding

3.4 Direct Shear(DS)

The direct shear test is used to determine the shear strength parameters of the soils. This test allows the study of the resistance in a predetermined plane of rupture. The specimen is formed from an undisturbed specimen. Initially, the top of the undisturbed sample is set. Placing the nozzle (metal mold) on it, pressing it lightly and forcing it to penetrate the sample. As the nozzle is introduced, the soil around it is roughly trimmed with a small knife. This operation must continue until the soil appears just above the metal mold. Then the top of the spout is scraped off and the base is highlighted, scraping also on the other side. Once this is done, the sample will be ready for the direct shear (DS) test. Figure 6, below, shows a Direct Shear (DS) molding.

IV. RESULTS AND DISCUSSION

4.1 Soil Physical Classification

4.1.1 Point 1 and Point 2

The soil of point 1 can be characterized as an inorganic clay soil of high plasticity (CH). On the other hand, the soil of point 2 can be characterized as a medium plasticity (CL) inorganic clay soil.

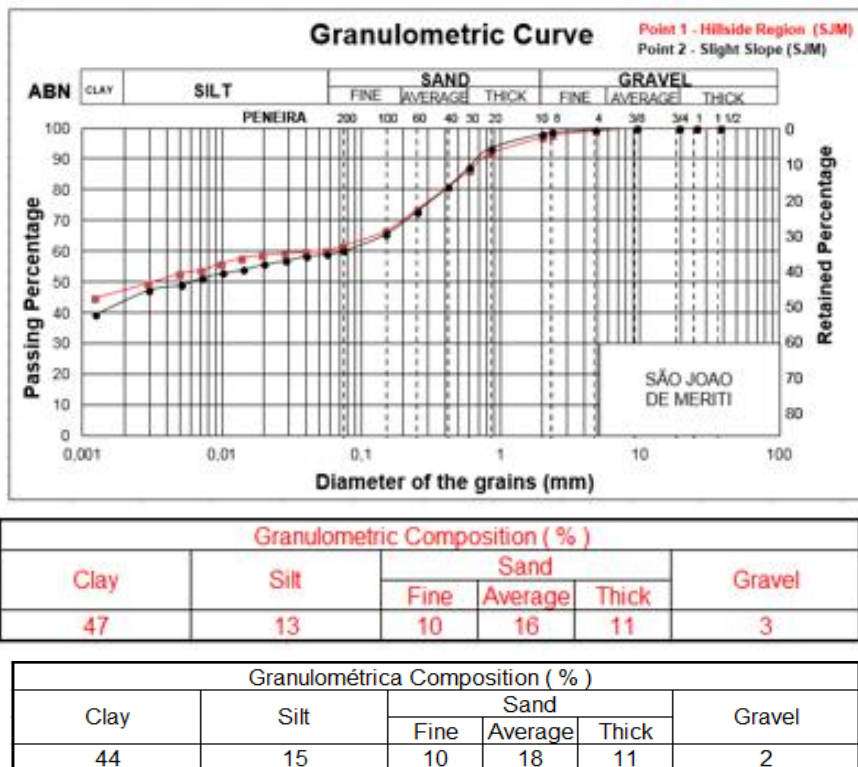


Fig. 7: Particle-Size Distribution Curves

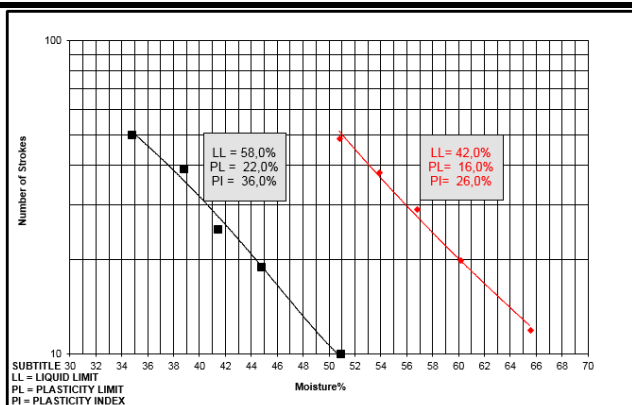
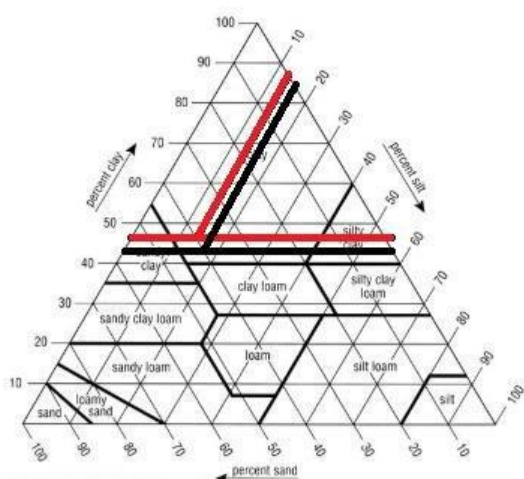


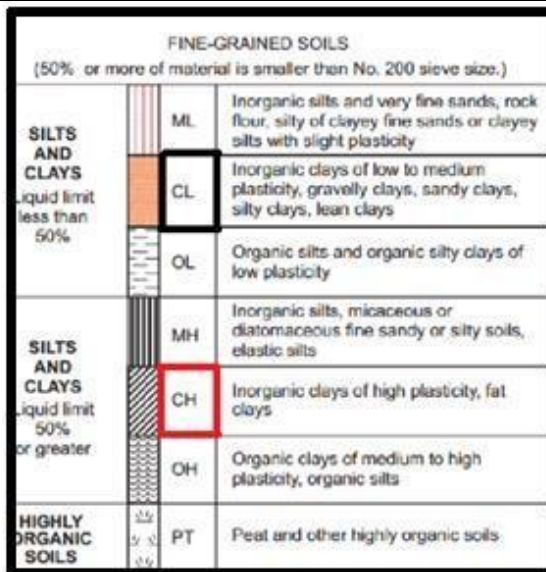
Fig. 8: Atterberg Limits

Figure 8 below shows the Feret Triangle used by the U.S. Department of Agriculture Soil Texture that was used to determine the soil type of point 1 and point 2. Figure 9 shows the Unified Soil Classification System (USCS) created by Civil Engineering Arthur Casagrande that was used to determine the soil characteristics.



Point 1 - Slight Slope (SJM) Point 2 - Hillside Region (SJM)

Fig. 9: Feret Triangle



Point 1 - Slight Slope (SJM) Point 2 - Hillside Region (SJM)

Fig. 10: Unified Soil Classification System (USCS)

4.2 Oedometric Test

The consolidation coefficients presented to the soil varied from 34.61×10^{-3} to 44.24×10^{-3} cm² / s, according to table 1 with average results (Point 1 and Point 2) and relative standard deviation.

Soil moisture ranged from 16 to 19% on days of field trials before to soil consolidation.

The initial void indices ranged from 0.59 to 0.86 depending on the soil removal local, also varying according to the effective stresses applied according to the graphs.

Figure 11 and Figure 12 below shows the variation of the void indices by the applied vertical tension for Point 1 and for Point 2. Table 1 and Table 2 shows the initial soil moistures in the field tests (different days) and after the oedometric tests. Table 3 shows the values of the consolidation coefficients.

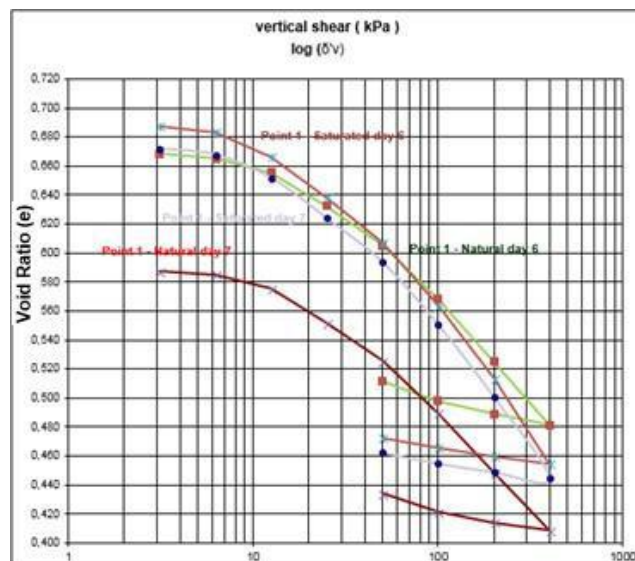


Fig. 11: Void Ratio (e) x Vertical Shear (kPa) –

Point1

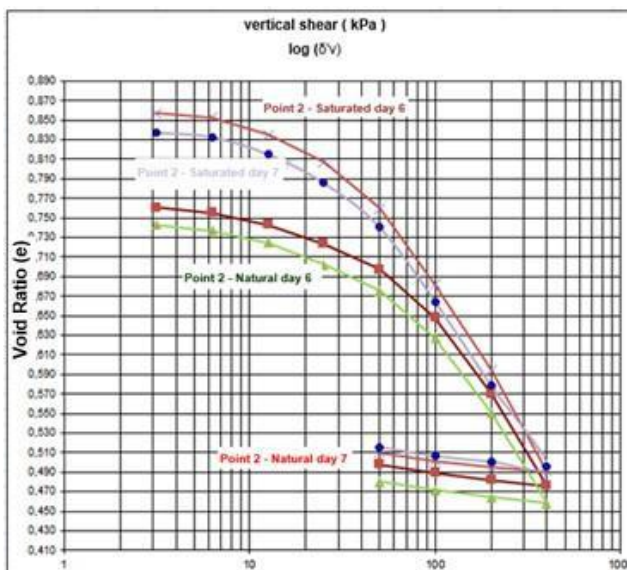


Fig. 12: Void Ratio (e) x Vertical Shear (kPa) – Point2

Table 1: Moisture initial and final of the samples –Point 1

N°	w _{initial} (%)	w _{final} (%)
Sample Point 1 (Natural)	16,83	12,62
Sample Point 1 (Natural)	16,82	12,62
Sample Point 1 (Saturated)	16,68	27,98
Sample Point 1 (Saturated)	16,68	27,50

Table 2: Moisture initial and final of the samples – Point 2

	w _{initial} (%)	w
Sample Point 2 (Natural)	18,24	
Sample Point 2 (Natural)	18,23	
Sample Point 2 (Saturated)	18,57	
Sample Point 2 (Saturated)	18,47	

Table.3: Consolidation Coefficient

	Consolidation Coefficient (average) x 10 ⁻³	Standard Deviation x 10 ⁻³
Point 1 (Natural)	32,12 cm ² /s	13,45 cm ² /s
Point 1 (Saturated)	37,09 cm ² /s	10,14 cm ² /s
Average Point 1	34,61 cm ² /s	11,91 cm ² /s
Point 2 (Natural)	47,82 cm ² /s	25,69 cm ² /s
Point 2 (Saturated)	40,66 cm ² /s	7,37 cm ² /s
Average Point 2	44,24 cm ² /s	18,90 cm ² /s

4.3 Direct Shear(DS)

4.3.1 Point 1 and Point 2(Natural)

With the values of normal tension and shear stress tension, referring to the peak points of each test, the

Mohr-Coulomb failure criterion is constructed. From the straight line developed between the normal stress and the shear stress the values of the cohesion intercept and the friction angle of the soil are drawn.

The Mohr-Coulomb failure criterion, τ (kPa) = $c + tg(\Phi) * \sigma$, is adjusted with the points below (Table 4 and Table 5):

Table 4: Normal Stress and Shear Stress – Point1

τ (Kpa)	σ (Kpa)
154	77
182	160
253	326

Table 5: Normal Stress and Shear Stress – Point2

τ (kPa)	σ (kPa)
118	85
201	173
381	317

From the previous points they are obtained the lines that best fit the points, providing an equation. Figure 13 below shows the lines provided.

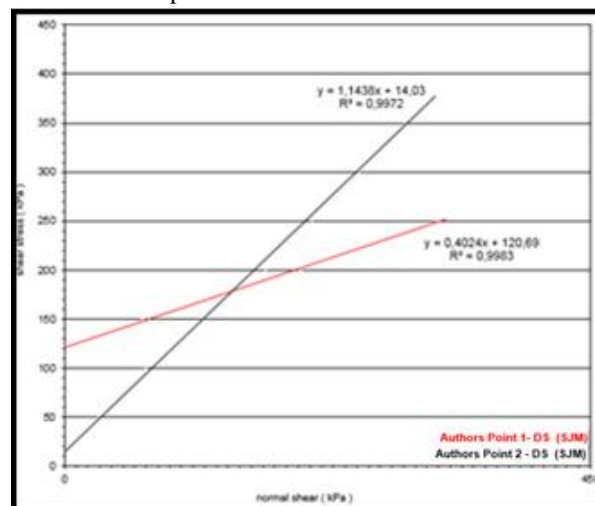


Fig. 13: Shear Stress (kPa) x Normal Shear (kPa)

From this equation the cohesion intercept and friction angle of the material are obtained. Values follow below:

$\Phi_1 = 24.33^\circ; c_1 = 120.69\text{kPa}$

$\Phi_2 = 54.16^\circ; c_2 = 14.03 \text{ kPa}$

4.3.2 Point 1 and Point 2(Saturated)

With the values of normal tension and shear stress tension, referring to the peak points of each test, the Mohr-Coulomb failure criterion is constructed. From the straight line developed between the normal stress and the shear stress the values of the cohesion intercept and the friction angle of the soil are drawn.

The Mohr-Coulomb failure criterion, τ (kPa) = $c + tg(\Phi) * \sigma$, is adjusted with the points below (Table 6 and Table7):

Table.6: Normal Stress and Shear Stress – Point1

τ (kPa)	σ (kPa)
60	86
90	170
163	346

Table 7: Normal Stress and Shear Stress – Point2

τ (kPa)	σ (kPa)
65	86
102	173
219	346

From the previous points they are obtained the lines that best fit the points, providing an equation. Figure 14 below shows the lines provided.

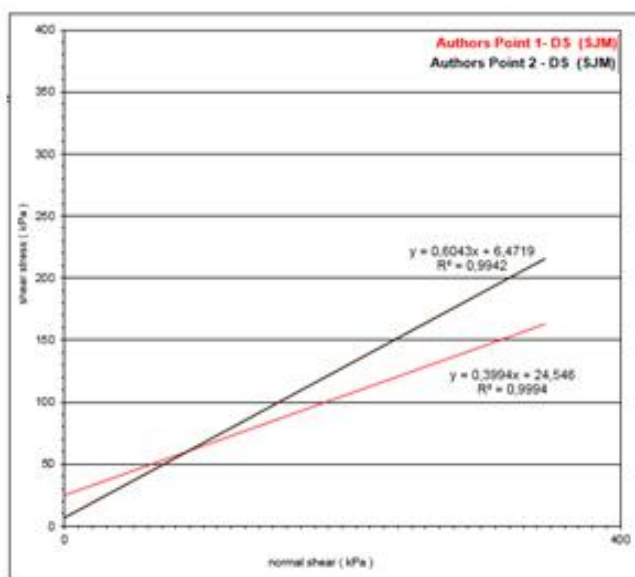


Fig. 14: Shear Stress (kPa) x Normal Shear (kPa)

From this equation the cohesion intercept and friction angle of the material are obtained. Values follow below:

$$\Phi_1 = 24,22^\circ \quad c_1 = 24,55 \text{ kPa}$$

$$\Phi_2 = 34,59^\circ \quad c_2 = 6,47 \text{ kPa}$$

4.3.3 Comparative Results

It is observed in Table 8 and Table 9 below, which based on the results, the curves performed by authors present an average value among the analyzes present in the literature. This assertion further supports the degree of reliability of the data, already calculated probabilistically. The only exception is the point 2 of the consolidated drained direct shear test (CD) where it is possible to visualize (black line) that the soil behaves more like a sand than a clay. This is due to the fact that the soil of point 2 has a greater percentage of sand in relation to point1.

Table.8: Friction Angle and Cohesion Intercept – Consolidated Undrained (CU)

Nº	Friction Angle (°)	Cohesion Intercept (kPa)
Authors Point 1 – DS	24,22	24,55
Authors Point 2 – DS	34,59	6,47
Stein et al. (2018) - DS	27,7	20
Coutinho et al. (2011) - Triaxial	40	0

Figure 15 and Figure 16, below, plots the different Mohr-Coulomb failure criterion for the compacted clays studied.

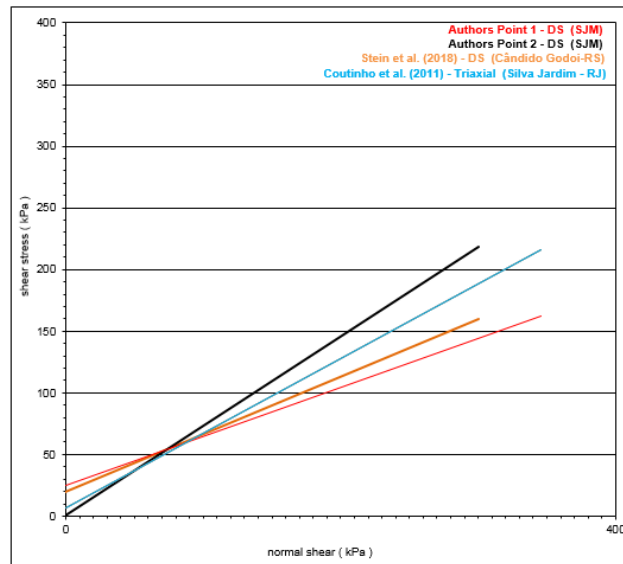


Fig. 15: Different Mohr-Coulomb failure envelope (CU)

Table 9: Friction Angle and Cohesion Intercept – Consolidated Drained (CD)

Nº	Friction Angle (°)	Cohesion Intercept (kPa)
Authors Point 1 – DS	24,33	120,69
Authors Point 2 - DS	54,16	14,63
Stein et al. (2018) - DS	37,7	145
Stein et al. (2018) - Triaxial	31	180
Merighi et al. (1987) - DS	24,40	95,60
Merighi et al. (1987) - Triaxial	37	65

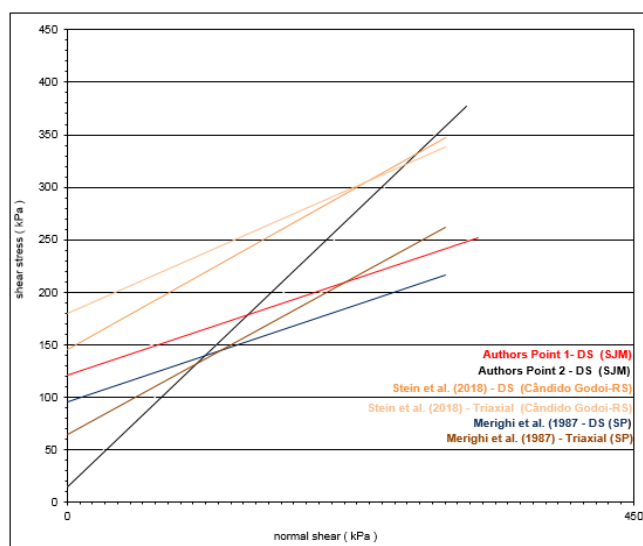


Fig. 16: Different Mohr-Coulomb failure envelope (CD)

V. CONCLUSIONS

1987, p.29-45, Maceió, Alagoas, Brazil.

The results obtained were very satisfactory. The curves were within the range of expected values, the results being reliable both probabilistically and in the literary comparison. A possible problem, the undisturbed block of soil was well performed, and the soil was characterized as homogenous. Thus, the tests proved to be a good alternative, efficient for the determination of resistance parameters of contaminated compacted tropical soils. For this tropical soil the results were positive, but it is not possible to affirm that other tropical soils, with different proportions of sand and clay, will have the same behavior.

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The Effect of the Seawater Treatment on the Thermal and Morphological Properties of Oil Palm Empty Fruit Bunches Filled Poly (vinyl alcohol)

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Abstract— Since Malaysia and the surrounding of the South East Asian countries has developed a large amount of oil palm EFB as a waste product after being processed as a fuel or other application, thus oil palm EFB fibre has displayed great potential as reinforcing material in polymer. The aim of this study to characterize the morphological and thermal effects of the seawater treated of oil palm empty fruit bunch single fibres and composites. The fibres of oil palm EFB has been treated using seawater from Pulau Tiga, at day-3 until day-30, the different filler loading of 1%, 3% and 5% of untreated and treated composites were prepared using casting method. The thermal properties of the composites of untreated and seawater treated were analysed using Thermogravimetric Analysis (TGA). Based on the thermal effect, Pulau Tiga composites have the good thermal stability due to the highest onset temperature. The morphological examined using Scanning Electron Microscopy (SEM). The morphological changes enhanced with the seawater treatment, however, at the filler loading of 5%, the composites easily cracked with more voids detected. In conclusion, seawater treatment significantly improved an extra enhancement in thermal stability and the morphological changes improved with the seawater treatment at 1% of the fibre loading.

Keywords— Empty fruit bunch, sea water treatment and polyvinyl alcohol.

I. INTRODUCTION

Polymer composites have been recognized in hundreds of new applications from sports equipment to Jet Ski, airplane body component, missile, spacecraft and marine applications. Further application include transportation, chemical equipment and machinery construction, electrical and electronics tools, fishing rods and storage tanks. Past research performed on the study of the oil palm fibre composites filled with both thermoset and

thermosetting polymers. Other application include transportation, chemical equipment and machinery construction, electrical and electronics tools, fishing rods and storage tanks.

The studies focused on the electrical, thermal, mechanical, physical, and biodegradation properties (Shinoj *et al.*, 2011). Currently, poly(vinyl alcohol) (PVA) resin plays an important role in the plastic industry as the core constituent for the manufacturing of composites. PVA is a synthetic polymer, which is biodegradable and biocompatible, which has great mechanical properties in application of tissue engineering (Ngadiman *et al.*, 2015). A numerous of studies have been finished utilizing existing fibre surface treatment strategies to improve the interfacial bonding properties of diverse natural fibre reinforced composites (Sreekala and Thomas, 2003; Herrera-Franco, 2005; Van de *et al.*, 2003). Conversely, only a few studies have completed in turn to find a new biological-based treatment that can to hunt down another organic-based treatment that can replace the chemical treatment. As the alternative, seawater treatment can be used to improve the mechanical properties of the biocomposites.

The objective of this study is to characterize the thermal and morphological properties of the sea water treated composites of oil palm empty fruit bunches filled with polyvinyl alcohol.

II. MATERIALS AND METHODS

The methodology of the research comprises of two main parts of the preparation of the composites and the characterization of thermal and morphological properties using Thermogravimetric Analysis (TGA) and Scanning Electron Microscopy (SEM). The preparation of composites involved the fabrication of composites of Oil palm EFB filled poly(vinyl alcohol) (PVA) using casting method. Oil palm empty fruit bunches were collected

from Beaufort, Sabah, Malaysia, it is used as a filler. The oil palm EFB fibers were brownish in color with an average 0.175 ± 0.073 mm. The matrix used was poly(vinyl alcohol). The oil palm EFB composites of untreated and treated were prepared based on the blending formulation shown in **Table 1**. PVA powder (5-10 g) mixed with distilled water and diluted on hot plate at the consistent temperature of 90 °C for 2 h until it fully dissolved and became viscous and transparent. Untreated and treated EFB were milled at the size of ± 3 mm and transferred on the PVA solution for three different

loading of 1%,3% and 5%, the mixture of filler and polymer placed in open mould with dimension (24 cm length x 12 cm width x 1 cm thick) and dried consistently at room temperature for 3 days. Lastly, the composites were cured over-night by compressing the top with the glass plate in order to maintain the uniform thickness and prevent bubbles produced in the samples. Seawater that used for the fiber treatment was taken from Pulau Tiga, Sabah, Malaysia. The seawater was located at South China Sea. The research area lies on the latitudes of 5°71' N and 5°80' N.

Table.1: Blending formulation of oil palm EFB on the respective fillers loading.

Component	PVA (g)	Distilled Water (mL)	Oil Palm EFB (treated) /g	Oil Palm EFB (untreated) /g
Neat	10.0	100.0	-	-
1%	9.0	90.0	1.0	1.0
3%	7.0	70.0	3.0	3.0
5%	5.0	50.0	5.0	5.0

III. RESULTS AND DISCUSSION

Thermogravimetric analysis of oil palm empty fruit bunches (EFB) filled poly(vinyl alcohol) (PVA) were studied as a function of percentage weight loss with temperature and shown in **Fig. 1** and **Fig. 2**. Generally, incorporation of plant fibers into polymeric matrix increases the thermal stability of the system. Increased thermal stability was also confirmed by the decrease in the activation energy of the composites (Shinoj *et al.*, 2011).

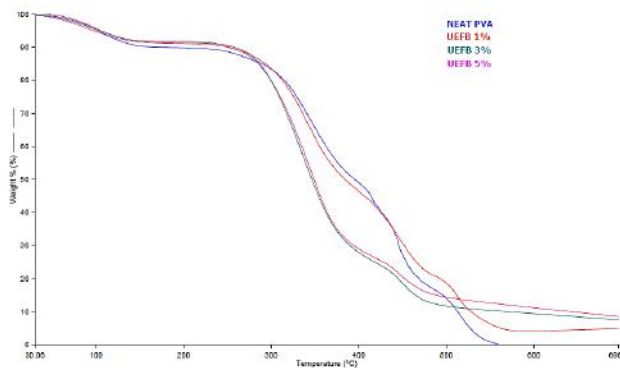


Fig.1: TGA of neat PVA and untreated oil palm EFB fibre filled PVA composite

The initial temperature, temperature at 50% of loss weight (maximum temperature) and final temperature the of composites are recorded at **Table 2**. The decomposition of neat PVA started at temperature of 30.28 °C and the final degradation occurred at 561.08 °C with maximum

temperature at 50 % of decomposition happened at 395.24 °C. The untreated composites at 1% fibre loading start to decompose at the temperature of 30.39 °C followed by 30.06 for 3% and 5% fibre loading. The maximum degradation of the composites of 1, 3 and 5% fibre loading occurred at 384.32, 346.40 and 348.87 °C with the final temperature of 697.11, 696.58 and 696.49 °C respectively. The final temperature for the composites of Pulau Tiga recorded at the range of 697.10 until 697.32 °C, which is a little high that temperature at which neat PVA concluded degradation. The polymer interaction of interchain and intrachain of PVA makes it partially crystalline-structured polymer due to the H-bonding in between hydroxyl groups (Gaaz *et al.*, 2015).

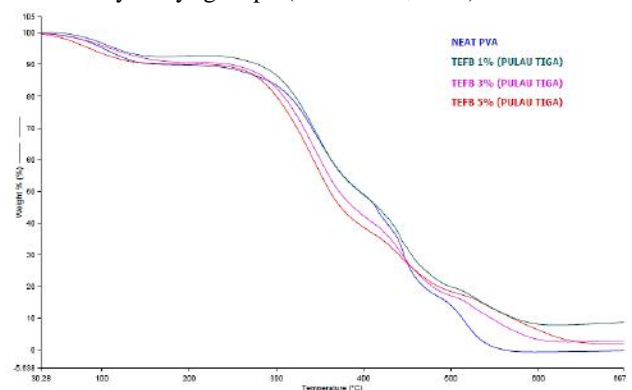


Fig.2: TGA of neat PVA and seawater treated (Pulau Tiga) oil palm EFB fibre filled PVA composite.

Table.2: Initial temperature, temperature of 50% weight loss and maximum degradation temperature of neat, untreated and seawater treated of oil palm EFB composites at different fibre loading.

	Filler loading (%)	*T _i (°C)	**T _{50%} (°C)	***T _f (°C)
Neat PVA	0	30.28	395.24	561.08
Untreated	1	30.39	384.32	697.11
	3	30.06	346.40	696.58
	5	30.06	348.87	696.49
Pulau Tiga	1	30.38	394.28	697.10
	3	30.30	371.32	697.24
	5	30.64	365.27	697.32

*T_i initial temperature, **T_{50%} temperature at 50% weight loss and ***T_f final temperature

As can be observed, the fibre loading had a very small impact on the composites melting temperature than neat PVA with 395.24 °C. In contrast to neat PVA, the T_{50%} of the composites decreased as the fibre loading increased. This indicates that the thermal stability of neat PVA increased with the addition of oil palm EFB fibre at 5% fibre loading. More heat energy absorbed by a filler in the melting of the composites (Essabir *et al.*, 2016).

The surface morphology of the untreated and seawater composites at different fibre loading shows at the Figure 3 (a), (b), (c), and Figure 4 (a), (b), (c) respectively. From Figure 3 (a), the untreated oil palm EFB composites at 1% filler loading shows the oil palm EFB fibre disengaged from the surface of matrix, as a result of weak interfacial adhesion and cracks that formed on the matrix surface. The cracks observed from the oil palm EFB composites filled PVA cause the oil palm EFB fibre to pull out from the matrix and thus causing a failure. This damage can be overcome by right composition of PVA matrix with a right filler loading of oil palm EFB fibres (Sathish *et al.*, 2015).

This observation demonstrates that the untreated oil palm EFB fibre has poor interaction with the matrix. The cementing materials at the surface of untreated oil palm EFB fibre composites also contribute to the unsuccessful fibre-matrix bonding and poor wetting (Jayaramudu *et al.*, 2014). As been shown in Fig. 3 (b) and (c), it can be observed that the formation of holes as well as the fibre pull out from the matrix.

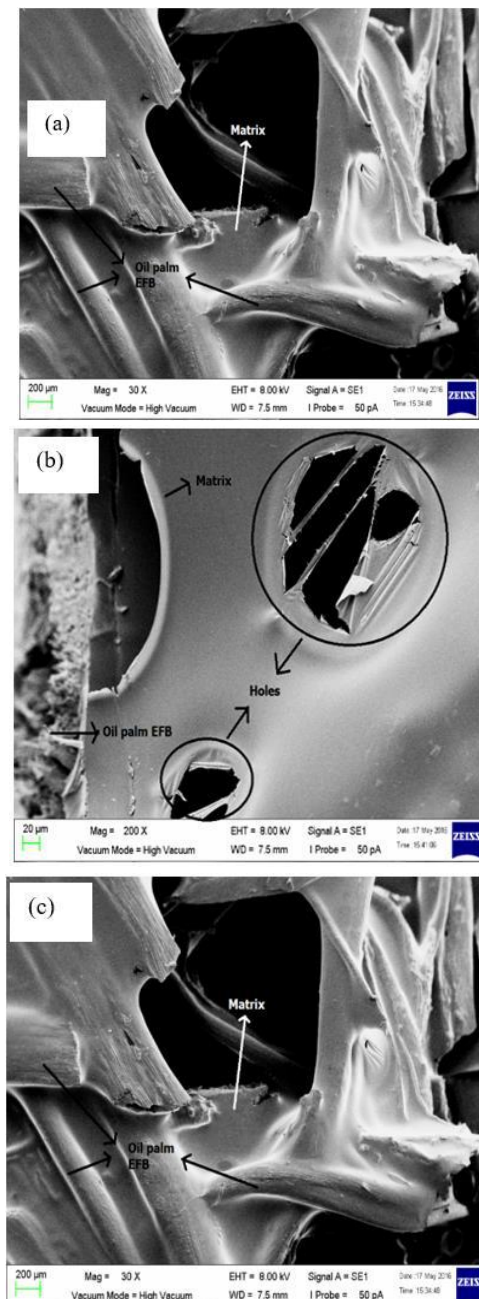


Fig. 3: SEM micrograph of untreated composites of different filler loading (a)1%; (b)3%; (c)5%.

Seawater treated composites of Pulau Tiga are shown in Fig. 4, at different fibre loading of 1, 3 and 5%. Fig. 4(a) shows that the oil palm EFB fibres attached smoothly to the matrix, this can be concluded that the interaction of the oil palm EFB fibre and the fibre matrix at the fibre loading of 1% gives good interfacial bonding, which gives the highest tensile strength among all the composites.

The oil palm EFB fibres shows good intact with the PVA matrix, these suggest that there is good wetting of the fibres by PVA matrix. In addition, less holes and cracks observed at the surface of matrix at the Fig. 4(b), this indicates better interfacial bonding between the fibre and matrix. Fig. 4(c) indicated that the surface of seawater composites shows a fibre breakage instead of fibre pull-out, which indicates better interfacial strength between the matrix (Annie *et al.*, 2008).

At the filler loading at 5% the tensile strength declined as there is a holes indicated at the fibre surface. However, the strong interaction between the fibre and matrix confirmed by the present of the fibre pull-out from the matrix as well as the crack formation by the force. This may be due to the hydrogen bonds that formed within the hydrophilic surface groups of the oil palm EFB fibre and the oxygen-containing species in the PVA matrix (Alzeer and Mackenzie, 2013).

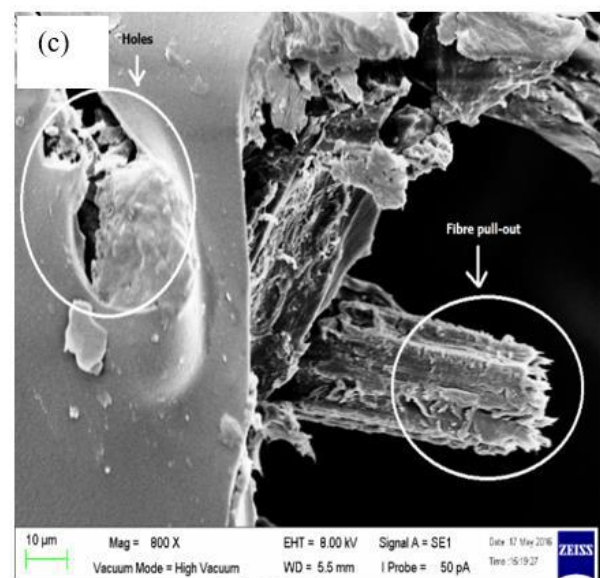
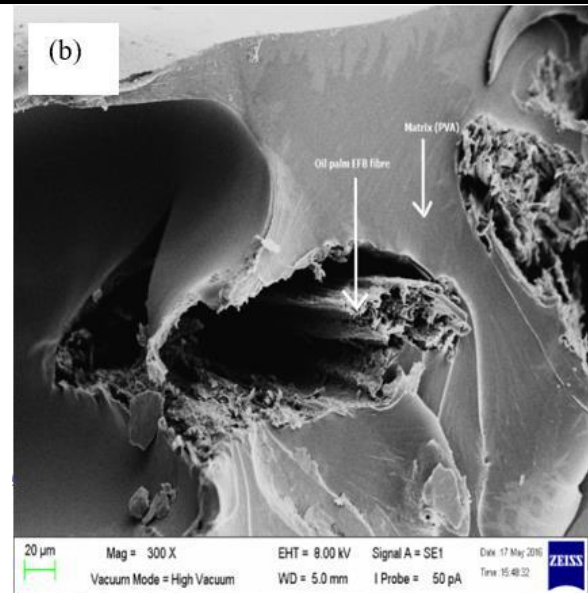
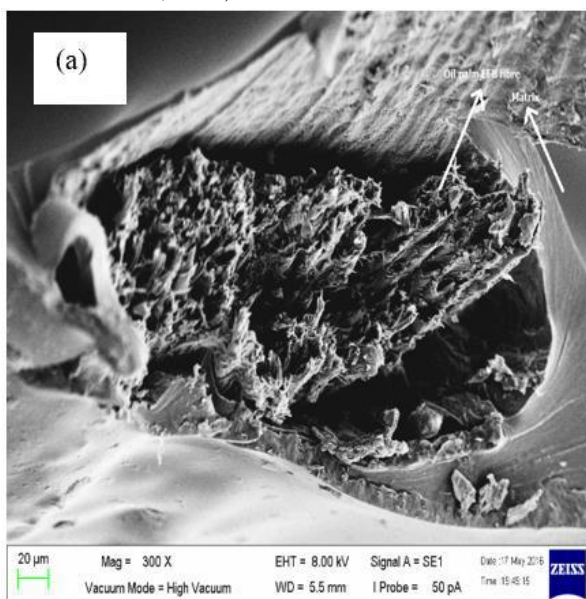


Fig. 4: SEM micrograph of treated composites of different filler loading (a)1% ; (b)3% ; (c)5%.

IV. CONCLUSION

Seawater treatment can be used as nature treatment of the fibre that bring to the same result as the chemical treatment such as alkali treatment. The composites of the untreated and treated filled PVA was fully fabricated. The characterization of the composites was characterized Scanning electron microscopy (SEM) and Thermogravimetric analysis (TGA). The morphological properties of single fibres and composites were clearly showed upon the treatment. The seawater treated single fibres has smooth surface than the untreated single fibres, this is due to the removal of the outer layer of hemicellulose, lignin and pectin. The seawater treated composites shows the good interfacial bonding with the PVA matrix than the untreated composites. The thermal

stability of the composites enhanced as the fibre loading increased at 5%. Seawater treatment can be used as the alternative to replace the chemical treatment of the fibres due to the same effect arise from the treatment.

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Regional Development and the Indicators for Mapping of Local Productive Arrangements of Rondônia (Brazil)

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Abstract—This is a documental research, whose main objective is to present indicators for a new mapping of Local Productive Arrangements (APLs) in Rondonia and, specifically, discuss the dynamics of reference data and its importance to the investment policies with a view to regional development. The data were calculated from tables of the Annual List of Social Informations (RAIS, 2012), presented by the Regional Secretariat of the Ministry of Labor and Employment (MTE) (BRAZIL, 2014), and by census of vegetal extraction, agriculture and sylviculture available on the IBGE website, relative to 2013. It was observed that most of the APLs identified in previous studies have not been confirmed by the data of the RAIS and of the IBGE. From these data, we identified more than 100 potential APLs in the State, while are currently presented only 18. The cattle breeding, for example, appears in the previous studies restricted to a microregion only, but it is significant in seven of the eight microregions of the State. Are also quite significant the production data of fruit and fish, among other products, confirming a diversified economy in the agricultural sector; in the secondary sector, however, there are few references, most notably in larger businesses involving wood, civil construction, and strictly in Porto Velho, electricity. It is suggested to be made larger investments for APLs studies in the State, including for full mapping not only per Microregion, but also by the city, in order to identify best opportunities, fill the gaps, offer support and strengthen the endeavors. There is much that can be allocated as resource in the Multi-Annual Plans of State.

Palavras-chaves— APLs. Indicators. Regional development.

I. INTRODUCTION

A local productive arrangement (APL, in Brazil and on this paper) is more than a cluster or “enclave”,

because it does not always correspond to an industrial agglomeration and is not limited to a aggregate of economic organizations “incrusted” in a territory, although considered the interaction, interdependence or even cooperation between the elements that compose it — conditions not necessarily always present but expected or encouraged by government agencies or leaders who require governance. The terminology, evolved for Productive Arrangement, Cultural and Local Social is therefore much more complex and complete. According to Costa (2010, p. 126-127), a APL is a “[...] social, economic space, historically constructed through an agglomeration of companies (or producers) similar and/or strongly interrelated, or interdependent, that interact in a local spatial scale defined and limited by flows of goods and services.” An APL can be defined also as a group of companies or producers with common activity in the interrelation process and with sufficient representation on its territory to indicate the market trend or development condition that stands out in relation to other endeavors or forms of economy.

The Permanent Working Group for Local Productive Arrangements (GTP APL), of the Ministry of Development, Industry and Foreign Trade (MDIC), (BRAZIL, 2007), identified 460 APLs in 2004 and 957 in 2005 in the Country. Costa (2010) presented the mapping of 958 by MDIC and 762 by the Institute of Applied Economic Research (IPEA). The Brazilian Observatory site of APL (OBAPL) inserted in the Portal of the Brazilian Institute for Information in Science and Technology (IBICT), the Ministry of Science, Technology and Innovation (BRAZIL, 2015), updated these numbers to 714, distributed by region: in the North, 126; in the Midwest, 111; in the Northeast, 197; in the Southeast, 191; in the South, 89. For Rondonia, according to Costa (2010), the MDIC pointed 13 APLs, and the

IPEA, 21. It is observed, therefore, a considerable disparity of indicators of all APLs between the two institutions. Currently, the website of the OBAPL (BRAZIL, 2015) points 18 in the State.

Over time, some arrangements may disappear, while others arise, reason why is important to keep an observatory and studies for timely mapping of the arrangements, considering inclusive by microregion or city. In general, APLs are treated by geographical regions or state, neglecting the minor arrangements that are developed locally. Research must focus on microregions, justly to not despise local demonstrations or take only national parameters of reference to the definitions, classifications and subsequent interventional actions. Thus, a state matrix is much more interesting than a national as parameter, given the high concentration of business in metropolitan areas or of more advanced development and low concentration or lower diversity in the peripheral regions and of less expressive development. There is often a minor specialization in areas of greater concentration and diversity of business and a super-specialization where there is less diversity and more rarefied distribution of indicators, in relation to the volume of employment and endeavors. This happens when the comparative basis are in these two opposite conditions of concentration, as would be on a relationship between the national matrix and the of less developed states.

Given the lack of an updated mapping and presented the importance of lifting APLs from the perspective of regional parameters, the objective of this study is to present indicators for a new mapping of APLs in Rondônia/BR and specifically discuss the dynamics of the data of reference and its importance to the investment policies with a view to regional development.

II. CURRENT APLs MAPPING IN RONDÔNIA STATE

Changes in the quantity and types of APLs in the State came happening since beginning of the presentation of demonstratives. Some are expected, due to the dynamics of the arrangements, which appear and disappear over time, but others stem from the fragility of mapping studies. While Costa (2010) indicated 13 APLs from MDIC studies or 21 according the IPEA, the NEAPL (RONDÔNIA, 2012) indicated 13. According the IBGE table (BRAZIL, 2012) entitled “General data of industrial local units of enterprises with 5 or more persons employed, by Federation Units, by activity divisions — North Region — 2012”, Rondônia has been outstanding in low-tech sectors. On dimension of the extractive industry, the extraction of metallic minerals and non-

metallic are highlight, considering that the first activity comprises 13 local units with 422 persons employed, and the second, 38, whose occupational quantity is not indicated. On dimension of the manufacturing industry, stand out “manufacture of food products”, with 244 units and 14.887 people employed; the “manufacture of wood products”, with 325 enterprises and 6.149 employed persons; and the “manufacture of non-metallic materials”, with 143 units and 3.042 employees. Can also be highlighted the “maintenance, repair and installation of machinery and equipment”, the “manufacture of beverages”, the “making of clothing items and accessories”, the “manufacture of metal products, except machinery and equipment”, the “metallurgy” and the “manufacture of furniture”, according to the total of quantitative indicators. Are incipiente the activities that require technology, such as in the manufacture of chemical products or of machines, equipments and appliances.

Some of these activities with larger volume of endeavors and occupied persons already consolidate APLs in the State, such as the furniture industry. However, as Rondonia has agricultural economy profile, should be considered more informations to better map the arrangements. Currently, the Brazilian Observatory of APLs (OBAPL) (BRAZIL, 2015) indicates 18 APLs in Rondônia, according to box 1, below.

Are considered three APLs of pisciculture, located in Porto Velho, Ariquemes and Pimenta Bueno, grouped as Fishing, Aquaculture and Related Services; two of Furniture Industry in Ariquemes and Ji-Paraná; two of Fruticulture in Porto Velho and Cacoal; one of Agroforestry Systems, in Ouro Preto do Oeste; one of Sociobiodiversity and other of Tourism in Guajará-Mirim; one of Coffee Culture in Cacoal; one of Apiculture in Vilhena, and one that appears as Agriculture/Apiculture in Porto Velho; one of Cattle raising of Milk in Ji-Paraná; two of Confections in Pimenta Bueno and Porto Velho; one of Hortigranjeiro in Porto Velho; and one of Handcraft in Porto Velho, classified as Creative Economy. Are presented, therefore, eight municipal poles, most distributed along the BR 364¹.

¹ Highway connecting the north and, mainly, the Midwest of Brazil.

Box 1 — Local production arrangements according NEAPL/RO, in 2015.

APLs	Polos	Municipalities Covered
Wood and Furniture (1)	Ariquemes	Ariquemes, Rio Crespo, Monte Negro, Alto Paraíso, Cacaulândia, Itapuã do Oeste, Cujubim, Buritis, Machadinho do Oeste
Wood and Furniture (2)	Ji-Paraná	Not indicated
Pisciculture (1)	Porto Velho	Porto Velho, Costa Marques e Pimenteiras do Oeste
Pisciculture (2)	Ariquemes	Ariquemes, Rio Crespo, Machadinho do Oeste, Monte Negro, Alto Paraíso, Cujubim, Campo Novo de Rondônia, Cacaulândia, Buritis, Theobroma, Jaru
Pisciculture (3)	Pimenta Bueno	Pimenta Bueno, Espigão do Oeste, Cacoal, Nova Brasilândia do Oeste, Vilhena, Rolim de Moura, Ministro Andreazza
Fruticulture (1)	Porto Velho	Porto Velho, Candeias do Jamari, Cacaulândia, Cujubim
Fruticulture (2)	Cacoal	Cacoal, Rolim de Moura, Presidente Médici, Alta Floresta do Oeste, Ministro Andreazza, Espigão do Oeste, Alto Alegre dos Parecis, Vilhena, Pimenta Bueno
Sociobiodiversity of the Mamoré	Guajará-Mirim	Guajará-Mirim and Nova Mamoré
Agroforestry Systems of Ouro Preto	Ouro Preto do Oeste	Ouro Preto do Oeste, Theobroma, Ji-Paraná, Nova União, Mirante da Serra, Urupá, Presidente Médici
Coffee Culture	Cacoal	Cacoal, Rolim de Moura, Alta Floresta do Oeste, Ministro Andreazza, Espigão do Oeste, São Felipe do Oeste, Nova Brasilândia do Oeste
Agriculture/Apiculture	Porto Velho	Porto Velho, Ariquemes, Cacaulândia, Cujubim, Candeias do Jamari
Tourism	Guajará-Mirim	Guajará-Mirim and Nova Mamoré
Cattle raising of Milk	Ji-Paraná	Ji-Paraná, Jaru, Presidente Médici, Alvorada do Oeste, Urupá, Ouro Preto do Oeste, Castanheiras
Confections (1)	Porto Velho	Porto Velho
Confections (2)	Pimenta Bueno	Pimenta Bueno, Cacoal, Rolim de Moura, Alvorada do Oeste
Handcraft	Porto Velho	Porto Velho, São Francisco do Guaporé, Ariquemes, Vilhena, Rolim de Moura, Ji-Paraná, Cacoal
Hortigranjeiro	Porto Velho	Porto Velho and Candeias do Jamari
Apiculture	Vilhena	Vilhena, Colorado do Oeste, Cerejeiras, Pimenteiras do Oeste

Source: NEAPL-RO/OBAPL (BRAZIL, 2015)

In comparison with demonstrative of Costa (2010) from MDIC data, there are many differences, because does not appear anymore the APLs of the Rice, of the Soybean and of the Wood and Furniture of Vilhena; the of the Red Ceramics and of the Sheep and Goat Criation, in Porto Velho; the of the Fruticulture of Ariquemes and Ji-Paraná; and the of Cocoa, of Ji-Paraná. In relation to the demonstrative of the IPEA, there is an almost complete replacement, because only two remain on the map of the OBAPL (BRAZIL, 2015), the of Wood and Furniture of Ariquemes and the of Confections of Porto Velho. Already the five priority APLs of planning of the NEAPL (RONDÔNIA, 2007 a, b, c, d, e) remain indicated.

III. METHOD AND TECHNICAL RESEARCH

According to the objectives, the research is quantitative and qualitative, to present databases systematized per Microregion of the State, with an analysis of their expression and application possibilities for intervention policies or opening and business growth. According to the procedures, this is a documental research restricted to the data of employability and production of the primary and secondary sectors of the economy of Rondônia, from demonstratives of the Annual Relation of Social Information (RAIS/2012) of the Ministry of Labor and Employment (MTE) — according to its Regional Secretariat for Labour and Employment (SRTE) (BRAZIL, 2014) — and the census

of the Brazilian Institute of Geography and Statistics (IBGE) (BRAZIL, 2013). For comparative analysis, were used the data of Costa (2010), involving demonstratives of APLs of the studies of the Ministry of Industry, Development and Foreign Trade (MDIC) and of the Institute of Applied Economic Research (IPEA).

1.1 MAPPING ACCORDING TO EMPLOYABILITY DATA OF THE MTE

Due to the large informality of manpower in Brazil, as notably in Rondonia, the mapping of APLs requires different matrices of data to be related, crossed or compared. The employability matrix of RAIS, presented by the Regional Secretariat of the Ministry of Labor and Employment (SRTE/RO) (BRAZIL, 2014), on e-mail dated of April 28, 2014, indicates the volume of endeavors and persons employed during the year of 2012,

in Rondônia. The distribution of indicators by microregion was systematized in auxiliary tables, which helped to compose the synthesis of the results. Was involved in the study the calculation of the locational quotient (QL), the representativity percentage of the sector as to the number of jobs for the microregion (PRE/M) and the volume of direct and associates business. Are understood as direct business the endeavors that develop certain listed activity in the National Classification of Economic Activities (Class CNAE 2.0), presented by the IBGE (BRAZIL, 2007) and, as associates, those who have commercial, managerial or institutional relationship, as the industry dairy linked to cattle breeding bovine. Table 1 lists the main sectors of employability and their relative representation by sector in the State.

Table 1 — Personal volume occupied in Rondônia in the main sectors — RAIS 2012

Order	Type of venture (Class CNAE 2.0)/Occupancy rate	Total in the State	PRE of the Sector in the State
1	Public administration in generally	110.713	30,32
2	Artworks for generation and distribution of electricity and telecommunications	23.327	6,39
3	Slaughter of quadrupeds, except pigs	9.373	2,57
4	Retail trade of general merchandise, especially food products — hypermarkets and supermarkets	9.341	2,56
5	Bovine breeding	8.269	2,26
6	Retail trade of apparel and accessories	7.330	2,01
7	Construction of buildings	6.376	1,75
8	Retail trade of iron materials, wood and building materials	6.385	1,75
9	Vigilance and private security activities	5.865	1,61
10	Restaurants and other food service and drinking establishments	5.470	1,50
11	Trade of parts and accessories for motor vehicles	5.058	1,39
12	Unfolding of wood	4.798	1,31
13	Justice	4.569	1,25
14	Road freight transport	4.258	1,17
15	Retail trade of pharmaceutical products for human and veterinary use	4.232	1,16
16	Retail trade of fuels for motor vehicles	3.990	1,09
17	Retail trade specialized furniture, bedding and lighting equipment	3.388	0,93
18	Construction of special artworks	3.142	0,86
19	Higher education — graduate and post graduate	3.153	0,86
20	Assembly of industrial plants and metal structures	3.063	0,84

* PRE = Relative participation of the employability of the sector in the State (in %)

Source: Self elaboration, with data of the SRTE/RO (BRAZIL, 2014)

The “Administration public in general” is the sector that more focuses occupied people, according to data from RAIS/2012 to Rondônia. Were 110.713 employees at the

rate of 30,32% of occupancy. This follows, in part, of a fragmentation of the State in 52 municipalities, which

largely has not developed a potential of diversified productive chain or more intensive yet.

In following the 20 cases presented, included the works for generation and distribution of electric energy and telecommunications, with 23.327 employees (6,39% of total), the slaughter of quadrupeds, that do not include pigs (2,57%), the retail of general merchandise in which predominate the food products of hyper and supermarkets (2,56%) and the cattle breeding bovine (2,26%). A total of 11 of the 20 selected sectors are repeated as the most representative in the allocation of volume of projects and volume of employed persons, featuring a pointing logic of business trends in the State. It must be noted that the second business of the table, in volume of employment, consists in a referential that will lose much of representativity when are completed the main works of the hydroelectric plants located in Rondônia.

The locational quotient was calculated by the following formula, adapted from Crocco et al. (2003) and suggested by Costa (2010):

$$QL = \frac{E_j^i / E_j}{E_{RO}^i / E_{RO}}$$

E_j^i = Employment in the Sector i in the Microregion j

E_j = Total employment in the Microregion j

E_{RO}^i = Employment in the Sector i in Rondônia

E_{RO} = Total employment in Rondônia

Here the national matrix, of comparative base for the ascertainment of the manifestations of productive arrangements, was replaced by the state matrix, given the large differences of populational concentration, employability and business in relation to other states, such as São Paulo, whose density is disproportional to the data collected in Rondônia. Thus, a national basis would become smaller local indicators of the industry, for example, or would increase data of the agricultural sector, especially about creation of cattle breeding. As the formula adjust to the choices of the researcher as to the dynamics of its corpus, the replacement of the national matrix by the statewide shows to be appropriate to the studies developed for this article.

Employability sectors were selected (a) with the best locational quotient rates, but after definite (b) a cut from 1% of representativity in the sector in the Microregion and (c) the volume of at least 10 business or direct enterprises. Some items with volume of employability inferior to cutting patterns in the relation sector/microregion remained when other data, combined,

thereby justified in terms of representativity or importance.

1.2 MAPPING ACCORDING WITH DATA OF AGRICULTURE AND LIVESTOCK FARMING PRODUCTION AND EXTRACTIVE OF IBGE

Unlike the sectors of industry, commerce and services, whose reference (volume of persons employed) is quite specific and generic, the agriculture and livestock production data, silvicultural and extractive varies according the volume of production, unit of measure (kg, t, m³, l), the geographical occupation and market prices, as well as there is much informality in manpower occupation, so that the employability factor does not provide enough informations. Thus, it was obtained a specialization index (IE), which reflects the distribution of production in relation the territorial dimension of the region researched. To better understand this index (for microregion or city), we must confront the relative participation of production of each item (cattle breeding, manioc, orange, etc.) of the region in the state (Pr/Pe) with the relative territorial dimension (Tl/Te), similarly to the investigation of the locational quotient, thus:

$$IE = \frac{Pr/Pe}{Tl/Te}$$

Pr/Pe = Production in the region divided by the production of the State per item

Tl/Te = Local territory (em km²) divided by the total territory of the State

The indicators obtained by means of the calculations of this formula can be used to support other forms of mapping the APLs and, at the same time, subsidize the analysis of the regional development in face of public policies and others conditions of intervention. IE equal to or greater than 1 indicates specialization in setting arrangements, but, associated with the percentual representation of the local production in face of the production of the State, reflects better the results.

IV. SUMMARY OF THE INDICATORS

The mappings of productive arrangements through the locational quotient combined with the representation indices and volume of direct and indirect business are very efficient; however, in view of informality, which affects mainly the agriculture and livestock farming sector, were necessary other quantitative and qualitative measures for the demonstration of APLs of the State, with update. As this sector it could not therefore use employability as a reference, it was necessary to consider the volume of

production, the representation per sector in the State and the index of specialization in face of the territorial extension of each Microregion.

Despite the informality, it is observed in the IBGE data (BRAZIL, 2010) that the highest volume of the employed persons of Rondonia is in the sector of the agriculture and extrativism (11,88%) and in the skilled work of the agriculture, livestock farming and of the forestry extraction (8,40%). Are highlighted also the elementary occupations (9,46%) and trade and repair of cars and motorcycles (8,3%). In the industry sector, yet according to the IBGE (BRAZIL, 2012), the largest volume of local enterprises units is of the dairy industry, bovine meat, besides skin and leather of bovine and equine. The majorith of the products that are highlighted belong to the categories of “unprocessed” and low technology, with productivity in most cases much lower than expected. This information is important to define the methods and qualitative analysis of the data, in mappings.

The identification of APLs, in Rondônia, was given formally in 2007, when were drafted Preliminary Development Plans (PDPs) by the SEPLAN on request of the MDIC. However, the appointments were limited to only five priority APLs. Studies of Costa (2010) revealed new mappings of the MDIC and of the IPEA, with many differences between them. Currently, the NEAPL/RO keeps, in the website of the OBAPL (BRAZIL, 2015), 18 mapped APLs, but it was noted that the apresentação list does not include all the arrangements and it exceeds in some indications.

In studies of the employability expressed in the RAIS/2012 (BRAZIL, 2014) and of the volume of extractive production, silvicultural and of the agriculture and livestock farming provided by IBGE (BRAZIL, 2013), were not confirmed the APLs Rice (Vilhena), Red Ceramics and Confections (Porto Velho), and Wood and Furniture (Ji-Paraná and Vilhena), indicated by Costa (2010) from MDIC data; were not confirmed also all those indicated by the same author from the informations of the IPEA, except Wood and Furniture (Ariquemes). Were not confirmed, finally, 9 of the 18 APLs that appear related by NEAPL/RO in the website of the OBAPL (BRAZIL, 2015), namely: Wood and Furniture (Ji-Paraná), Sociobiodiversity of Mamoré, Handcraft and Tourism (Guajará-Mirim), Agroforestry Systems (Ouro Preto do Oeste), Confections and Hortigranjeiros (Porto Velho), Confections (Pimenta Bueno).

Four of the five priority APLs presented by GTAPL of the MDIC (BRAZIL, 2007) were confirmed in this study, staying of out the of Apiculture, of Porto Velho. Among the 13 listed by NEAPL between 2008 and 2012, were not confirmed Agroforestry Systems (Ouro

Preto do Oeste), Confections (Pimenta Bueno and Cacoal), Hortigranjeiros (Porto Velho) and Tourism and Sociobiodiversity of the Region of the Madeira-Mamoré (Guajará-Mirim). From among the 18 that the same NEAPL points out in the website of the OBAPL (BRAZIL, 2015), also were not confirmed as the volume of occupation and business, in addition to those already mentioned for the previous case, the APLs Wood and Furniture (Ji-Paraná), Agriculture/Apiculture (Porto Velho) and Handcraft (Porto Velho), classified in the Preliminary Development Plans (PDPs). One has to consider, in the case of the Handcraft, whose manpower is also quite informal, the lack of specific data for the sector in the information matrices of the RAIS/2012 and the IBGE. In view the volume of occupied personal that the Development Plan of the SEPLAN/RO (RONDÔNIA, 2014) presents, the APL Handcraft should be considered.

In industry, the number of local units, according to IBGE (BRAZIL, 2012), was more significant in sectors such as fabrication of food products (244), manufacture of clothing and accessories (77), manufacture of wood products (325), manufacture of non-metallic mineral products (143) and furniture fabrications (67), among others. Thus, the indicators relative for these sectors, obtained from RAIS/2012 (BRAZIL, 2014), should be highlighted. The six sectors that the RAIS indicates with higher volume of employment are the constructions for generation and distribution of electricity and for telecommunications (23.327), the slaughter of quadrupeds, that do not include pigs (9.373), the trade predominantly of food in supermarkets and hypermarkets (9.341) — in addition to this same indicator in smaller markets —, the bovine cattle breeding (8.269), retail sales of articles of clothing and accessories (7.330) and construction of buildings (6.376). However, trade and services do not constitute, in themselves, productive arrangements — just configure an interrelationship scenario with the respective sectors, appearing much more like business associates, in view of they usually involve common activities of all cities and are more in the ambit of maintenance than of production. Exception occurs for large business chains, but that does not appear in the information matrices in analysis.

Box 2 below is a new proposed of indication of possible APLs in the state, from the two matrices of data: RAIS/2012 (BRAZIL, 2014), that covers mainly the industry, trade and services; and the production demonstratives of the IBGE (BRAZIL, 2013), of the scope of the vegetal extraction, forestry and of the agriculture and livestock farming. It remains to observe, in the field, the relations of production, interaction, cooperation and learning.

A total of 109 agglomerations in the state for analysis of the existence of APLs were identified. In all the regions, the primary sector had the largest volume of indications, in reason of agricultural production. Fruticulture, culture of the manioc, pisciculture, poultry

culture and cattle breeding of meat and milk, especially, are a constant in all regions. The secondary sector shows up little, except for activities involving wood and building construction.

Box 2 — APLs update in Rondônia, according to data the RAIS/2012 and the IBGE (2013)

Meso-region	Micro-region	Possible APLs
Madeira-Guaporé	Porto Velho	Primary sector: 1) Products of the sociobiodiversity; 2) Extraction of wood in logs; 3) Fruticulture; 4) Culture of the peanut; 5) Culture of the manioc; 6) Pisciculture; 7) Aviculture: quails; 8) Caprinocultura; 9) Cattle breeding: bubaline Secondary sector: 10) Generation and distribution of electricity; 11) Construction of buildings; 12) Handcraft*
	Guajará-Mirim	Primary Sector: 1) Cattle raising meat and milk; 2) Sociobiodiversity products; 3) Coagulated latex production; 4) Annatto production; 5) Pineapple production; 6) Sheep breeding Secondary sector: 7) Wooden unfolding
Leste Rondoniense	Ariquemes	Primary Sector: 1) Cattle raising of meat and milk; 2) Tin ore extraction; 3) Guarana seed extraction; 4) Extraction of wood in logs and firewood; 5) black Production of kingdom pepper; 6) Fruticulture; 7) Coffee culture; 8) Rice culture; 9) Culture of the manioc; 10) Pisciculture; 11) Caprine and sheep breeding; 12) Poultry farming: chickens; 13) Pig farming; 14) Apiculture Secondary sector: 15) Wood and Furniture; 16) Construction of buildings
	Ji-Paraná	Primary Sector: 1) Cattle raising of meat and milk; 2) Forestry; 3) Fruticulture; 4) Palm production; 5) Annatto production; 6) Culture of the manioc; 7) Production of beans; 8) Horticulture: tomato; 9) Caprine and sheep breeding; 10) Pig farming; 11) Poultry farming: chickens; 12) Pisciculture; 13) Apiculture Secondary sector: 14) Construction of buildings
	Alvorada do Oeste	Primary Sector: 1) Cattle raising of meat and milk; 2) Forestry; 3) Passion fruit production; 4) Coffee culture; 5) Palm production; 6) Production of kingdom pepper; 7) Rice culture; 8) Caprine and sheep breeding; 9) Pig farming; 10) Poultry farming: chickens Secondary Sector: 11) Wooden unfolding
	Cacoal	Primary Sector: 1) Cattle breeding of meat and milk; 2) Vegetable extraction of latex and palm; 3) Forestry; 4) Fruticulture; 5) Coffee Culture; 6) Production of kingdom pepper; 7) Cocoa culture; 8) Production of beans; 9) Horticulture: tomato; 10) Culture of the manioc; 11) Corn production; 12) Pisciculture; 13) Apiculture; 14) Pig farming; 15) Poultry culture: chickens; 16) Sheep culture Secondary sector: 17) Construction of buildings; 18) Wood and Furniture; 19) Not refractory ceramics
	Vilhena	Primary sector: 1) Cattle breeding of meat and milk; 2) Extraction of wood in logs; 3) Extraction of palmetto; 4) Forestry; 5) Fruticulture; 6) Cereal production (maize and sorghum); 7) Production of soybean; 8) Pisciculture; 9) Poultry culture: chickens; 10) Apiculture Secondary sector: 11) Wooden unfolding; 12) Not refractory ceramics; 13) Construction of buildings
	Colorado do Oeste	Primary Sector: 1) Cattle breeding of meat and milk; 2) Production of soybean; 3) Extraction of latex; 4) Extraction of wood in logs; 5) Forestry; 6) Annatto production; 7) Sugarcane production; 8) Production of palmetto; 9) Fruticulture; 10) Production of kingdom pepper; 11) Cereal production (sorghum, corn and rice); 12) Production of peanut; 13) Production of tomato; 14) Pisciculture; 15) Pig farming; 16) Sheep culture; 17) Apiculture; 18) Poultry culture: chickens Secondary sector: 19) Construction of buildings

Source: Own elaboration, with data of IBGE (BRAZIL, 2013) and RAIS/MTE (BRAZIL, 2014)

The non-allocation of business of the tertiary sector (trade and services) in the box does not mean they are not important, but that trade and services may not be considered as procutive arrangements by themselves. They are important in the dynamics of the existing of the APLs, because they constitute the environment in which flows the goods and, often, where does most of the demands, when the exportation is not the main “destiny” of the products. They are the result of investments in the respective sectors and, at the same time, referentials of induction of development of the APLs.

According to the Actuation Manual on Local Productive Arrangements, of the Federation of Industries of São Paulo (FIESP) and of the MDIC (2007?, p. 9), an APL

includes companies that producing final goods and services, suppliers of equipment and other supplies, service providers, commercialization companies, customers, syndicates, associations and representations and other organizations devoted to formation and human resources training, information, research, development and engineering, promotion and financing. (Our translation).

This integration (or agglomeration) is not given as something ready, drawn, established of outside, but as a trend that is taking shape and that can grow in business volume and production, also motivated by public policies and other forms of induction.

In the wholesale and retail trade sector, the food products, the clothing articles and accessories, the furniture and other utensils or decorations, the construction materials, the pharmaceutical and veterinary products, the automobiles, motorcycles and fuel and the transports involve a large volume of personnel occupation and of enterprises in all the microregions, except for only one or some in the less dense regions. In the service sector, the motorcycle workshops and automobile and the transports also following highlighted in all the regions. In Porto Velho and Cacoal, the higher education of graduate and undergraduate shows up how important reference for the strengthening of APLs, especially in view of the

presence of the Federal University of Rondônia, of the Federal Institute of Rondônia and private training institutions in level higher.

The vegetal extraction is little expressive in the microregions, except, in some cases, for the production of wood in logs, as in the microregion of Porto Velho, in which were reached 2.389.574 m³ (59,69% of the volume in the State), according the IBGE census (BRAZIL, 2013). In the primary sector, the cattle breeding of meat and milk has not been identified only in Porto Velho, which has how differential the generation and distribution of electric energy, pisciculture and fruticulture, accordance the volume of employed persons in the first case, and the diversity or varieties species, in all other cases.

When it comes to variety of business, escaping of the alleged (and false) indication of monoculture in Rondônia, or of the expectation of APL limited to the cattle breeding sector, the Microregions of Ariquemes, Cacoal and Colorado are the most diverse, with 17 to 20 possible APLs. In addition to the cattle breeding of meat and milk, the pisciculture and the horticulture appear like strong trends of the State. Alternatively, following highlighted still wood and furniture and extraction of tin ore, in Ariquemes; the coffee culture, in Cacoal; the apiculture, in Vilhena; the cereal production, in Colorado do Oeste; and soybean production, in Vilhena and Colorado do Oeste.

The handcraft is a typical activity in all regions, but, due to the large informality resulting of individual or family manpower, does not appear in RAIS records. The location of this arrangement in several centers in the Development Plan of the SEPLAN/RO (2014) is still primary, but can affirm its presence in the State. In Ji-Paraná, for example, there are institutions such as the Craftsman House, which support the activity, as well as there are public policies of investing in actions such as the organization of municipal fairs weekly.

Box 3 rearranges APLs willing in Box 2 by type and its overflow to more than one area, only to purpose of general recognition and emphasis according to business affinity between regions.

Box 3 — Simplified distribution of the APLs of Rondônia, according with RAIS/2012 and IBGE (2013)

N.	Local Productive Arrangements	Microregions
Vegetable and mineral extraction products		
1	Sociobiodiversity products	Porto Velho, Guajará-Mirim, Ariquemes, Cacoal, Vilhena, Colorado do Oeste
2	Wood logs of vegetable extraction	Porto Velho, Ariquemes, Vilhena, Colorado do Oeste
3	Tin ore extraction	Ariquemes

Temporary crops		
4	Horticulture: tomato	Ji-Paraná, Cacoal, Colorado do Oeste
5	Peanut culture	Porto Velho, Colorado do Oeste
6	Cassava culture	Porto Velho, Ariquemes, Ji-Paraná, Cacoal
7	Rice culture	Ariquemes, Alvorada, Colorado do Oeste
8	Bean production	Ji-Paraná, Cacoal
9	Corn and sorghum production	Cacoal, Vilhena e Colorado do Oeste
10	Soybean production	Vilhena, Colorado
11	Sugarcane production	Colorado do Oeste
Permant crops		
12	Fruticulture	Porto Velho, Guajará-Mirim, Ariquemes, Ji-Paraná, Alvorada do Oeste, Cacoal, Vilhena, Colorado
13	Coco aculture	Cacoal
14	Coffee culture	Ariquemes, Alvorada do Oeste, Cacoal
15	Production of condiments: pepper of kingdom and annatto	Guajará-Mirim, Ariquemes, Ji-Paraná, Alvorada, Cacoal, Colorado
16	Palmetto production	Ji-Paraná, Alvorada do Oeste, Colorado do Oeste
17	Silviculture	Ji-Paraná, Alvorada do Oeste, Cacoal, Vilhena, Colorado do Oeste
Livestock: small animals		
18	Apiculture	Ariquemes, Ji-Paraná, Cacoal, Vilhena, Colorado do Oeste
19	Pisciculture	Porto Velho, Ariquemes, Ji-Paraná, Cacoal, Vilhena, Colorado do Oeste
20	Aviculture	Porto Velho, Ariquemes, Ji-Paraná, Alvorada do Oeste, Cacoal, Vilhena Colorado do Oeste
21	Pig farming	Ariquemes, Ji-Paraná, Alvorada do Oeste, Cacoal, Colorado
Livestock: medium and large animals		
22	Goat raising and sheep breeding	Porto Velho, Guajará-Mirim, Ariquemes, Ji-Paraná, Alvorada do Oeste, Cacoal, Colorado do Oeste
23	Livestock meat and milk: cattle breeding	Porto Velho, Guajará-Mirim, Ariquemes, Ji-Paraná, Alvorada do Oeste, Cacoal, Vilhena, Colorado do Oeste
Wood, furniture and civil construction		
24	Wood and furniture	Guajará-Mirim, Ariquemes, Alvorada do Oeste, Cacoal, Vilhena
25	Civil construction	Porto Velho, Ariquemes, Ji-Paraná, Cacoal, Vilhena, Colorado
26	No refractory ceramic	Cacoal, Vilhena
Others sectors		
27	Generation and distribution of electric energy	Porto Velho
28	Handcraft	State (Rondônia)

Source: Own elaboration, with data of the IBGE (BRAZIL, 2013) and RAIS/MTE (BRAZIL, 2014)

It was decided by an organization, in this box, that was able to demonstrate, of the shape more closely possible, the production trends, but without neglecting some specificities. So, instead of generalizing the APLs of the production of cereals, for example, were separated the of the rice, maize and sorghum, beans and soy, because each has important characteristics, such as in relation to climate and space. It is observed that soybeans, for example, only is common or constitutes APL in Vilhena

and Colorado, which are contiguous and of mildest climates, in the Southern Cone of the State; other products, such as the of the fruticulture, are quite diffuse, as well as the APLs of meat and milk cattle, pisciculture and aviculture.

It was possible, by the approximation of profiles of the APLs, so define the existence of 28 APLs, different from each other, that, when replicated by region, constitute the 109 identified in box 2. Didactically, these

APLs can be taken as reference per State, per Region or per Municipality, as per the need of use. As the site of the OBAPL (BRAZIL, 2015) considers the APLs with their multiples, when they are duplicated between regions, is needed do a review of the principles of mapping adopted by its researchers, once it that the volume is much bigger. Therefore, we can not speak of the APL of the Livestock of Meat and Milk only in Ji-Paraná, but throughout the State or in each microregion or municipality. It is urgent a process of homologation of these APLs, to establish bigger or better governance, assistance, organization.

Half of the types of APLs involves the sectors of temporary and permanent crops, followed of the livestock of small, medium and large animals. In the livestock sector, are six. Added to the extractivism, they result in 23. In secondary sector, involving wood, furniture, civil construction and power generation, only four are found. In sector, should be considered the food industries related to the agricultural sectors, but the manpower employed is less expressive that production volume in the calculations of identification of the presented specializations.

The sector of generation and distribution of electric energy is centered in Porto Velho. Its importance in terms of volume of employed persons tends to change dramatically over time, due to the completion of construction of the big works, leaving only maintenance activities.

V. FINAL CONSIDERATIONS

The APLs are not just business sets allocated in a given space, but organized in a certain way and with volume of occupation and productivity coordinated by a process of interaction, with generating income and promoting development. Not necessarily arise from a project off, but should be subsidized by public policies and other intervention proposals that lead to enjoyment of opportunities and strengths and at the same time combat the weaknesses and threats.

In Rondônia, they have not yet been fully mapped, and the corresponding studies are not diffused sufficiently, although of the records of planning, as the Preliminary Development Plans (PDPs), there since 2007 (RONDÔNIA, 2007 a, b, c, d, e; 2014). There are many differences between the data of the MDIC and the of the IPEA (COSTA, 2010) and of these in relation to those presented by NEAPL/RO in the website of the OBAPL (BRAZIL, 2015). The studies presented in this article brought an information update for a final mapping, involving the fundamental bases of appointment: employability, business volume (direct and associated) and production volume. The calculation of the locational quotient for employability and of the specialization index

for the sector of agriculture and livestock farming production (created in this study), integrated, have allowed to combine the data and identify the possible APLs of Rondônia.

The not proof of some APLs identified by the MDIC, IPEA (COSTA, 2010) and by the NEAPL/RO in the website of the OBAPL (BRAZIL, 2015), confronted by data of the RAIS/2012 (MTE, 2014) and of the IBGE census (BRAZIL, 2013), justifies the need to extend studies in this field. The proposal of indication of APLs per Microregion is an alternative to overcome the logic failure of business identification very generically, that despises the regional or local manifestations. This is what is confirmed in this study, that indicate the possibility of existence of more than 100 APLs, against only 18 identified by NEAPL/RO currently.

For example, the confections sector showed great volume of occupation and business in the commercial sector, but not in the of production, so that had not sufficient bases for identifying a APL. In parallel, many businesses have been neglected in the Microregions, as the of the fruticulture, that have enough representation for APL in six of the eight microregions, but appears in only two in the demonstratives disclosed in the website of the OBAPL. The same can be said in relation to cattle breeding of meat and milk, identified only in Ji-Paraná, but constituting the most significant APL in practically the entire State.

It is confirmed the profile of the State in agriculture and livestock farming production, with large-scale of production of fruits, cereals, coffee (in Cacoal, more necessarily), culture of the manioc, bovines, small animals (fish, chickens, pigs, bees), besides soybeans, among others, in certain locals. The economy, therefore, is quite diverse, but the productivity, too low in most cases.

Furthermore, it is suggested that be made larger investments for APLs studies in Rondônia, including full mapping not only per Microregion, but also per city, in order to identify opportunities, fill the gaps, offer support and strengthen the endeavors. There is much that can be allocated, as resource, in the Multi-Annual Plans of State and in other references of participatory planning.

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Fully Casualized Design: A Brief Literary Review

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Abstract — *The term experimental design is characterized by the manner in which the portions are distributed in a given experiment. The completely randomized design is the most commonly used among experimental designs because the principles of randomization and repetition provide authenticity of the conclusions due to guarantee that the experimental units (plots), even if distinct and exhibit equal probability of being distributed to the groups. It is widely used in experiments have uniform conditions as the experimental conditions are critical in obtaining a good experimental design. It offers a wide experimental application, but must pay attention to the test, that even homogeneous, can present experimental conditions that will harm the experiment. So in order to get a good design, an early collection of information to evaluate the homogeneity of the experimental conditions is critical. This study is a literature review on the DIC, with their main characteristics, mathematical modeling, analysis of variance technique (ANOVA) and analysis of assumptions for ANOVA.*

Keywords— *statistic, experimental design, ANOVA, DIC.*

I. INTRODUCTION

The relevant variables to the object of study that focus on units of a sample or population, we use in statistical analysis, they are obtained from previously planned experiments, known experimental data (BERGAMASCHI, et al., 2011). The implication of factors that may or may not be controllable during experiment necessitates the use of statistical methods of analysis, to verify their prominence in bringing random variation or error experimental (ANDRADE & OGLIARI, 2007).

Among the factors that cannot be controlled stand out environmental heterogeneity not provided by the experimenter and the variations inherent to the experimental material. Thus, in order to minimize the variation of chance, the experimenter you must set the design so that it is possible to isolate the effects of the

factors that, indeed, can be controlled. Thus, the experiment relates to the set of rules that determines the definition of treatment, the arrangement of in the experimental plots and their assignments to treatment and how to analyze the Data from the experiment (DUARTE, 1996).

The completely randomized design (CRD) is the simplest of all experimental designs, it contains only the principle of randomization and repetition. Requiring homogeneity of the material and environmental conditions Experimental since their treatments are distributed in the form of parcels entirely random. The static scope of DIC is given by equation 1 (Silva 2007).

$$y_{ij} = \mu + \alpha_i + e_{ij} \quad (\text{Eq. 1})$$

At where,

y_{ij} is the value observed in experimental plot that received i - in th treatment j th repetition;

μ is a general constant associated with this random variable;

α_i is the effect of the treatment;

and e_{ij} is the error associated with observation y_{ij} , supposed to have normal distribution.

II. EXPERIMENT MODEL DATA BALANCED WITH DIC

According Padovani (2014), the operation of this design since is conditioned to the presence of homogeneous parcels is to designate the treatments to experimental units of pure and simple draw, i.e. without any restriction.

The greater the degree of homogeneity between the experimental units in terms of dependent variables, therefore the design Experimental is more efficient. But for heterogeneous units the same It does not occur. Highlighting the importance of balancing the replicates in treatments employed experimentally.

Therefore, it is an appropriate plan for experiments in laboratory that the parcels may be represented by petri plates or test tubes, as well as in a greenhouse in pots (DUARTE, 1996).

The model indicates that the shape of the biological response of a unit Experimental subjected to the treatments is given by: Biological Response Treatment Average + = Error Casual Biological and described in Equation 2.

$$y_{ij} = \mu + e_{ij} \quad (i = 1, \dots, k \text{ and } j = 1, \dots, r) \quad (\text{Eq. 2})$$

At where,

i the index referring to treatment;

j The experimental unit.

III. STATISTICAL PROCEDURE: ANALYSIS OF VARIANCE

Statistical inference for analysis of variance (ANOVA) is obtained from Distribution F of Snedecor considering two independent random variables, one being

due to other treatments and due to the experimental residue (PADOVANI, 2014).

According to Duarte (1996), if we consider an experiment aimed at test treatment (t) using repetitions (r) for each of the model determines the partition of degrees of freedom and the sum of squares for the variation Total being observed, according to equation 3.

$$y_{1j} = m + t_1 + e_{1j} \quad (\text{Eq. 3})$$

At where,

y_{1j} is the data collected in the experimental unit received at a given treatment repetition;

m is the constant inherent in the overall average;

t₁ is the effect provided by the treatment; and l_j It is the error of the experimental unit.

If the data meets the principles of analysis of variance, then the proposal the model can summarized as shown in Table 1.

Table.1: Scheme for analysis of variance installed in experiments completely randomized design.

FV	GL	SQ	QM	T
Treatment	t- 1	SQ treatment	QM treatment	QM treat/ QM error
Error	t(r - 1)	SQ error	QM error	
Total	tr- 1	Total SQ		

Source: Smith, 2007.

IV. ANOVA TO TEST HYPOTHESES

Duarte (1996) describes that there are some assumptions that must be used to make valid the application of ANOVA because the error greatness experimental and forward answer to the mathematical model assumption guarantee effectiveness and quality of a particular experiment.

These assumptions are: a) additivity, in this condition the effects of the factors that occur in the mathematical model must added together, so do not there interactions; b) independence of errors; c) homoscedasticity of variance and; d) normality of errors (BARBIN, 2003).

Carvalhoet. al., (2010) describe who should use tests to confirm whether the assumptions of the mathematical model are being met. proof these hypotheses should be performed prior to any analysis and testing assumptions including Student's distribution, F Snedecor or chi-square.

The main tests are: Test not Tukey additivity, to ascertain the additivity; random testing, to verify the randomness of the errors on the Experimental map; Lilliefors test to verify the normality of the provision of and errors; Bartlett test to analyze the homogeneity of the errors between the treatments (CONAGIN et al., 1993).

4.1 ANOVA Applicability

The main objective of the trial is to analyze alternatives (treatment) in order to identify among them those of greater biological return, agronomic and even economic (DUARTE, 1996). In this sense, all experiments aim for transparent and clear results in the environmental field need means efficient statistical.

As an example of the applicability of completely randomized design for scientific nature of experiments, Angels (2005) brings the following question:

"Consider the following experiment was conducted considering a design randomized. Nine Strains of fungi were compared by measuring growth rates in microns / hour. "

Table.2: Strains growth rates of fungi in microns / hour

Strains	Reps						Total
	I	II	III	IV	V	VI	

L1	385	323	417	370	437	340	2272
L2	406	385	444	443	474	437	2589
L3	354	292	389	312	432	299	2078
L4	271	208	347	302	379	264	1762
L5	344	292	354	354	401	306	2051
L6	354	354	410	453	448	417	2436
L7	167	115	194	130	240	139	985
L8	344	385	410	437	437	410	2423
L9	385	385	396	453	458	417	2494
Total							19090

The hypotheses for this experiment are therefore the following:

$$H_0: T_1 = T_2 = T_3 = \dots = T_9$$

$$H_1: T_1 \neq T_i \text{ 'to at least one pair with } i \neq i'$$

Assuming that one or more treatments have difference significant with regard to the efficiency of the same, is used for ANOVA check this difference.

It has been that

$$\sum_{i=1}^i \sum_{j=1}^j y_{ij} = 385 + 323 + \dots + 417 = 19090$$

$$\sum_{i=1}^i \sum_{j=1}^j y^2_{ij} = 385^2 + 323^2 + \dots + 417^2 = 7168788$$

$$I_i = 1 \quad I = 9 \text{ degrees of freedom treatments} = I-1 = 8$$

$$J = 6 \text{ degrees of freedom residue} = I (J-1) = 9 (6-1) = 45$$

$$N = IJ = 9 \times 6 = 54, \text{ degrees of freedom} = \text{Total } IJ-1 = 53$$

From these results, based on the ANOVA formula, they have the sum of squares are as follows:

$$SQ \text{ Total} = 420,119.5$$

$$SQ \text{ Treatment} = 332,918.1$$

$$SQ \text{ Residue} = 87201.4 \text{ (SQ Total-SQ Treat)}$$

With these results, it is possible to obtain the values of the mean squares and F and calculated by ANOVA formula being:

$$QM \text{ Treat} = 41614.763$$

$$QM \text{ Res} = 1937.8089$$

$$F \text{ calculado} = QM \text{ Treat} / QM \text{ Res} = 21.48$$

Table.3: Filling the table with the obtained data, we have:

FV	GL	SQ	QM	T
Treatment	8	332.918,1	41.614,763	21.48
Error	45	87.201,4	1937.809	
Total	53	420,119.5		

Once you get all of these values, compares it with the F calculated F tabulated (1%, as called for example, the value is 2.9475).

According to the F test was significant difference between treatments, and therefore, this calculation allows us to reject the null hypothesis (H₀). That way, it means that one of the fungal strains is more efficient with respect to the rate of growth, and this is the basis for the next steps for obtaining data Statistical through the use of some means comparison test or contrasts.

4.2 Independence of errors

Padovani (2014) describes that the independence of errors is guaranteed by principle of randomization. If the errors of the independence assumption is satisfied, on graph-standardized residuals versus the order of data collection, the waste must be casually distributed around zero, without following a pattern.

In the graph construction is considered the ordinary residue (and ij): residue on the jth observation of the i-th group (i = 1, ..., K; j = 1, ..., r) (Equation 4) and residue standardized (z ij): standardized residue on the jth observation of the ith group (Equation 5). The graphical conformation of waste enables confirm that hypothesis independence errors can be accepted (LIMA and LIMA, 2014).

$$(e_{ij}) = y_{ij} - y_i \tag{Eq. 4}$$

$$(z_{ij}) = e_{ij} / \sqrt{QM \text{ Res}} \tag{Eq. 5}$$

At where, QM Res It is the Mean Square Residual

$$QM \text{ Res} = S^2 = \frac{\sum_{i=1}^k (n_i - 1) S_i^2}{(n - k)}$$

4.3 Homocedasticity

It can be verified by the Bartlett test, Levene and Hartley (F_{max}) in which errors must submit a variance (δ

2) in common. THE homogeneity of variance has two hypotheses from data groups obtained from a given experiment, as the assumptions below, and δ^2 The variance of each of the data groups (LIMA, 2014).

$$H_0: \delta_1^2 = \delta_2^2 = \dots = \delta_n^2$$

H_1 : one of δ^2 'S is different from the others

Box (1953) recommends that the results of an ANOVA are considered valid, the largest variance should not exceed four times the smaller. . Dean et al, (1999), discloses that in a more analytical decision tests: Cochran, Hartley, Bartlett and Levene were highlights for the homogeneity of variances.

Based on further in the example cited by Angels (2005), for the homoscedasticity, realized by the following figure (Figure 1), there is heterocedasticity between treatments, because some of them are showing different behavior regarding the distribution of errors.

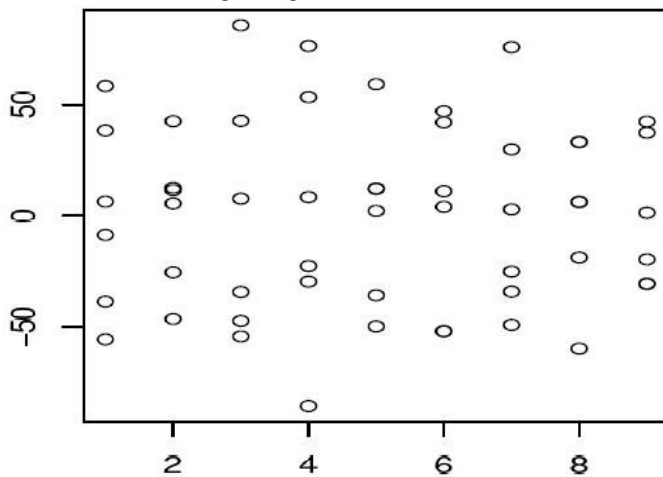


Fig.1: Verification of homocedast

Source: Angels, 2005.

4.3 Normality of the errors

The normal probability plot is a graphical technique for assessing whether a data set is approximately normally distributed and is a special case the probability plot. The data are plotted in relation to a distribution Normal theoretical such that the dots should form an approximate straight line. Matches this straight line indicate departures from normality (Chambers et al., 1983).

The probability graph is formed by the vertical axis the values of requested response and the horizontal axis with the median statistics for ordered the given distribution. According Filiben (1975), the median statistics order They may be approximated according to Equation 6.

$$N_i = G(U_i) \tag{Eq. 6}$$

At where,

U_i is the median uniform statistical order (defined below);

G is the percentage point function to the desired distribution.

The function of a percentage point is the inverse of cumulative distribution function (Probability that x is less than or equal to some value). That is, given a probability, x is the corresponding cumulative distribution function. At medians uniform statistics order are defined as:

$$m_i = 1 - m \text{ for } i = 1$$

$$m_i = (i - 0.3175) / (n + 0.365) \text{ for } i = 2, 3, \dots, n-1$$

$$0.5 m_i = (1 / n) \text{ for } i = n$$

Furthermore, a straight line may be fitted to points, added as a reference line. The more points vary this line, the greater the indicating a departure from the specified distribution. This definition implies that a probability plots can be easily generated for any distribution to which point the percentage can be calculated (ANSCOMBE, 1973).

A disadvantage of this method of calculating probability plots is that estimates of intercept and slope of the fitted line are in fact estimates for the parameters of location and distribution scale. Although this is not very important for the normal distribution, since the location and scale are the estimated mean and standard deviation, respectively, can be useful for many other distributions (WILK et al, 1968).

In addition to the graphical methods we have just considered for assess the residual normality, we can perform a hypothesis test in which the null hypothesis is that the errors have a normal distribution. A large value of p , therefore, fails to reject the null hypothesis is a good result. This means that it is reasonable to assume that the errors have a normal distribution. Normally, assessment of the appropriate residual plots is sufficient to diagnose deviations from normality. However, more rigorous and formal quantification of normality can It is requested (TUFTE, 1983). Therefore, one can apply several test procedures common to normal.

4.3.1 Anderson-Darling

Test The Anderson-Darling test measures the area between line an adjusted (based on chosen distribution) and a non-parametric function (based on points of Plot). The statistical distance is a squared which is heavier tails distribution. (TUKEY et al., 1977) under Anderson-Darling values indicate that the distribution fits the data better. The test statistic is given by Equation 7.

$$AD = -n - \frac{1}{n} \sum_{i=1}^n (2i - 1) \{ \text{Ln}F(X_i) + \text{Ln}[1 - F(X_{n-i+1})] \} \tag{Eq. 7}$$

When the statistical Anderson-Darling test is an associated p -value no We reject the null hypothesis and

conclude that it is reasonable to assume that the errors have a normal distribution.

4.3.2 Shapiro-Wilk test

The Shapiro-Wilk test uses the test statistic. First it is necessary reorganize the data in ascending order so that $x_1 \leq \dots \leq x_n$. Then calculate SS according to equation 8.

$$SS = \sum_{i=1}^n (x_i - \bar{x})^2 \quad (\text{Eq. 8})$$

If n is even, allowed to $m = n / 2$, while if n is odd, left to $m = (n - 1) / 2$. If n is odd, the median data value b is not used in the calculation (Equation 9). To calculate the test statistic used-if $W = \pm 2$

$$b = \sum_{i=1}^m a_i (x_{n+1-i} - x_i) \quad (\text{Eq. 9})$$

These values a_i are calculated using the means, variances and covariance's of (i) . W is compared with tabulated values of distribution of this statistic. Smaller values of W will lead to rejection of the null hypothesis (Shapiro, 1965).

4.3.3 Kolmogorov-Smirnov test

The Kolmogorov-Smirnov test (also known as Lilliefors Test) compares the empirical cumulative distribution function of the sample data with the expected distribution if data were normal. If this difference is observed sufficiently large, the test will reject the null hypothesis of normality of the population (CALLEGARI-JACQUES, 2003). The test statistic is given by equation 10.

$$D_{\max} = (D^+, D^-) \quad (\text{Eq. 10})$$

Where

D^+ It is the $\max_i \{ i/n - Z(i) \}$;

D^- It is the $\max_i \{ Z(i) - (i-1)/n \}$.

Being that,

Z it's the same as $F(X(i))$;

$F(x)$ is the probability distribution function of the normal distribution;

$X(i)$ it's the same as i The order statistics of a random sample, $1 \leq i \leq n$;

n it's the sample size.

The test statistic is compared with the critical values of a distribution Normal to determine the p value.

4.3.4 Chi-square test

The chi-square test is used to test whether a data sample came from a population with a specific distribution.

An attractive feature of the chi-square adequacy test is that it can be applied to any univariate distribution for which you can calculate the cumulative distribution function. The suitability of the chi-square test is applied the binary data (ie, data placed into classes). In fact, this is not a restriction because you can simply calculate the histogram or table often before generating the chi-square test. However, the statistic value Chi-square depends on

how the data are categorized. another disadvantage Chi-square test is that it requires sufficient sample size for the approximation of chi-square is valid (Snedecor and Cochran, 1989).

The chi-square test is an alternative to test suitability Anderson-Darling and Kolmogorov-Smirnov. The chi-square test adjustment can be applied to discrete distributions as the binomial and Poisson. tests of Kolmogorov-Smirnov and Anderson-Darling are restricted to continuous distributions. O chi-square test is set for the event:

H_0 : The data follow a specified distribution.

H_a : The data do not follow the specified distribution.

Test statistic: For the computation of chi-square adjustment, the data They are divided into k (Equation 11).

$$\chi^2 = \sum_{i=1}^k \frac{(O_i - \Sigma_i)^2}{\Sigma_i} \quad (\text{Eq. 11})$$

At where,

O_i is observed for the frequency bin i ;

Σ_i It is the expected frequency for i .

In which Σ_i it is calculated by:

$$\Sigma_i = C [F(Y_u) - F(Y_l)]$$

Being,

F cumulative distribution function for distributing being tested;

Y_u it is the upper limit for class i ;

Y_l is the lower limit for class i ;

N is the sample size.

V. TECHNICAL ANOVA

ANOVA is a statistical technique to analyze the variation in one variable response (continuous random variable) measured under conditions defined by factors discrete (classification variables, often with nominal levels). Often used ANOVA to test the equality of several means, comparing the variance between groups regarding the variance within groups (Random error). Sir Ronald Fisher pioneered the development of ANOVA analyze the results of agricultural experiments (Fisher, 1925).

Today, the ANOVA It is included in almost all statistical packages, which makes it accessible to researchers in all experimental sciences. It is easy to insert a set of data and perform a simple ANOVA, but it is challenging to choose the ANOVA suitable for different experimental designs, examine whether the data adhere to modeling assumptions and interpret the results correctly (STEEL et al., 1980).

To determine the appropriate ANOVA model, we must know the relationships between factors and experimental units. Statistical distinguish two types of factors in experimental design and ANOVA: "fixed factors" and "random factors". a "Fixed factor" is one for

which specific levels are of interest. a researcher could repeat the experiment using identical factor levels in twice. (SCHEFFE, 1959).

Conceptually, each level of a fixed factor is a distinct population with a single response average. When one researcher deliberately organizes or modifies the levels of a fixed factor, called these levels treatments. The primary objective of the ANOVA is to test whether the means response are identical between the levels of the factors. In contrast to a fixed factor, levels of a "random factor" represent a random sample of a number potentially infinite levels. Different levels of factors would be chosen randomly if the experiment was redone. With random factors, the objective of ANOVA is to make an inference about random variation within a population. When a factor level is applied to two or more experimental units independent, he is "replicated". If replicates are equal in number to each factor level, the experimental design is "balanced" (LEVENE, 1960).

The ANOVA concept provides details for two common models. The first model, one-way ANOVA fixed end, is an extension test t Student- Independent 2 that allows you to simultaneously compare averages of several samples independent. The second model, fixed effects ANOVA 2-way has two factors, A and B, and each level of factor A appears in combination with each factor level B. This model allows us to compare the means of the factor A levels and between levels B. factor Moreover, we examined whether the combined factors induce effects interaction (synergic or antagonistic) in response (SCHLOTZHAUER et al., 1987).

VI COEFFICIENTS DETERMINATION AND CHANGE OF AN EXPERIMENT

In addition to hypothesis testing and confidence intervals, otherwise analyze whether the model adopted in a given experiment is efficient or not treated if the coefficient of determination or explanation and the coefficient of variation.

The coefficient of determination or explanation is represented by the symbol R^2 . This indicator determines what percentage of the variance explained by Regression is the total variation (VIALI, 2018).

It is given by the ratio between SQ_{Treat} (sum of squares of treatment) and SQ_{Tot} (total sum of squares of the values found), indicating the proportion of the total variance explained by the variation due to treatment ($0 \leq R^2 \leq 1$) (PADOVANI, 2014).

The coefficient of variation of an experiment, represented by (CV) estimates the accuracy of experiments representing the standard deviation expressed as average percentage (MOHALLEM et al., 2008).

According to Snedecor (1980), the distribution coefficient of variation allows the establishment of tracks values that guide researchers on the validity and veracity of their experiments.

It is given by the ratio between the standard deviation (ANOVA, is the square root a positive QMR_{es}) and the overall mean data, inferring how data comportam-in relation to the general average. The magnitude of the reverse precision CV refers to the idea the experimental data (PADOVANI, 2014).

VII MULTIPLE COMPARISONS

Multiple comparisons are used when the variance analysis detects that there is a significant effect on certain treatment of an experiment, the certain level of significance, where it rejects the null hypothesis (SOUSA et al., 2012). They have his theory based on the normality of the model residues linear used to fit the data (and BORGES FERREIRA, 2003).

The test multiple comparisons of means are of great importance in applied research (CONAGIN et al., 2008) when trying to compare the Qualitative treatments.

In this sense, several tests are used for this purpose, and the same usually take the name of its author, the main ones being: Tukey, Student-Newman Keuls (SNK), Student's t test (LSD), Duncan, among others (BORGES & FERREIRA, 2003).

The choice of test to be used should be based on statistics qualities the study aims, considering it is always for the non-violation of the assumptions Basic to their application, such as normality and homoscedasticity errors of independence (EAX. et al., 2005).

7.1 Tukey test

Tukey's test is based on the amplitude of estudentizada distribution, and can It is used to compare any and all contrast between two averages treatment, with accuracy when the number of repetitions is equal in all treatments. When there is a different number of repetitions Test Tukey can still be used, however, the result will approximate (GOMES, 2000).

For the minimum significant difference in the Tukey test, is used to formula described in equation 12:

$$d.m.d = q \sqrt{QMR/r} \text{ (Eq. 12)}$$

At where:

q: refers to the value of the table Tukey significance level;
QMR: refers to the mean square of ANOVA;

A: refers to the number of repetitions of each treatment (Oliveira, 2008).

Again using the example proposed by Angels (2005), after identifying the existence of significant differences between treatments using the F test can evaluate the magnitude of these differences through

multiple comparisons test. O Tukey Test, which is based on the least significant difference (LSD) is a means of obtaining this magnitude.

Applying we test:

$$\Delta(5\%)=4,64\sqrt{1937,8/6}=83,39$$

$$q=4,64$$

$$\alpha=0,05$$

If the contrast is greater than the value of Δ , then the average level differ α of significância.

In addition to the Tukey test, it is also possible to carry out comparison tests multiple of that example by Duncan test, SNK, among others.

7.2 Student-Newman-Keuls test (SNK)

The SNK test is performed the same way as the Tukey test, however, exception is that the critical value in SNK is not the number of treatments, but the number average amplitude included in the medium being tested (CALLEGARI-JACQUES, 2003).

One of the advantages of using SNK test is that it allows separating means in discrete groups, without overlap between the groups (CANTERI et. al., 2001).

In terms of accuracy, it is intermediate between the Tukey test and Duncan, using Duncan's method with Tukey table. When the average treatment have the same number of repetitions, the following formula is used (Equation 13):

$$\text{SNK (5\%)} = q \frac{s}{\sqrt{r}} \quad (\text{Eq. 13})$$

At where,

q: refers to the value of the total amplitude estudentizada 5% probability;

s: refers to the square root of QMR (error mean square), which corresponds the estimate of the standard deviation of the experimental error;

A: refers to the number of repetitions of the experiment and / or average (FERREIRA, 2011).

According to Sampaio (2002), when average compared feature different numbers of repetitions, the formula will be shown below (Equation 14):

$$Q = \text{SNK} \sqrt{\frac{s^2}{2} \left(\frac{1}{R_a} + \frac{1}{R_b} \right)} \quad (\text{Eq. 14})$$

At where,

Ra: refers to the number of repetitions of treatment experiment "A";

Rbb: refers to the number of repetitions of the experiment Treatment "B".

7.3 t test Student

The Student t test, t test or simply seeks to reject or not a hypothesis null when the test statistic (t) follows a Student's t distribution. Can be conducted to compare a sample of a population, comparing two samples compare two parallel and independent samples (Lopes et. al., 2015), two means A and B obtained in experimental

groups can be compared in the following relationship by t test (Equation 15).

$$t = \frac{x - \mu}{\frac{s}{\sqrt{n}}} \quad (\text{Eq. 15})$$

At where,

X: refers to the median of the sample;

μ : refers to the average population (or reference);

S: refers to standard deviation; n: refers to the number of subjects (JUNIOR, 2012).

7.4 Duncan test

Duncan test is taken to a new method for the comparison of averages, with a more difficult application of the Tukey test, however, much more efficient with regard to the breakdown of the results and breakdown of treatments. It requires that all treatments have the same number of repetitions so that their results show accuracy (OLIVEIRA, 2008).

Typically, it is applied at 5% probability, and despite being more work is less rigorous than the Tukey test (VIANA, 2012). it should be point out that when using three or more averages, Duncan's theory is wrong, because the global significance level is not maintained (BANZATTO & KRONKA, 2006).

According to Gomes (2000), when the number of averages is very large (greater than 10, for example), the application of this test becomes very cumbersome.

According Vieira and Hoffmann (1989) to obtain DMS is the following formula applied (Equation 16):

$$d.m.s = z \sqrt{\text{QMR} / r} \quad (\text{Eq. 16})$$

At where,

Z: refers to a standard value at significance level and the number means covered by the range delimited by the medium in comparison;

QMR: refers to the mean square of ANOVA;

A: refers to the number of repetitions.

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A Strategic Location Model of Stationary Production Units: A Case study in the Albacora Leste field

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Abstract — *The imminent interest in issues related to the oil and gas sector has always proved to be a profitable source of investment and research, with incremental gains and innovations in the various sectors of the offshore industry. Particularly in the context of resource localization, the adoption of mathematical models presents itself as a challenging theme. In this context, the research has the purpose of proposing a localization model of Stationary Production Units (SPU) of an oilfield located in the Campos Basin, Rio de Janeiro (Brazil). The computational tests were conducted using the Lingo software, based on data from the Albacora Leste field. The results of the proposed model demonstrated a reduction of approximately 12% in the configuration costs, compared to the current location.*

Keywords— *Location of Facilities, Stationary Units of Oil and Gas Production, Mathematical Programming.*

I. INTRODUCTION

Considered a strategic aspect for most companies, the layout of the distribution system plays an important role in the productive scenario. The resource location problem covers core topics of the distribution system design. In the Oil and Gas (O&G) sector, there is a growing search for methods that optimize the distribution of products or services.

Particularly in the scope of resource localization, numerous researches have been conducted in order to treat the theme from the perspective of optimization, as observed in the works of Figueira (2014); Ignacio; Sampaio (2012); Rosa (2006); Souza (2011).

The location of equipments and production units is one of the main problems in oil industry projects. The choice of the system and the geographic location of the system are extremely important to obtain the planned results and maintenance of the operation of the plant. Given this, a series of mathematical programming models were proposed in order to solve the problem of finding platforms and multi-skilled facilities (IGNACIO; SAMPAIO, 2012).

With a focus on minimizing investment costs, we mention the works of Hansen; De Luna Pedrosa Filho; Carneiro Ribeiro (1992). Frair; Devine (1975) proposed a model to locate the SPU, or platform, according to the oil flow over time, seeking to maximize the net present value (NPV). The development of a model to minimize the investment costs, considering the location, capacity and amount of production of the platforms, was object of study of Devine; Lesso (1972). However, a broader analysis of the applicability of such models can be observed in Galvão; Acosta Espejo; Boffey (2002). These authors state that because there is no single model that

optimizes the system globally, it is appropriate to adopt a hierarchical model, in order to avoid partial optimization of the system. An interesting fact is that none of these models consider fields not equipped with manifolds, which is a reality of the systems that were currently found.

Another problem encountered in the oil and gas sector, with regard to the location of equipment and SPUs is similar to the location of facilities of onshore companies (ROSA, 2006). Equivalence is explained by Devine; Lesso, 1972, who makes a parallel between inputs from the traditional productive sector and O&G. These authors affirm that the costs are directly proportional to the extension of the pipelines, to the place where the platform is allocated and the capacity of the platform. For this reason, the optimization of the submarine layout tends to improve the costs of the production line and the flow, as the location of the SPU is optimized.

In this scenario, we intend to perform an analysis of the current location of equipments and SPUs of an oil field in the Basin in Campos, with a view to proposing a localization model based on the hierarchical model of Ignacio; Sampaio (2012). In this way, we seek to investigate the hypothesis of cost optimization through the geographical reallocation of SPU in the field of Albacora Leste using mathematical models of operational research.

For the development of the mathematical model, it is of paramount importance to familiarize ourselves with the main aspects that make up the original model to be adapted. Theory considered important in relation to what is proposed in this project, the analysis of concepts and term relationships, such as oil wellheads, Manifolds, pipelines connecting wells and equipment, as well as SPU, were based on the work of Thomas (2004). In addition, given the similarity with the issue treated and the domain of the problem, which include specific oil and gas exploration devices and the hierarchical operational search localization models, the studies conducted by Cercaira (2005); Ignacio, Sampaio (2006) were valuable sources of knowledge in conducting the research.

Besides that, the hierarchical model of operational research described in Ignacio; Sampaio (2012) will be presented, since it will serve as the basis for the generation of the new model.

The experiments were conducted using actual data obtained from the National Petroleum Agency (ANP) (ANP, 2016), except for costs that are fictitious data. The use of real data approximates the reality model, considering the actual and proper geographic location for comparison with the data of the studied oilfield.

For the implementation of the model, we chose to use LINGO® software, version 10.0, belonging to LINDO Systems Inc®. Its adoption is justified by the ease of use and efficiency for solving linear and non-linear problems (BA; PRINS; PRODHON, 2016).

The optimal location results will be presented through tools of geographic information systems. In order to locate geographically the equipment and items of the oilfield, from the real data and calculated by the model, the software used was Google Earth.

The numerical results of the proposed model will be compared with the real location of the SPUs, with the aim of improving the efficiency of the system under the hypothesis of optimization through the geographic repositioning of the said production unit.

II. MATERIALS AND METHODS

2.1 Oil Field Projects

Planning facilities and submarine layout, known as the location of wells, platforms and pipelines of the project, can reduce costs, improve flow and optimize production. Currently, there are hierarchical localization models that propose to solve these problems. It should be noted that the intention is to locate the platform in an interconnected way to systems not equipped with manifolds.

Fig. 1 exemplifies a production system and the equipment to be located. The illustration shows the location of the wellheads, the point of the oil well where the oil is extracted. The equipment responsible for concentrating the oil and sending the platform is called a manifold, which may still have other functionalities. The ducts are responsible for transporting the fluid between the equipment. The SPUs are responsible for receiving the oil extracted from the wells for storage or sent to the refineries, concentration tanks or the manifolds to be injected.

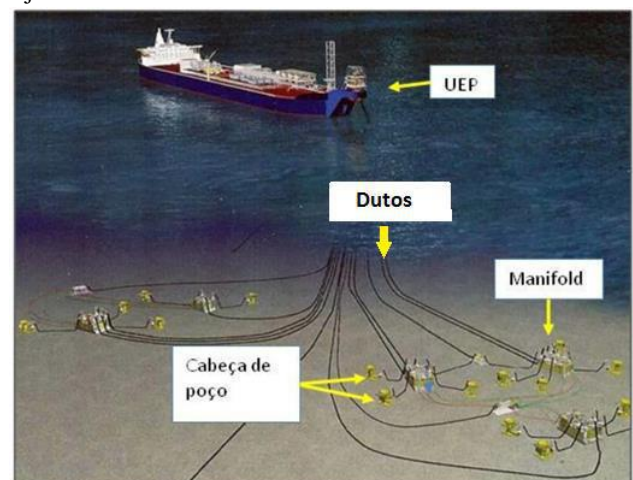


Fig.1: Underwater production system (SPU, manifold and wellhead)

Among the terminology of the constituent elements of an underwater production system (Fig. 1), the term "well head" can be defined as the location of the soil where drilling is started and where equipment for reservoir exploration and production flow will be installed (IGNACIO; SAMPAIO, 2012). The manifolds are equipment that serve to collect the flow coming from several points, gathering in a duct or set of ducts, or distributing the flow coming from a point (LIMA, 2007). They can be production, water and gas injection, gas lift, gas control and export. In short, they are a large set of valves of great complexity, responsible for receiving the oil and/or gas from one or more wells and directing the flow, or distributing, it to the SPUs. In addition, they may receive the flow of fluid or gas directed by the UEPs in order to inject it into the well.

The movement of fluids that will go to production or reinjection in oil fields is done through submarine pipelines. In the case of production, there is a flow of oil and gas from the wells, through the equipment, to the SPU and in the injection there is the reverse flow, from the SPU to the various equipments and consequently to the well (THOMAS, 2004).

According to Rosa (2006), a SPU can be understood as an industrial unit on the high seas, with characteristic functions such as separation of oil, gas and water, with the task of treating them so as to enable the unification of the elements for export of oil and gas, and the disposal of water. These units when allocated to a well can be anchored or in dynamic positioning, allowing the reception of production and insertion of fluids in the formation. The transportation of the materials to be exported can take place through oil pipelines or relief ships in the case of oil and gas pipelines for compressed gas. According to Ignacio, Sampaio (2012), the elements considered to design a SPU are: expected production, sea depth and environmental characteristics.

2.2 Hierarchical localization model

A hierarchical model can be characterized by a set of interrelated variables that relate to the location of a given facility and the respective allocations.

According to Ignacio and Sampaio (2012), the problem of locating SPU allocated to manifolds, which in turn are allocated to heads of oil wells, are solved by means of discrete models. That is, for a set of wellheads with a predefined location, a set of possible manifold locations must be allocated, which in turn must be allocated to a set of possible SPU locations. Finally, the model should generate the optimal location for this set of "possible locations" previously proposed, with the main objective of minimizing the total costs, from the fixed

costs of installation of each equipment. Fig. 2 shows the previously described system.

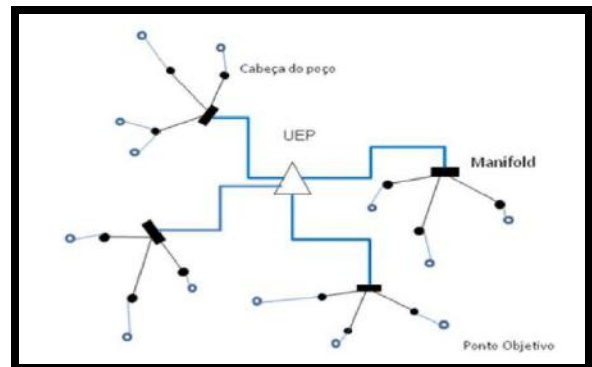


Fig.2: Schematic plant of an underwater field.

The following mathematical model presents the set of parameters and restrictions elaborated for the hierarchical problem presented by Ignacio and Sampaio (2012).

Indexes:

- i : Defines the set of possible locations of well heads;
- j : Defines the set of possible locations of n Manifold;
- k : Defines the set of possible SPU locations.

Parameters:

- a_j^1 = Cost of using a unit capacity of a Manifold;
- a_k^2 = Cost of using a unit of SPU capacity;
- c_{ij}^1 = Cost of connecting the wellhead i to the Manifold $j, i=1,2,...,m, j=1,2,...,n$;
- c_{jk}^2 = Cost of connecting the Manifold j to UEP $k, j=1,2,...,n, k=1,2,...,l$;
- f_j^1 = Fixed cost of installing a Manifold, on site $j, j=1,2,...,n$;
- f_k^2 = Fixed cost of installing a SPU, on site $k, k=1, 2,...,l$;

Parameters of Capacity:

- K_j^1 = Manifold Capacity $j, j=1,2,...,n$;
- K_k^2 = UEP Capacity $k, k=1,2,...,l$;
- M = large number that can be defined as: $M = \max\{K_k^2, \forall k\}$

Parameters / Demand variables

- d_{ij} = demand parameter of wellhead i , when allocated to Manifold $j, i=1, 2,...,m, j=1, 2,...,n$;
- w_{jk} = Variable of the amount of processing demand of Manifold j , allocated to UEP $k, j=1, 2,...,n, k=1, 2,...,l$;

Location and allocation decision variables:

- $x_{ij}^1 = \begin{cases} 1, \text{ Se a cabeça de poço } i \text{ está ligada} \\ \text{ ao manifold } j, \\ 0, \text{ Caso contrário.} \end{cases}$
- $x_{jk}^2 = \begin{cases} 1, \text{ Se o manifold } j \text{ é localizado em } k, \\ 0, \text{ Caso contrário.} \end{cases}$
- $y_j^1 = \begin{cases} 1, \text{ Se o manifold } j \text{ é localizado em } j, \\ 0, \text{ Caso contrário.} \end{cases}$
- $y_k^2 = \begin{cases} 1, \text{ Se a UEP } k \text{ é localizado em } k, \\ 0, \text{ Caso contrário.} \end{cases}$

Three components are responsible for the costs of a plant, they are: fixed costs of implementation of interconnection devices, variables of connection costs and processing costs of each device. Interconnection devices have limitations, which result in a cost defined as the cost of processing the oil flow.

Model:

$$\begin{aligned} \text{Min } Z = & \sum_{i=1}^m \sum_{j=1}^n c_{ij}^1 x_{ij}^1 + \sum_{j=1}^n \sum_{k=1}^l c_{jk}^2 x_{jk}^2 \\ & + \sum_{i=1}^m \sum_{j=1}^n a_j^1 d_{ij} x_{ij}^1 + \sum_{j=1}^n f_j^1 y_j^1 + \sum_{k=1}^l f_k^2 y_k^2 \end{aligned} \quad (1)$$

Subject to:

$$\sum_{j=1}^n x_{ij}^1 = 1, \forall i \quad (2)$$

$$\sum_{i=1}^m d_{ij} x_{ij}^1 \leq K_j^1 y_j^1, \forall j \quad (3)$$

$$\sum_{i=1}^m d_{ij} x_{ij}^1 = \sum_{k=1}^l w_{jk}, \forall j \quad (4)$$

$$\sum_{j=1}^n w_{jk} \leq K_k^2 y_k^2, \forall k \quad (5)$$

$$w_{jk} \leq M x_{jk}^2, \forall j, k \quad (6)$$

$$\sum_{k=1}^l x_{jk}^2 \leq 1, \forall j \quad (7)$$

$$x_{ij}^1, x_{jk}^2, y_j^1, y_k^2 \in \{0,1\}, \forall i, j, k \quad (8)$$

$$w_{jk} \geq 0, \forall j, k \quad (9)$$

Template settings:

- For the objective function (1): The first and second components represent the costs of connecting the heads of wells and the manifolds (at the first level) and between the manifolds and SPUs (at the second level), respectively. The third and fourth components represent the manifold operating costs, which are directly related to the quantity of oil processed at level 1

and the SPU at level 2. Finally, the manifold and SPU installation costs are expressed in the fifth and sixth components.

- Restriction (2): Requires each wellhead to connect to at least one manifold;
- Constraint (3): Represents the processing capacity limitations of a manifold;
- Restriction (4): Ensures that each manifold will have a balance in the flow of production;
- Restriction (5): Represents the limitations of SPU's processing capacity;
- Constraint (6) together with (5): Ensures that there will be a connection between a SPU and a manifold if, and only if, a SPU k is installed and servicing a manifold j;
- Constraint (7) together with (5): Require an open manifold to be allocated to a single SPU;
- Restriction (8): Guarantees the binary nature of decision variables;
- Restriction (9): Ensures non-negativity of processing demand variables.

III. PROPOSED MODEL

From the previous data and studies carried out on the national oil fields, which were made possible through ANP data, it was verified that not all of them have the configuration that meets the requirements of the model proposed by Ignacio and Sampaio (2012) aa. A configuration found constantly and with a certain naturalness is the absence of manifolds. According to data from the ANP, the relationship from the exit of the oil to the SPU can occur directly, that is, in a simplified way, risers connect the wellhead directly to the SPU, absent the flow control system, as well as shown in Fig. 3, which exemplifies the field to be treated in this work, the East Albacore Field.

IV. ADAPTATION AND MODEL GENERATION

From the need presented and the study of the model shown, it was concluded that a new model must be generated to meet these specific systems.

This new model was adapted to field configuration without the equipment known as manifold, which will portray a modification in structure and modeling as a whole. Among the main influencers of this new model are:

- Coordinates of the wells that connect to SPU and their depths;
- Maximum number of wells by SPU;
- Minimum number of wells to be connected to the SPU, according to the project;
- Installation bundle of each wellhead to SPU.

From the collection of this information, one must follow the next steps in order to minimize the costs of implementing the system:

- SPU co-ordinates with associated wells;
- Coordinates of wellheads.

The resolution of this type of problem must occur in stages, being the first one, to delimit the amount of SPU's that will act in the oil field. The second step is to locate all well heads, and finally locate the SPU. The treatment of this problem must be done through subproblems, whose solution results in a fixed parameter, which will serve as input for solving another subproblem. This type of treatment does not guarantee the optimization of the system, as it does not result in a global optimum model, but a hierarchical localization model contributes to the construction of a more integrated model, which reduces the partial optimization of the system (GALVÃO; ACOSTA ESPEJO; BOFFEY, 2002).

From these considerations, an adaptation of the model of Ignacio and Sampaio (2012) was developed for oil fields with only wellheads and SPUs. The model is shown below.

Indexes:

- i : Defines the set of possible locations of n well heads;
- j : Defines the set of possible locations of m SPUs.

Cost Parameters:

- c_{ij} : Cost of connecting well i to a SPU located at location j ;
- v_j : Fixed cost of establishing a SPU in place j ;

Capacity Parameters:

- a_{ij} : Capacity of SPU j to support well i , when allocated to such SPU;
- b_j : Maximum SPU capacity that can be installed at location j ;

Demand Parameters:

- p : Maximum number of facilities that can be installed;

Decision variables:

In terms of the above notation the problem can be formulated as:

$$\text{Min } Z = \sum_{i=1}^n \sum_{j=1}^m c_{ij} x_{ij} + \sum_{j=1}^m v_j y_j \quad (10)$$

Sujeito a

$$\sum_{j=1}^m x_{ij} = 1, \forall i = 1, \dots, n \quad (11)$$

$$\sum_{i=1}^n y_j \leq p \quad (12)$$

$$\sum_{i=1}^n a_{ij} x_{ij} \leq b_j, \forall j = 1, \dots, m \quad (13)$$

$$x_{ij} - y_j \leq 0, \forall i = 1, \dots, n; j = 1, \dots, m \quad (14)$$

$$x_{ij}, y_j \in \{0,1\}, i = 1, \dots, n; j = 1, \dots, m \quad (15)$$

Template settings:

- Regarding the objective function (10): The first component of the objective function represents the interconnection costs, while the second captures the installation costs of the SPUs which is assumed fixed independent of the size of the same.
- Constraint (11): Ensures that each well is connected to exactly one SPU.
- Constraint (12): Limits the number of SPU 's in the solution at p .
- Restriction (13): They express the capacity limitations of SPUs.
- Restriction (14): Ensures that the wells are only allocated to locations where SPUs exist.
- Constraint (15): Expresses the binary nature of the decision variables.

V. RESULTS AND DISCUSSIONS

For the application of the proposed model we used the data from the Albacora Leste field. For these non-real data (costs) care was taken to exemplify reality in the best possible way, adding well-sized values to the variables.

Using real data from the Albacora Leste field, it is assumed that the optimal quantity of SPUs for the field and the capacity of the field is already defined. The intention will be to flow from the wells to the amount close to the maximum, which is according to surveys done at the ANP. It is worth mentioning that the model would be able to choose between SPUs of different capacities to service the oilfield.

Data on the location of the oil wells were found in the ANP (ANP, 2016) database, as well as its depth and water depth, important information about the field under study, which helps to understand the use of some equipment, such as Local SPU, for example.

To locate the data geographically, and from that, to find the approximate distances between the elements was used the Google Earth software, based on the locality of Farol de São Thomé. The choice of this location based on the distances of the installation costs was based on the location of the Geographic Field, the influence of the site for the offshore operations and the easy knowledge of both the academic part and the localization software. This point will serve as a basis to find the data of platform implantation cost in the oilfield.

Implementation according to the original location

The actual field configuration is illustrated in Fig. 4, which shows the actual location of the well heads (represented by the circles) and the SPU P50 (symbolized by the triangle) for the Albacora Leste field. Due to space limitations, the geographical coordinates of the elements of said field will not be presented, nor will the results generated by the model given its great dimensionality.

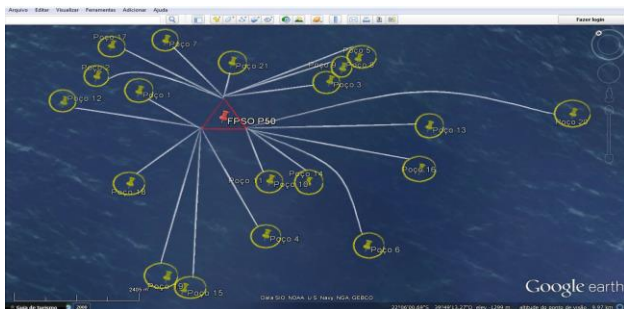


Fig.3: Actual field configuration of Albacora leste.

The implementation of these fixed coordinates in Lingo® resulted in an objective function of the order of R\$ 2.164800,00, which represents the total cost amount.

VI IMPLEMENTATION ACCORDING TO THE MODEL PROPOSAL

The configuration proposed by this methodology finds SPU P50 in a new geographical coordinate, which tends to optimize costs and improve the production flow. The new configuration proposed after implementing the model in the LINGO® tool can be seen in Fig. 4.

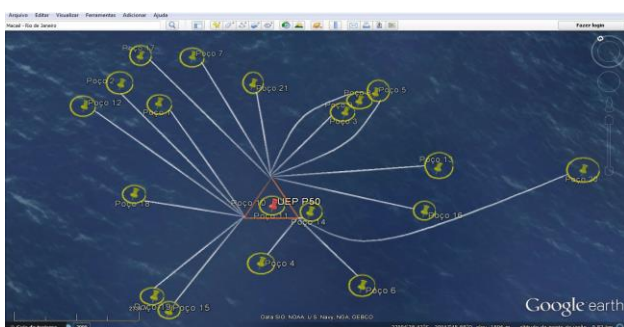


Fig.4: Location proposed by the model.

The model implementation in Lingo® was a new geographic location for a SPU and a total cost value of R\$ 1.905.360,00, represented through its objective function.

VII FINAL CONSIDERATIONS

The result obtained from the implementation of the model provides the analysis of project costs used in the Albacora Leste oilfield. Even with the use of some fictitious sources they remain identical for both cases, which does not influence the output data of the model.

The result of the original configuration of the field was R\$ 2.164.800,00 while the costs of the new configuration, according to LINGO®, were R\$ 1.905.360,00, resulting in a decrease in expenses of R\$ 259.440,00, approximately 12% savings. It is a considerably high value, however, which cannot be taken as the real value that would be saved by using fictitious cost data in the model.

The analysis of the obtained results proves the validity of the model and the capacity of this methodology to improve the allocation of resources in the oil fields, better allocating the facilities and dimensioning the equipment, which allows to reduce expenses not only in certain equipment, but in any system of production.

The generated model suffers considerable influence of the costs of each variable of the system, with this it is valid to emphasize that the implementation of real data tends to improve the resolution of the problem.

The proposed model showed robustness in the optimization of the SPU's location, even when implemented a mixture of real and fictitious data, the percentage gains analyzed validate its proposition and show what can be done in the current fields and future projects. The intention of today's industries and companies from diverse sectors is to generate innovative systems that provide exactly what this model of operational research has determined: competitive advantages, profits and focused investments.

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Influence of Mind Mapping and Problem Based Learning Models to Interest Learning Basic Concepts IPS Students

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Abstract— Education is a very important human need to prepare human resources for the development of the nation and state of Indonesia. The advancement of science and technology (Science and Technology) has an increasingly complex impact on society. Therefore, education is expected to develop the potential of learners to become human beings who believe and piety to God Almighty, have a noble character, healthy, knowledgeable, capable, creative, independent and become citizens of democratic and responsible (Act number 20 of 2003). Such a society is expected to be able to counteract and solve problems due to the development of science and technology. The emergence of social problems and unpredictable new demands. Education will always face problems because of the gap between expectations and the outcomes of an educational process (Syah M, 2004: 39).

This type of research is quasi experiment. Quasi experimental research is a similar study with experimental research, but the difference in experimental research is usually the subject grouped at random.

Based on the results of experimental research on primary teacher education students of University Jember campus Bondowoso Lesson Year 2017/2018. through the model of learning Mind Mapping more effective than the model of learning Problem Based Learning on the interest of students of primary teacher education University of Jember Campus Bondowoso Lesson Year 2017/2018. This can be seen from the average of different results in the experimental class with the model of

learning Mind Mapping for 85,85 and control class with Problem Based Learning model of 70,27.

Keywords: *Mind Mapping Model, Problem Based Learning, Interest Learning Learner.*

I. INTRODUCTION

Education is a very important human need to prepare human resources for the development of the nation and state of Indonesia. The advancement of science and technology (Science and Technology) has an increasingly complex impact on society. Therefore, education is expected to develop the potential of learners to become human beings who believe and piety to God Almighty, have a noble character, healthy, knowledgeable, capable, creative, independent and become citizens of democratic and responsible (Act number 20 of 2003). Such a society is expected to be able to counteract and solve problems due to the development of science and technology. The emergence of social problems and unpredictable new demands. Education will always face problems because of the gap between expectations and the outcomes of an educational process (Syah M, 2004: 39).

To overcome these problems, the role of education is needed. Education requires the attention and participation of all parties. With the education will be able to educate students and form a whole human being that is pious to God Almighty. Development of education should take precedence because a nation's progress can be seen from the progress of education. Therefore, the components that exist in the educational process such as learners, teachers,

teaching-learning process, management, education services and other supporting facilities must be coordinated and cooperate well (Azwar, 2003).

At the elementary school / junior level, the social Sciences subject contains Geography, Sociology, and Economics in each branch of the subject concerning long theories and more detailed drawings. So if students are given learning using mind mapping model then it will be more interesting to see and will pay attention to the learning. Through the mind mapping model of the IPS lesson, learners are directed to learn fun and see the geography, beauty, history that has been experienced.

Therefore Mind Mapping Models and Problem Based Learning can make it easier to stimulate the learner's brain. Can help learners to make their own material in a concise and easy to understand. Mind Mapping and Problem Based Learning can be a tool for pouring all the basic ideas that originally long reading becomes an interesting and easy to make summary. Realizing the benefits of Mind Mapping and Problem Based Learning and seeing the fact that Mind Mapping and Problem Based Learning has not been utilized in Basic of Social Science Concept Learning of primary teacher education Students of Jember University Campus Bondowoso Lesson Year 2017/2018 So It Needs to Do Research to know more further how the difference and which is more effective use of Mind Mapping and Problem Based Learning in learning to interest in learning Basic Concept of social science of primary teacher education Students University of Jember Campus Bondowoso.

II. REVIEW OF LITERATURE

2.1. LEARNING OF SOCIAL SCIENCE

The purpose of Social science education is to educate and provide basic skills to the students to develop themselves in accordance with their talents, interests, abilities, and environment, as well as a variety of provisions for students to continue higher education gap. Therefore, social science education plays an important role to realize the national education, because it can develop the potential of learners into human beings who berkaklak noble, healthy, knowledgeable, capable, creative, independent, love the homeland, and become citizens of a democratic and responsible.

2.2. LEARNING OF SOCIAL SCIENCE

According to Tony Buzan, (2006: 6) Mind Mapping is a colorful and visual form of writing, which can be done by one person or team consisting of several people. According to Femi Olivia, (2008: 2) Mind Mapping is providing a key basic principle. Mind Mapping is to make it easier to dig inside and outside information from the human brain, so it's an easy way to learn and practice

quickly and easily. Children are able to make notes that are not boring in their own way that is the best way to get new ideas and plan projects to be summarized.

2.3. PROBLEM BASED LEARNING MODELS

Problem-Based Learning (PBL, Problem Based Learning) is identical with the problem. This learning model trains and develops the child's ability to solve problems that are oriented to authentic problems of real life, to stimulate the child's high-level thinking ability.

2.4. LEARNING INSTRUCTIONS

According to Djaali, (2012: 121) interest is a sense of preference and interest in a thing or activity. According to Slameto, (2010: 57) interest in learning great influence on learning achievement, because if the lesson learned is not in accordance with the interests of students, students will not learn as well. Students will be reluctant to learn and do not get satisfaction from the lesson. With the growth of interest in a person will give attention to doing something diligently for long periods of time, more concentrated, easy to remember and not easily bored with what is learned.

III. RESEARCH METHOD

This type of research is quasi experiment. Quasi experimental research is a similar study with experimental research, but the difference in experimental research is usually subjected to randomly grouped.

IV. DISCUSSION

Experimental Research Results on Primary Teacher Education Students of Jember University Campus Bondowoso Lesson Year 2017/2018 Through Mind Mapping Learning Models is more effective compared to the model of Problem Based Learning learning toward the interest of Primary Teacher Education students of Universitas Jember Campus Bondowoso Lesson Year 2017/2018. This is seen from the average of different results in the experimental class with the Mind Mapping learning model of 85.85 and the control class with Problem Based Learning model of 70.27.

looking from the amount of t value from the result of manual test (mean difference test) IPS learning interest for the experimental class and control class obtained the following results: Hypothesis testing of IPS learning interest obtained results to $t = 3.08$ and more than $t_{1-\alpha}$; $dk_{30} = 1,70$. Thus $H_0: \mu_1 = \mu_2$ is rejected or $H_1: \mu_1 > \mu_2$ is accepted, means that there are differences in learning interest between learning models Mind Mapping and Problem Based Learning model of learning. Thus it can be concluded that Mind Mapping learning model is more effective than using Problem Based Learning model of learning toward the interest in learning social science

education primary teacher education students University of Jember Campus Bondowoso Lesson Year 2017/2018.

V. CONCLUSION

Based on the results of experimental research on PGSD students of Universitas Jember Bondowoso Campus Lesson Year 2017/2018. through the model of learning Mind Mapping more effective than the model of learning Problem Based Learning on the interest of students of PGSD University of Jember Campus Bondowoso Lesson Year 2017/2018 .. This can be seen from the average of different results in the experimental class with the model of learning Mind Mapping for 85,85 and control class with Problem Based Learning model of 70,27.

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Methodology to Vibrational Noise Attenuation of Panels in Vehicles through Sound Absorption Materials

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Abstract—The vibroacoustic comfort in vehicles is an important quality item and every day the carmakers look for new solutions for noise reduction and refinement of comfort. This study proposes the application of an experimental technique to determine the noise attenuation from the vibration of panels of a vehicle through the application of material for sound absorption. Sound absorbing materials are used in vehicles to attenuate high frequency noise, due to their characteristics. This study proposes the use of this type of material to attenuate noise of medium frequencies (100 – 600 Hz), predominant in structure-borne noise, complementing the existing ones, in order to refine the vibroacoustic behavior of the vehicle. Sound absorption materials are easy to handle, have a lower cost and require a short time for implementation. For the development of this work, a car cabin prototype was built using tubes and steel plates for the experimental tests. A finite element numerical model was created to obtain the vibrational behavior of the panels in this frequency range through modal analysis test. Experimental tests were performed on vibroacoustic frequency response function (FRF). It was observed in the tests performed that the application of sound absorption material attenuates significantly the vibration noise of panels in the range of medium frequencies, from 100 to 600 Hz. This methodology will allow the development of proposals for noise attenuation solutions and refinement of acoustic comfort with lower time and costs.

Keywords—Acoustic comfort, FRF, sound absorption, structure-borne noise, panels vibration.

I. INTRODUCTION

The vehicles have several sources of noise and vibrations that work simultaneously in the various static and

dynamic conditions in which the vehicles are exposed. In this way, solutions to problems related to noise and vibrations become complex because they presented wide frequency bands and a combination of transmission forms. Carmakers are looking for solutions for internal noise attenuation that contemplate short development time and lower cost.

The noise can be transmitted to the cabin through the air (airborne noise) and through the structure (structure-borne noise). Structure-borne noise originates from the vibrations that the structure receives, propagates throughout the body and the vibration of the panels generates noise in the internal cavity of the vehicle. The main sources of structural noise in a vehicle are the powertrain and the set of tires, wheels and suspension [7]. The structure-borne noise is perceived at frequencies up to 600 Hz, while airborne noise can be perceived in the range of 400 to 10000 Hz [4]. The graph of Fig. 1 shows the contribution of aerial and structural noise by frequency range.

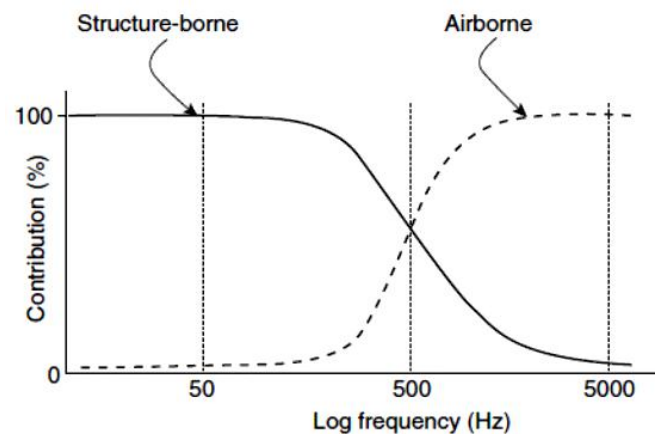


Fig.1 - Contribution of structure-borne and airborne noise in the overall noise of a vehicle [4]

Several experimental techniques were developed for the characterization of vibroacoustic trajectories, using the Frequency Response Function (FRF) [2]. The Frequency Response Functions characterize a path through relations between physical quantities of two points. The entry or beginning of the trajectory can be understood as the stimulus to the system. The exit or end of the trajectory can be considered as the response of the system to the applied stimulus. FRF is the ratio of the output signal to the input signal in the frequency domain. Fig. 2 demonstrates a FRF scheme.

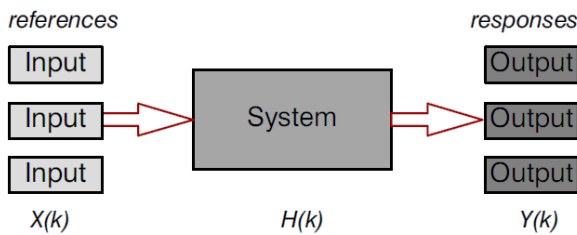


Fig.2: Frequency Response Function scheme.

Equations (1) and (2) demonstrate the FRF's calculation:

$$F(f) \times H(f) = X(f) \tag{1}$$

$$H(f) = \frac{X(f)}{F(f)} \tag{2}$$

Where $H(f)$ is the Frequency Response Function, $X(f)$ the output signal in the frequency domain and $F(f)$ the input signal in the frequency domain [5].

The Coherence function is a quantity that relates the input and output signals and can be interpreted as the fraction of the output spectrum that is coming from the input spectrum. The function, for each frequency value, assumes zero value when there is no relation between the input and output signals and assumes value one when the output is fully correlated to the input. The coherence function (γ_{xy}^2) is defined as equation (3):

$$\gamma_{xy}^2(f) = \frac{G_{xy}(f)^2}{G_{xx}(f) \cdot G_{yy}(f)} \tag{3}$$

Where G_{xy} is the cross spectrum between the input and output signals and G_{xx} and G_{yy} the autospectrum of the input and output signals, respectively [5].

The vibroacoustic transfer paths are Frequency Response Functions that describe paths that originate in the vibration of the structure and the response refers to a point located in the space surrounded by air. From the application of a force on the structure at any given point, it radiates sound energy that is transmitted through the air to the point of the receiver. It is referred to as a hybrid path that has a stimulus in the structure and response observed at some point in the passenger compartment of the vehicle, thereby determining the noise transmitted by

the structural route [5]. Fig.3 demonstrates the determination of structural noise.

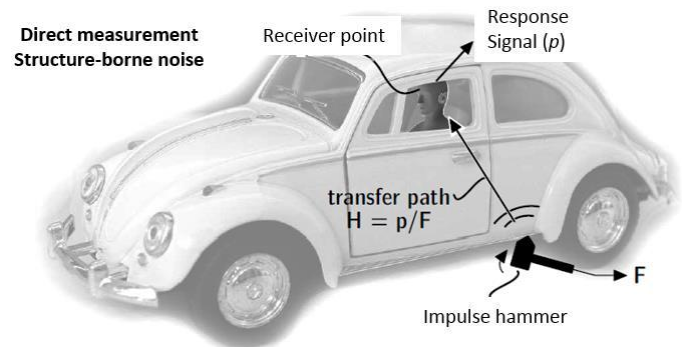


Fig. 3: Structure-borne noise measurement [10]

Solutions for structure-borne noise attenuation are more complex than solutions for airborne noise. Airborne noise is usually treated by materials that has insulation and absorption characteristics and are applied to the floor, firewall, engine region, and others [9]. These insulation works well for high frequency noise attenuation. A porous material is significantly more effective from the frequency range of 1000 Hz, as for sound absorption. Because of this behavior, its use is primarily for airborne noise treatment [1]. The graph of Fig. 4 shows a typical curve of sound absorption coefficient (α) as a function of frequency, of porous and fibrous sound absorbing materials installed on solid surface.

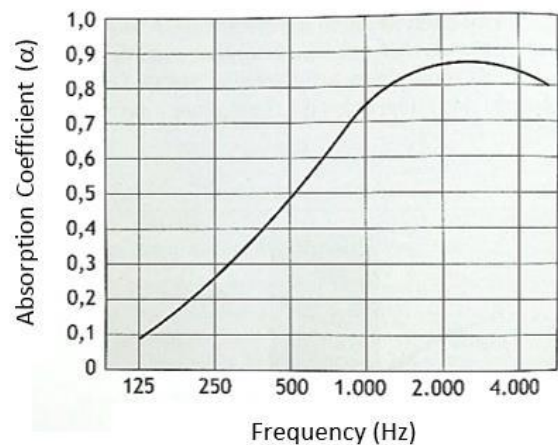


Fig. 4: Typical sound absorption graph for porous/ fibrous sound absorbing materials [1]

In order to attenuate the noise transmitted by the structure, the most effective forms require an optimization of the vibrational characteristics of the body, especially at the points of contact of the vibrational sources and in the supporting brackets or optimization of the elastic elements that are located between the source and the structure, which are the mounts. These components have other links, for example, the body has a controlled deformation in the event of a collision, the brackets and

mounts must support the systems without breaking. Due to these links, solution proposals need to be subjected to various studies, which makes the development time is long and cost high. In this way, problems related to the noises transmitted by the structural route in vehicles can remain without solution after the end of the development of a product, compromising its quality.

Thus, this work investigates the noise behavior of vibrating panels when sound absorption material is applied inside the car cabin in order to achieve an attenuation that improves acoustic comfort.

For this study, a body prototype of a small car was built using tubes and steel plates and a numerical model of this body for the evaluation of the modal behavior of the panels. Vibroacoustic frequency response functions (FRF) were performed, with force input signal in body and the response of sound pressure level (SPL) response in car cabin. The tests were performed under the conditions of the body with and without insulation. The insulations used were porous blankets of textile material of automotive application.

II. METHODOLOGY

2.1 Body Prototype

For the development of this work, a prototype of a car body was built, with approximate dimensions of a small car hatch model. The structure is composed of square steel pipes welded, according to Fig. 5.

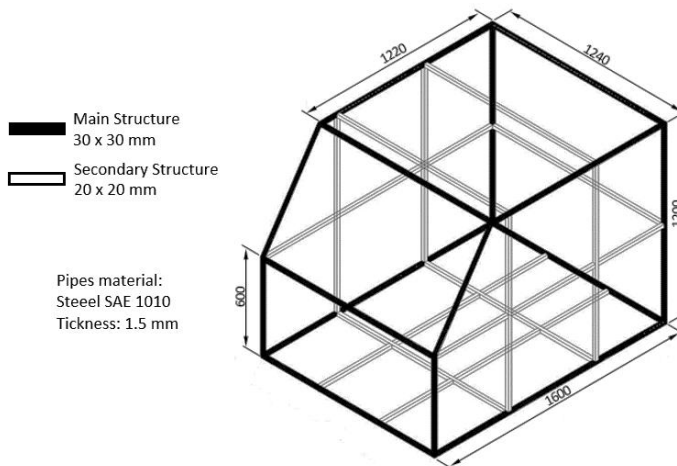


Fig. 5: Tubular structure of body prototype

The body is enclosed with steel plates with a thickness of 0.910 mm (SAE 1010) through rivets, sealed with silicone, except the front left side that is bolted to allow access to the interior, as shown in Fig. 6. The prototype is supported on four 6-inch casters to allow its locomotion.

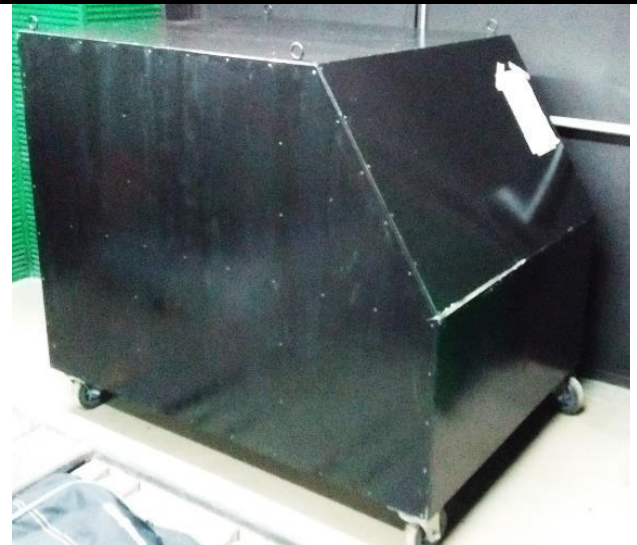


Fig. 6: Body prototype

2.2 Experimental Tests

The experimental tests for the development of the methodology consist of measurements of vibroacoustics Frequency Response Functions of the body, with excitation in the structure and response inside the cabin. The excitation is performed through an impact hammer with a force transducer and the response is measured through a microphone positioned in the region of the driver's right ear. Fig. 7 illustrates the FRF analysis system model.

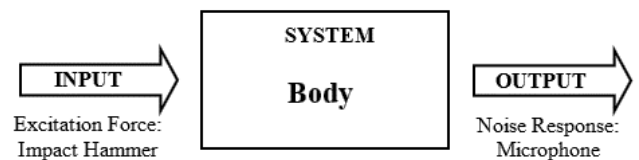


Fig. 7: Model analysis system

The excitation point in the body was defined in the lower left front region and was determined considering that it is a rigid point of the structure and region of important sources of structural noise, such as suspension and powertrain. The response point was defined in the region of the driver's right ear. Fig. 8 shows the measurement points.

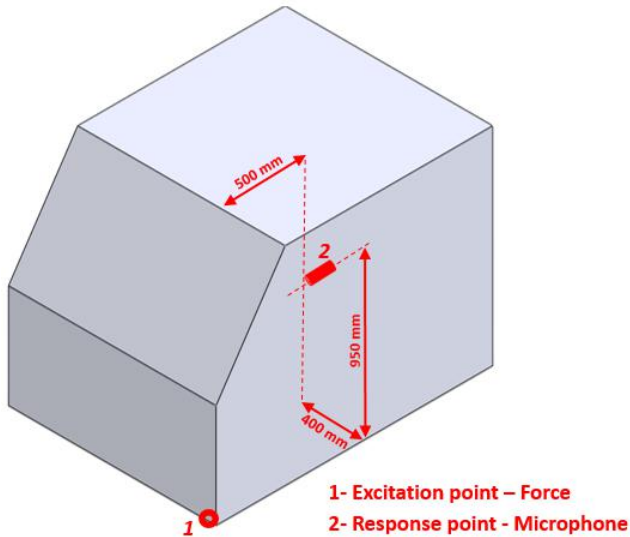


Fig. 8: Positioning of excitation and response points

The equipment used to the tests and analyzes are reported in Table 1.

Table.1: Equipment used for testing and analysis.

Equipment	Specifications	Manufacturer
Software	TestLab version 15	LMS Siemens
Analyser	Scadas Mobile 8 channels	LMS Siemens
Microphone	½" free field, 50 mV/Pa, mod. 46 AE	GRAS
Impact Hammer	2,25 mV/N, mod. 086C03	PCB

2.3 Tests Settings

The experimental tests were performed in two configurations, the first without insulation and the second with insulation applied on the floor, in the firewall and in the ceiling. The insulation consists in porous textile fibers blankets of automotive application from manufacturer Adler Pti, with grammage 1400 g/m², as shown in Fig. 9.

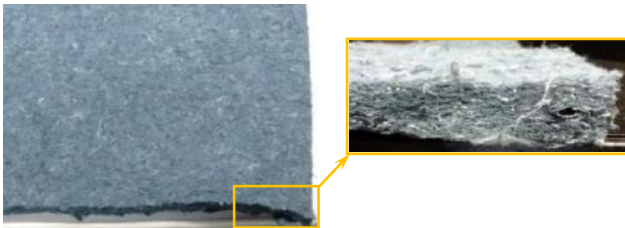


Fig. 9: Textile fiber porous insulation blanket 1400 g/m²

The Fig. 10 shows the regions of application of the insulation in the body prototype.



Fig. 10: Blankets application: floor and firewall (a) and ceiling (b)

The applied area of insulation is 4.24 m² and the total insulation mass is 6.0 kg.

2.4 Virtual Modal Analysis

The body model FEM (Finite Element Method) was built using the software HyperMesh version 13.0. The types of elements used were the PShell for the body and CWeld for the welds. The Fig. 11 illustrates the numerical model.

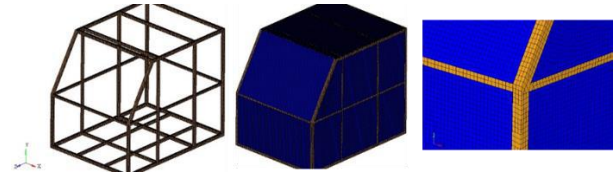


Fig. 11 – FEM model

III. RESULTS AND DISCUSSION

3.1 Body Frequency Response Function

Initially, the body FRF were obtained for the non-insulated configuration. The FRFs obtained are the sensitivity vibroacoustic functions. The higher sensitivity values indicate that the body responds more intensely to an excitation by frequency, so the higher the sensitivity value, the worse the acoustic's body behavior for a structural excitation. The graphic of Fig. 12 shows the result for the body without insulation.

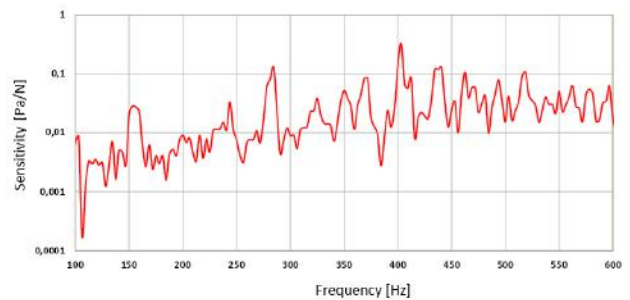
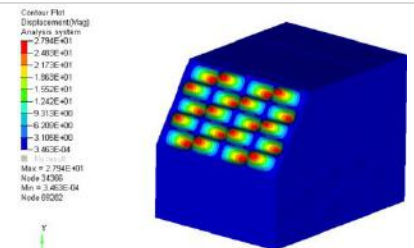
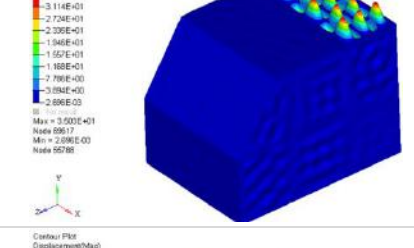
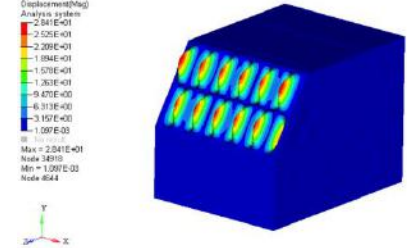
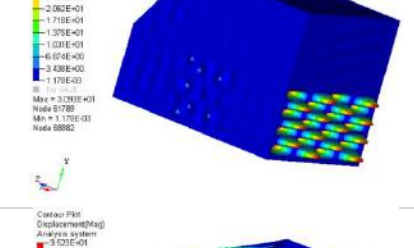
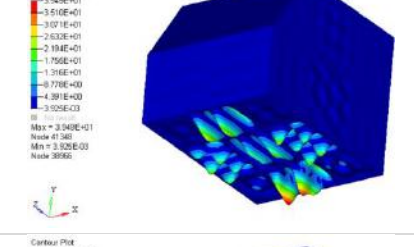
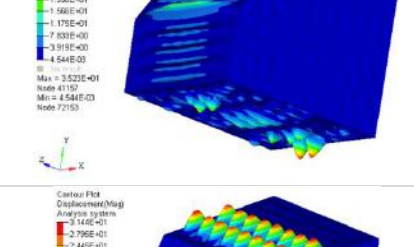
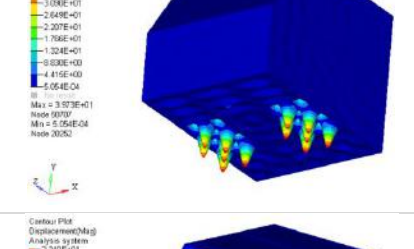
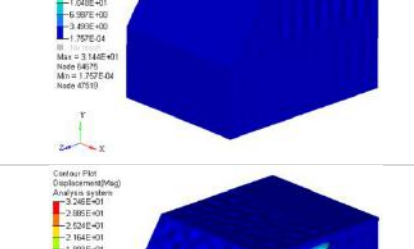
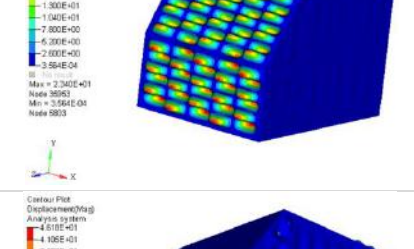
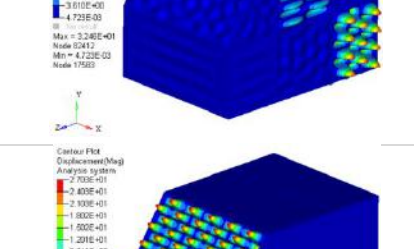
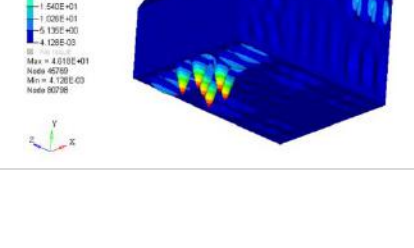
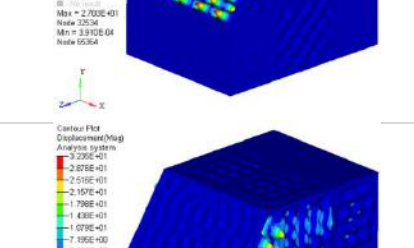
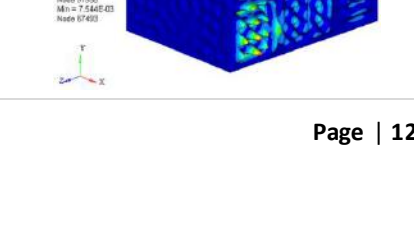


Fig. 12: Body vibroacoustic sensitivity function graphic

The peaks values that stand out in the graph were selected to determine the vibration modes. The frequency's values corresponding to the peaks are 156, 244, 285, 325, 350, 372, 403, 441, 462, 493, 519, 550, 562 and 581 Hz.

3.2 Body Modal Analysis

The FEM model analysis was performed using the OptiStruct 13.0 software, which determined the body modes in the desired frequency range for the study and which are presented in the Fig. 13.

Frequency	Mode	Frequency	Mode
156 Hz		403 Hz	
244 Hz		441 Hz	
285 Hz		462 Hz	
325 Hz		493 Hz	
350 Hz		519 Hz	
372 Hz		550 Hz	
		562 Hz	

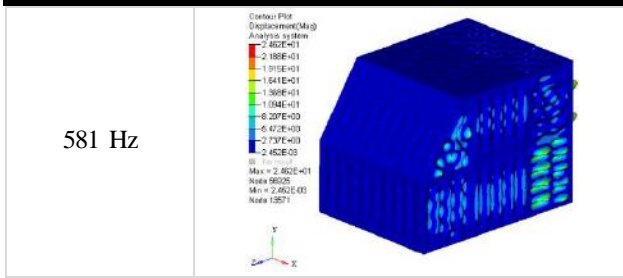


Fig. 13 – Body vibrations modes

The modal analysis results shown in Fig. 13 indicate that the modes in the selected frequencies refer to the body panels vibration.

3.3 Body Frequency Response Function with insulation

The comparative results of FRF vibroacoustics between the body with and without insulation 1400 g / cm² applied are presented below in Fig. 14.

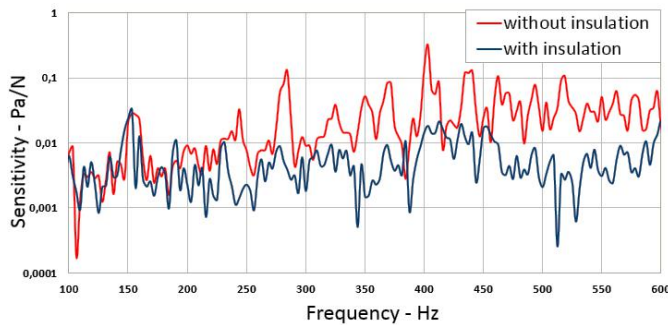


Fig. 14: Body vibroacoustic sensitivity with and without insulation

The results presented in the comparative graph of Fig. 14 demonstrate that significant structure-borne noise attenuation occurred with the application of insulation in the body, mainly in the previously selected frequency bands, related to the panels vibration.

The Table 2 shows the percentage of structure-borne noise attenuation in the selected frequencies, with the application of insulation.

Table.2: Structure-borne noise attenuation between body with and without insulation

Frequency [Hz]	Sensitivity [Pa/N]		Attenuation
	With insulation	Without insulation	
156	0,00204	0,02700	92%
240	0,00142	0,03288	96%
285	0,00391	0,12739	97%
325	0,00365	0,03861	91%
350	0,00157	0,03841	96%
372	0,00537	0,08406	94%
403	0,01853	0,32338	94%

441	0,01424	0,12920	89%
462	0,00953	0,10675	91%
493	0,00828	0,07842	89%
519	0,00274	0,10673	97%
550	0,00313	0,05097	94%
562	0,00560	0,06263	91%
581	0,00309	0,04647	93%

The reduction in vibroacoustic sensitivity indicates that the cabin has a lower noise level when subjected to structural excitation and consequent vibration of the panels. In this way, the application of porous insulation contributes significantly to reduce the noise emitted by the panels vibration, as shown in Table 2.

The coherence functions of each configuration were analyzed to verify the relationship between the input signal and the output signal. In the two configurations tested, the values of coherence presented values above 0.9 in the whole analyzed frequency range, therefore, considered satisfactory.

IV. CONCLUSIONS

From the results presented in this paper, it is concluded that the noise attenuation from the vibration of the panels can be attenuated significantly with the use of sound absorption material.

It should be noted that materials for sound absorption are light, relatively low cost and require little time to build tooling for their production, which can make implementation viable in a vehicle even in a short time.

With the construction of the prototype of the body and based on the evaluation methodology developed, it will be possible to perform comparative tests of materials, regions of application of the insulation, among others, reducing time and cost in the development of proposals to improve acoustic comfort.

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Effectiveness of the Module with Scientific Approach to the Study of Biology in Senior High School

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Abstract— *The learning process at first only lasted one direction or just focused on teachers (teacher centered), such as the concept of behavioristic. The process of learning that goes something like this causes students cannot develop creativity and he thought patterns tend to be monotonous. Therefore, the Government is encouraging a process the concept of learning and learning activities using the paradigm of Constructivism, concept of learning Constructivism form, i.e. by creating a media independent study that make proactive students. Module with scientific approach is media of learning in the form of independent learning materials include a series of learning process is arranged systematically with the steps that have been set, this module aims to help students learn independently but remain focused on the goal of the competence to learn, so that students master the competencies taught more easily and have an impact on the results of his studies, this research is research development. The subject of this development is research grade XI IPA high school Affairs Pakusari Jember Indonesian 2017/2018 academic year. Technique of data analysis used IE use the formula N-gain. Based on the results of the study showed that the scientific approach with the module on the respiratory system in high school Pakusari effective against student learning outcomes with high criteria.*

Keywords—*Effectiveness, Biology Module, Scientific Approach, Student Learning Outcomes.*

I. INTRODUCTION

Biology is the science of the knowledge learn of living things or the scientific study of life which has concept of biology, usually a theory, principle or science product containing a number of value through scientific measures (Rustaman, 2013). In accordance with the learning objectives of the 21st century, that is a fun

learning and encourage students to have the skills to become learners who can solve various problems with step and scientific attitudes (Park et al., 2006).

Curriculum learning done by 2013 demanding scientific approach to cultivating the ability to think, work, and communicate scientific attitude, as one of the important aspects in life skills. (Kemendikbud, 2016). As it has been known that learning in the curriculum 2013 demands change patterns of Teacher Centered Learning in the direction of Student Centered Learning, so that with any change that required a pattern of learning materials which can grow the positive response of the students against the lessons so that they can train students in learning high order thinking skill.

Based on the results of research by Sirait et al. (2016:7) stated that the media in General is learning books from publishers and student worksheets that contain exercises reserved or review of each topic. These materials have yet to train students in the process of scientific inquiry as a whole, but it was just a matter of practice. It is similar with research conducted by Tjiptiany et al. (2016:193) which stated that the Government has already published books but 2013 curriculum students are not clearly show how scientific steps in it. So that educators need a media learn can stimulate scientific activities and facilitate students to understand the concepts learned.

Based on the research of Jatmiko, et al., (2016) and Wicaksono, et al., (2017) the students more easily understand the concept of the existence of a medium of instruction. According to Nagpal, et al., (2013) understanding students will be more meaningful if learning is controlled independently For that, required a learning media that can help students understand the concept of human respiratory system by looking at events directly or independently.

The module is the one medium that can make students to work independently (Rufii, 2015). In addition to the practical, the use of the module can also improve the efficiency and effectiveness of learning in school, both efficient use of time, funds, facilities, and personnel in order to achieve the goal of optimally. Based on previous research by Compassion et al., (2015:249-252) developed modules development emphasizes the process reasoning, communicate the experiment and practice of reserved, rather than explaining the concept the material described, while students prefer and easy-to-understand the concept of learning when accompanied by examples of the real and scientific steps (Good, et al., 2010).

Biology module with this scientific approach can fill the deficiencies that exist because in this module includes scientific learning steps comprising steps (observe, ask yourself, try, reasoning, and communicating) so students more whole in receiving the learning, in this module there are also examples of existing problems in daily life and exercise problems supporting a scientific learning stimulate students to learn more effectively. According to Asta et al. (2015:21-10) States that the scientific approach is one approach that can be used to hone the students' ability to more critical and proactive because on this approach places emphasis on the aspect of thinking effectively and train students in its own way or independently.

II. METHODOLOGY

The type of this research is Research and Development. It was implemented at Vocational grade XI IPA2 high school Pakusari Jember Indonesia academic year 2017/2018 consisting of 35 students. This research is oriented on analysis of the impact of module with scientific approach on the respiratory system by students to improve students' learning outcomes and concept understanding. Data collection techniques used in this research, are observation, test, and documentation. Data collection techniques used in the measurement of effectiveness is in the form of written tests on post test amounted to five essay questions. While the data analysis techniques use N-Gain Test to determine the effectiveness of student learning outcomes.

III. RESULTS

Student learning outcome data is used to find the value of effectiveness by using N-Gain Test during teaching and learning activity by using Biology module with a scientific approach media which get from result of pre-test and post-test. The large increase in student learning outcomes by using the N-Gain test using Biology module with a scientific approach media can be seen in table 1.

Table.1: The effectiveness of student learning outcomes using Biology module with a scientific approach media

Category	Score
Average Overall Pre-test	50.1
Average Entire Post-test	83.2
Average Pre-test of Klasikal Pre-test	11.4%
Average Post-Test Klasikal Completion	90.5%
Average N-Gain	0.72
Category N-Gain	High

Based on the learning result analysis in table 1.1 in high school Pakusari Indonesia, shows that the average pre-test of students is 50.1 meanwhile post-test value 83.2 average of pre-test classical pre-test 11.4% while the average of 90.5% post-test completeness, and the average score of N-Gain 0.72. From the results of the above analysis can be concluded that the biological module with scientific approach of the respiratory system in humans can improve learning outcomes from the average of 50.1 to 83.2, from the level of completeness of the minimum criterion value of 77 increased from the average of the initial classical completeness 11.4% to 90.5% (over 80%), as well as the high-categorized N-Gain 0.72.

The data indicates that the module has been developed effectively against student learning outcomes, it is also supported by research conducted by Jatmiko et al. (2016: 55-61) concluded that the average activity in the learning activities of students who get learning with scientific approaches increased higher than the average value of the liveliness / role of students who received learning by conventional methods. It means that the scientific approach gives a positive influence on the activity of peseta learners in the process of teaching and learning activities, which will have an impact on the student's own learning outcomes. Learning with a scientific approach can emphasize students' involvement in various activities which enable them to actively observe, ask, try, reason, communicate (build network). The first four capabilities are to develop personal capabilities, while building networks of interpersonal skills. The capability emphasized in such scientific methods, whether related to personal abilities or interpersonal skills, can be applied in effective, creative, and fun learning (Kemendikbud, 2013).

Learning to use the biology module with scientific approach on the respiratory system in high school will involve students actively. The development of this learning module are also arranged systematically to make students study independently, where the concept of the new material actively adjusted with the knowledge that already exists, so it should start learning from things that

are already known and understood the student, then teacher adds elements of learning and new competencies tailored to the knowledge and competencies already owned, with students like that, the concept of the material more easily understood the students, so that later impact on student learning outcomes.

Learning using a module with a scientific approach on the respiratory system materials at senior high school will involve students actively. The development of this learning module is also structured systematically to make students learn independently, in modules with this scientific approach emphasizes on targeted steps, both supported by using a model and exercise questions which can lead to a five-stage activity on the learning module later will be linked to the concept of biological material to be conveyed, where the new material concept is actively aligned with existing knowledge, so that learning should start from what is already known and understood by the students, then the teacher adds new learning and competency elements tailored to the knowledge and competencies which have been owned by students, later will impact on student learning outcomes are getting better and better.

Based on the results of the research, it is suggested that the next researcher is expected to create a biological module of scientific approach with broader material and pay attention to the material content applied in the steps of scientific approach.

IV. CONCLUSION AND SUGGESTIONS

Based on the research objectives and the result of the research that has been done then it can be concluded the use of scientific approach to Biology module on the respiratory system can increase student learning outcomes with increased score N-Gain 0.72 and fairly high category. It is supported by the can improve learning outcomes from the average of 50.1 to 83.2, from the level of completeness of the minimum criterion value of 77 increased from the average of the initial classical completeness 11.4% to 90.5%, so that scientific approach to Biology module media can be said to be effective.

Based on the research results, it is advisable for the next researcher can make a scientific approach to biology module with broader material, pay attention to the content of the material being applied with scientific measures and stimuli as well as examples problems existing in real life students to students more easily understand.

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Development of Brazilian Soybean Cultivars Well Adapted to Cerrado and Rust-Tolerant

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Abstract— *The major diseases limiting soybean growth and yield must be either controlled or mitigated. Among these, soybean rust is the most harmful; in addition, Phakopsora pachyrhizi populations less susceptible to both IDM and IQe fungicides were observed. Therefore, this invention aimed at developing a new soybean cultivar rust resistant and highly productive. Generations were advanced by single seed descent method on the Capim Branco farm, Federal University of Uberlândia. Value for Cultivation and Use were carried out during a 3-year period (2010/13) in several locations, and Distinctness, Uniformity and Stability experiments for a 2-year period (2011/13) on the Capim Branco farm. Hence, we developed the novel soybean cultivar designated UFUS 7415. UFUS 7415 has shown high contents of oil (20%) and protein (40%), and high yield potential (4.300 kg ha⁻¹) even in environments with Asian rust.*

Keywords— *Cultivar release, Glycine max, Phakopsora pachyrhizi, Plant disease resistance, Soybean breeding.*

I. INTRODUCTION

Since its establishment in 1996, the Soybean Breeding Program of the Federal University of Uberlândia (UFU) has been developing and releasing new soybean cultivars, which are resistant to biotic and abiotic stresses, highly productive, and well adapted to the Brazilian states Minas Gerais (MG), Maranhão (MA), Tocantins (TO), Mato Grosso (MT), Piauí (PI) and São Paulo (SP).

The program strategy is to initiate the development of a new cultivar by the establishment of the program goals, the definition of problems and weaknesses of the current germplasm, and the definition of specific breeding objectives. Next step is the selection of germplasm that holds the traits required to meet the goals defined. The crossing between divergent parents produces the genetic variability of the specific features intended to be transferred into the new variety. The progenies from these crosses are then allowed to natural genetic segregation through generations of self-fertilization. Finally, promising breeding lines are tested and compared to appropriate standard cultivars in environments representative of the commercial target areas for three or more years; as recommended by The Ministry of Agriculture, Livestock, and Supply (Ministério da Agricultura, Pecuária e Abastecimento, abbreviated MAPA).

Value for Cultivation and Use (VCU) and Distinctness, Uniformity, and Stability (DUS) assays are mandatory as part of the process to register, protect and add any new cultivar on the National Register of Cultivars. VCU assays are established to assess differences in productivity, biological and chemical features and technological characteristics, resistance to pests and diseases, and other commercially important traits. These must be carried out for a minimum two year to compare the performance of candidate variety with varieties already on the National Register of Cultivars. In

addition, DUS assays are carried out to provide evidence that the cultivar subject to protection is distinct from other(s) whose descriptors are well known, as well as homogeneous within generations and stable to the same traits over successive generations.

Soybeans production is dominated by Brazil and United States, which together account for nearly 80% of global exports. Brazilian soybean production is prospected to grow at 2.6% per annum, and Brazil is projected to overtake the United States as the largest soybean producer in the coming decade mainly because of its unique ability to expand the planted area [1]. However, primary factors limiting crop growth and yield must be either controlled or mitigated in order to reach this achievement. Although soybean-breeding programs have been effective solving many issues by increasing the diversity of new well-adapted crops, there are approximately 40 caused by fungi, bacteria, nematodes, and viruses already identified in Brazil, and this number continues to increase with the expansion of soybeans into new areas [2].

Among soybean diseases, the Asian-rust caused by the fungus *Phakopsora pachyrhizi* is the most harmful; losses might account more than 80% when environmental conditions are appropriate to the disease development [3]. The impact of the Asian-rust has been associated with the high specialization and variation of the pathogen concerning virulence in soybean cultivars bearing specific genes of resistance [4]. In order prevent the fungus from multiplying on the fields, the farmers are accomplishing some strategies as sanitary empty, use of cultivars with genes of resistance, sowing at the beginning of the recommended season, use of early maturity soybeans, and applications of recommended fungicides [5].

However, some populations of the *P. pachyrhizi* less sensitive to IDM fungicides were observed in 2007 [6]. In 2013-2014 were observed less sensitive populations to IQe fungicides [7]. In March 2017, the FRAC (Fungicide Resistance Action Committee) reported a lower sensitivity of *P. pachyrhizi* to ISDH fungicides in populations collected in 2015/16 and 2016/17 [8]. During the co-evolutionary race with their hosts, the pathogens evolved a vast repertoire of virulence proteins (effectors) to facilitate colonization and host infection. Many effectors are believed to directly manipulate processes within host cells by promoting the reduction of immunity, probably through their inhibitory effect on host RNA mediated defense [9].

Therefore, our goal with this invention was developing a new soybean cultivar to meet producer requirements as disease resistance, high yielding, and high oil and protein contents. As a result, we developed a new soybean cultivar called UFUS 7415, which presents comparative

advantages over others in high productivity and good tolerance to *P. pachyrhizi*.

II. MATERIAL AND METHODS

To develop this new cultivar we chose breeding and selection methods based on the heritability of traits intending to be improved. Therefore, we derived UFUS 7415 from the double-crosses [(UFV-16 x Liderança) x (BR 95015308 x UFV-18)], carried out on the Capim Branco farm, Uberlândia, MG, Brazil; Latitude 18° 52' 94" S, Longitude 48° 20' 45" O, Altitude 835 m (Table 1). By manual crosses, we produced the hybrid seed (F1). The F1s were then grown on the field and allowed to self-pollinate to produce the F2 seeds. One single seed from each F2 plant was collected and bulked to grow the F3 generation. We then, advanced the F3 seeds by single seed descent (SSD) method until F6. Other methods as single-pod descent (SPD) and bulk methods (BM) produce redundant inbred lines, which are descended from either F2 or F3 same plants. However, single seed descent (SSD) has the advantage of minimizes the amount of genetic variability, although SSD method requires more time to process the seed than SPD or BM [10].

We grow superior plants F6 on the field, and the best lines were selected and assessed in progeny tests (F7). We carried out the final yield assays in many locations for a 2-year period, and promising advanced breeding lines were thoroughly tested and compared to appropriate standards in environments representative across several locations in the Brazilian states Minas Gerais (MG), Goiás (GO) and Mato Grosso (MT) (Table 1).

Table.1: Breeding procedures applied to develop of UFUS 7415, preliminary and standard yield trials.

Place	Generation (Yr.)	Method	Selected Traits
	F1 (2003)	Double-cross	Selective breeding
	F2 (2004)	Bulk	-
	F3 (2004)		
Capim Branco Farm	F4-F5 (2005)	^a SSD	Disease resistance
	F6 (2006)		
	F7 (2006)	Progeny-test	
	F8 (2007)	Preliminary yield assay	Disease resistance, quantitative traits
	F9 (2007/08)	Intermediate yield assay	
^c Several cities	F10 - F11 (2008/10)	Final yield assay	

^dSeveral areas F11 - F12 (2010/13) ^bVCU

^aSSD = single seed descent method; ^bVCU = value for cultivation and use; ^cSeveral cities: Uberlândia (MG), Alto Taquari (MT), Campo Alegre, Goiatuba and Palmeiras de Goiás (GO); ^dSeveral areas in the states: MG = Minas Gerais, GO = Goiás, MT = Mato Grosso.

The VCU trials were carried out on a randomized blocks design with three replications during a 3-year period (2010/13). Plot sizes were equal to 5.0 m². We have labeled regions as Region 302 (Ituverava, SP), 303 (Uberlândia, Urutaí, Itumbiara, MG), 401 (Rondonópolis, Alto Taquari, Palmeiras de Goiás Goiás), 402 (Lucas Rio Verde, Sinop, MT) and 403 (Porto Alegre do Norte, MT). The agronomic traits number of days to flowering, plant height at flowering, number of days to maturity, plant height at maturity, first pod height, number of nodes on the main stem at maturity, number of pods with one, two and three seeds per plant, total number of pods per plant, number of seeds per pod and grain yield were assessed. We had computed the number of days from the emergence to maturation when 95% of the pods were found dried; vegetative cycle accounted for the number of days from emergence to flowering (50% of flowering plants), and maturity on the first day in which 95% of the pods turned brown. We measured the height of the first pod from the soil level to the insertion of the first pod. We assessed pod dehiscence using a scale ranging from 0 (no dehiscence) to 10 (complete dehiscence); and lodging resistance with a scale from 1 (no lodging) to 5 (all plants are prostrate) [11].

Cultivars and lineages productive performance was assessed per useful plots; standardized to 13% of humidity and transformed into kilograms per hectare [12]. NIR spectrophotometry measured oil and protein.

In the Analysis of Variance (ANOVA), we considered the randomized block design model $Y_{ij} = \mu + G_i + B_j + E_{ij}$, where: Y_{ij} = observed value of the i -th genotype in the j -th block; μ = general mean; G_i = effect of the i -th genotype; B_j = effect of the j -th block; E_{ij} = experimental error. We grouped the means by the Scott-Knott test at 5% probability level. Significance tests regarding genotype x environment (GxA) interactions were performed using the model $Y_{ijk} = \mu + g_i + b/a_{jk} + a_j + g_{aij} + e_{ijk}$. Where: y_{ijk} = trait value observed for the i -th genotype in the j -th environment in the k -th block; μ = overall mean; g_i = effect of the i -th genotype; b/a_{jk} = effect of the k -th block within the j -th environment; a_j = effect of j -th environment; g_{aij} = effect of genotype-environment interaction; and e_{ij} = effect of experimental error. We do not have included the experiments with

Coefficients of Variation (CV) higher than 20% in the analysis of yielding by region. Statistical analysis of data was made through the software GENES [13].

UFUS 7415 resistance was assessed on the field and greenhouse conditions regarding the diseases caused by the pathogens: *Xanthomonas axonopodis* pv. *glycines*, *Pseudomonas syringae* pv. *glycinea*, *Cercospora sojina*, *Phialophora gregata*, VMCS, *Microsphaera diffusa*, *Diaporthe phaseolorum* f. sp. *meridionalis*, *Fusarium solani*, and nematodes *Pratylenchus brachyurus*, *Meloidogyne incognita*, *Meloidogyne javanica*, and *Heterodera glycines*.

We assessed soybean rust severity and lesion type in experiments carried out on the *Capim Branco* farm in the 2016/17 growing seasons. Experiments were made up of fourteen soybean genotypes assessed in a randomized complete block design with three replicates; no chemical was used for preventive the Asian-rust. We applied Godoy's diagrammatic scale to assess rust severity [14]. We performed three evaluations per week for three weeks, and the mean of five plants per plot was used to calculate the area under disease progress curve or AUDPC. We included both, TMG 801 and BRSGO 7560 in the experiments as parameters of resistance.

DUS experiments were carried out over a 2-year period (2011/13) under conditions ensuring normal development of plants on the *Capim Branco* farm, latitude 18° 52' 94" S, longitude 48° 20' 45" O, altitude 835 m. We utilized characteristics included in the official descriptor of the species/genus with the purpose of differentiation regarding other cultivars. As required by the MAPA to completion of the technical report, 300 plants with three replicates made up each assay, and we assessed distinguishability and stability in 20 plants. The descriptors hypocotyl color, type of growth, pubescence color, flower color, pod color, the shape of the seed, integument color and peroxidase reaction were evaluated.

III. RESULTS

UFUS 7415 was found distinct from any other cultivar, homogeneous to the descriptors that had identified it, as well stable through successive generations. MSoy 6101 was the most similar cultivar to UFUS 7415; thus, it was used for differentiation purposes; traits that differentiate them both are in Table 2.

Table.2: Most similar cultivar to UFUS 7415 and characteristics that differentiate them both.

Differentiating features	Features expression MSoy 6101	Features expression UFUS 7415
Anthocyanin pigments	Absent	Present

Type of growth	Determinate	Semi Determinate	05		b	
Flower color	Wight	Purple	UFUS 1117-06	19.7 a	257.3 a	2656.74 a
Pubescence	Brown	Light brown	UFUS 1117-07	16.8 a	91.6 b	2368.32 a
Hilum color	Black	Imperfect black	UFUS 1117-08	18.8 a	136.3 b	2523.92 a
Plant size	Medium/height	Medium	UFUS 1117-09	20.5 a	163.6 b	2599.65 a
Hypocotyl Color	Green	Purple	UFUS 1117-10	13.5 b	64.3 b	2283.12 b
Fertility	High	Low	UFUS 1117-11	14.3 b	114.0 b	1040.67 b
<i>Meloidogyne incognita</i>	Susceptive	Susceptive				466.78 a
<i>Meloidogyne javanica</i>	Susceptive	Susceptive				

We found UFUS 7415 resistant to the virus VMCS (soybean mosaic virus) and bacterium *X. axonopodis* pv. *glycines* (bacterial pustule) and *P. syringae* pv. *glycinea* (bacterial blight). UFUS 7415 was also resistant to frogeye leaf spot (*C. sojina*), brown stem rot (*P. gregata*), stem canker (*D. phaseolorum* f. sp. *meridionalis*), fusarium root rot (*F. solani*) and powdery mildew (*M. diffusa*).

UFUS 7415 was found susceptible regarding the root-knot nematodes *M. incognita* and *M. javanica* (Table 2).

3.1 Soybean cultivars performance in the presence of *Phakopsora pachyrhizi*

As shown in Table 3 UFUS 7415 was found among the most productive genotypes under natural infection by *P. pachyrhizi*. It did not differ statistically from both parameters of resistance TMG 801 and BRSGO 7560.

Table.3: Yield-performance of 14 soybean genotypes under natural infection by *Phakopsora pachyrhizi* on the Capim Branco farm, Uberlândia, MG, Brazil. 2016/17 growing season.

Genotypes	^a NPG	^b NPA	Yield (kg ha ⁻¹)	^c AUDPC
UFUS1117-01	17.3 a	125.3 b	2283.12 a	237.77 b
TMG 801	18.0 a	122.3 b	2805.11 a	191.57 b
UFUS 1117-02	16.5 a	64.0 b	1638.52 b	287.23 a
BRSGO 7560	12.1 b	32.0 b	3468.56 a	94.78 b
UFUS Riqueza	19.5 a	161.0 b	2200.95 a	320.60 a
UFUS 1117-03	18.8 a	266.0 a	1392.39 b	395.73 a
UFUS 7415	17.4 a	83.0 b	2385.66 a	285.60 a
UFUS 1117-	12.5 b	84.6 b	1378.72	396.90 a

^aNPG: number of pods with grains; ^bNPA: number of aborted pods; ^cAUDPC: area under the disease progress curve. Means followed by the same vertical letters belong to the same group, by the Scott-Knott test, at 5% level of probability.

3.2 Yielding and agronomic traits

UFUS 7415 presented determined growth; it is also resistant to the lodging and the pod dehiscence. Plant height at maturity ranging, days to 50% flowering, life cycle and 100-seed weight are in Table 4.

Table.4: Average results of UFUS 7415 agronomic traits and yielding assessed during a 3-year period (2010/13).

Regions	^a DF	^b DM	^c PH	^d FPH	100-seed weight (g)
302	47	116	68	10	15
303	43	109	66	10	14
401	48	114	78	11	15
402	45	112	77	10	14
403	42	110	75	10	15

^aDF = Number of days to 50% flowering; ^bDM = Number of days to maturity; ^cPH = Plant height at maturity (cm); ^dFPH = First pod insertion height (cm).

Productivity was assessed by comparison of grain yield of UFUS 7415 with other standard cultivars, by region, locality and year. Table 5 shows grain yield (kg ha⁻¹) average results of the data assessed during a 3-year period.

Table.5: Comparative grain yield (kg ha⁻¹) results assessed during a 3-year period (2010/13).

Regions	^a (CV %)	302 (13)	303 (14)	401 (12)
<i>UFUS 7415</i>		3300	3400	3650
<i>BRSMG 752S</i>		3150	3500	3450
<i>Witnesses</i>				
<i>Emgopa 316</i>		3200	3200	3200
<i>M SOY 6101</i>		3350	3350	3750
Regions (CV %)		401	402	403

		(12)	(12)	(13)
	UFUS 7415	3600	3700	3600
	BRSMG 752S	3550	3660	3550
Witnesses	M SOY 6101	3330	3750	3640
	M SOY 8001	3650	3650	3450

^aCV = Coefficient of variation

Table 6 shows two-year average assessments of UFU 7415 seeds quality and industrial yield compared with other standard cultivars, according to the region where tests were performed.

Table.6: Percentage of protein and oil content found in the UFUS 7415 seeds in evaluations performed during a 3-year period (2010/13).

^a Reg.	UFUS 7415		Witnesses					
			BRSMG 752S		M SOY 6101		Emgopa 316	
	Oil	^a Pr	Oil	Pr	Oil	Pr	Oil	Pr
302	18	39	19	39	18	39	-	-
303	19	38	18	39	19	38	-	-
401	19	39	18	38	18	39	-	-
			BRSMG 752S		M SOY 6101		M SOY 8001	
401	18	39	18	39	18	38	19	38
402	19	38	18	39	19	38	19	38
403	19	39	19	39	18	37	18	39

^aPr = protein.

IV. DISCUSSION

Although UFUS 7415 did differ from both resistant checks TMG 801 and BRSGO 7560 regarding the AUDPC, it was found among the most productive genotypes under natural infection by *P. pachyrhizi* (Table 3). UFUS 7415 yielding (2385.66) did not differ statistically from both parameters of resistance TMG 801 (2805.11) and BRSGO 7560 (3468.56); however, all genotypes have shown averages below the national average yield (2998 kg ha⁻¹) [15]. Genotypes TMG 801, BRSGO 7560, UFUS 7415 and UFUS 1117-07 were found with high general adaptability.

Therefore, UFUS 7415 is highly productive and well adapted even to environments with natural populations of *P. pachyrhizi*. Among soybean diseases, rust is the most harmful; losses can reach more than 80% when environmental conditions are conducive to the development of this disease [3]. Soybean rust genetic resistance is a complex issue since the fungus presents a sizeable genetic variability and so, over the years, materials have lost resistance. Hence, cultivars moderately susceptible such as UFUS 7415 are an excellent alternative to environments with rust.

Arabidopsis is non-host resistant (NHR) to *P. pachyrhizi* and has been used as a model to study the basis of genetic resistance to *P. pachyrhizi* [16, 17]. *Arabidopsis* rust resistance comprises different layers of defense; epidermal penetration resistance requires functional genes PEN1, PEN2 and PEN3, while post-invasion resistance in the mesophyll depends on the combined functionality of PEN2, PAD4, and SAG101. Other genetic components of post-invasion resistance remain elusive in *Arabidopsis* [18].

UFUS 7415 present desirable characteristics such as determined growth and lodging resistance; excessive vegetative growth might lead to lodging reducing yield potential, and increasing harvest losses as lodged plants are more difficult to cut and gather into the combine [19]. Buzzello et al. [20], found a negative correlation between lodging and grain yield, and a positive correlation between plant height and lodging. Besides, UFUS 7415 has also shown to be pod dehiscence resistant. Pod dehiscence (shattering) is a significant source of yield loss of mechanically harvested soybeans. Harvesting shattering-susceptible soybean varieties in dry weather conditions can lead to seed losses of 50 to 100% [21].

UFUS 7415 displayed average of 10 cm height for the first pod insertion. Pereira Júnior et al. [22], described standard values greater than 14 cm to the insertion of the first pod. However, according to Almeida et al. [23] at least 10 cm height is enough to avoid losses of uncollected pods due to low insertion height.

UFUS 7415 plant height at maturity ranging from 66 to 78 cm, and days to 50% flowering from 42 to 48 (Table 4). A study performed in Jaboticabal, SP, 2012/2013 harvest, assessed agronomic the traits of 30 soybean genotypes and plant heights at maturity were reported ranging from 55.67 to 108.13 cm [24]. Soybean flowering period is relatively extended (ranging from 30 to 40 days) and overlaps with the formation of pods and seeds, which makes it resistant to short periods of drought during flowering [25]. Sudhanshu et al. [26], found days to 50% flowering and plant height have the negative and direct effect on seed yield.

UFUS 7415 100-seed weight oscillated from 15g to 14g (Table 4); the average weight of 100 seeds may vary depending on the sowing season and locality [27]. UFUS 7415 grain yield (3300 to 3700 kg ha⁻¹) was above national average production (Table 5), which ranges from 2.5 to 3 thousand kg ha⁻¹ in the last ten years [15]. Yielding depend on numerous traits, which might have their action linked. Therefore, the selection practiced on one trait may simultaneously bring change in the other related trait. Path coefficient analysis has shown that seed yield/plant shows positive and significant association with biological yield, pods per plant, and 100-seed weight;

indicating that an intense selection for these characters might improve seed yield in soybean. Among these traits, 100 seed-weight exhibited the highest positive direct effect on seed yield [26].

Soybean seeds are an essential world's source of vegetable oil and protein meal, being widely used to feed animals like poultry, swine, and cattle. Soybean oil is composed of saturated, monounsaturated and polyunsaturated fatty acids. It has a typical composition of 11% palmitic, 4% stearic, 25% oleic, 50% linoleic and 9% linolenic fatty acid content according to the Economic Implications of Modified Soybean Traits Summary Report, Iowa Soybean Promotion Board and American Soybean Association Special Report 92S [28]. UFUS 7415 seeds presented 20% oil and 40% protein contents (Table 6).

V. CONCLUSION

We have developed a new non-GMO (non-genetically modified organism) soybean well adapted to MT, MG and GO. Population size 250.000 to 310.000 Plants/ha; recommended cropping from October 20 to December 10 in growing seasons; yielding potential 4.300 kg ha⁻¹.

UFUS 7415 aspects that represent comparative advantages over others cultivars are the high oil and protein contents and the high seed yielding, even in environments with *P. pachyrhizi*.

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Role Analysis of Cooperative Business at Serba Guna Indah Lestari Binjai.

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Abstract—One of the developments economies is the development of cooperatives. Cooperatives contain the meaning of "cooperation". From an economic point of view, "cooperation" can be "profit oriented" and can also be "non-profit oriented". Profit-oriented cooperation is cooperation in capital. This partnership grow up as business entities whose main purpose is to foster capital to gain maximum profit as applicable to the company. While non-profit oriented is the cooperation that forms a business entity that is not solely emphasized to profit but more strived to serve or demands of its members. Because the cooperative is a business entity consisting of people, a cooperative or legal entity, with the basis of its activities based on the principle of cooperatives as well as the people's economic movement, which is based on the principle of kinship. That obliges its members to work together . The internal controls applied to the Multifarious Business Koperasi of Binjai City and the crediting system has been effective. Internal controls applied have been effective and adequate. With the effectiveness of internal controls composed of elements. The crediting system implemented in the Multipurpose Business Koperasi Indah Lestari of Binjai city has been effective.

Keywords—Cooperative Business, Koperasi Serba Guna Indah Lestari Binjai.

I. INTRODUCTION

Indonesia is a developing country where some residents in rural areas so that the national development aims to improve the welfare of the people, then the rural areas get priority as the field of development. This is not only about the problem of equitable development, but considering in rural areas there are many potential development resources. These potential resources are in the form of Human Resources or Natural Resources , both of them should be involved and utilized optimally, so they can be efficient and effective for the community.

Part of the development sector that absolutely must be held or enhanced is the development in the economic sector that will greatly affect the progress of the state and the people of Indonesia because it is directed to the

realization of an independent national economy and reliable based on economic democracy. One of economy developing is the development of cooperatives. Cooperatives contain the meaning of "cooperation". From an economic point of view, "cooperation" can be "profit oriented" and can also be "non-profit oriented". Profit-oriented cooperation is cooperation in capital.

This partnership built business entities whose main purpose is to foster capital to gain maximum profit as applicable to the company. While non-profit oriented is the cooperation that forms a business entity that is not solely emphasized to seek profit but more strived to serve or meet the needs of its members. Because the cooperative is a business entity consisting of people, a cooperative or legal entity, with the basis of its activities based on the principle of cooperatives as well as the people's economic movement, which is based on the principle of kinship. That obliges its members to work together and help.

The Problems of the Study

From the description above the problems of the study can formulated as follows:

1. How is the effort of Multifarious Business Sustainable by Koperasi Lestari Binjai City to develop of society through savings and loan?
2. What is the role of Koperasi Serba Usaha Indah Lestari Binjai to develop of members and society?
3. How is the mechanism saving and loan at Koperasi Serba Usaha Indah Lestari Binjai City?

The Objectives of the Study

In relation to the problems of the study, the objectives of this study are.

1. To know the effort of Multifunctional Business Koperasi Lestari Indah Binjai City to develop of society through savings and loans.
2. To know the role of Koperasi Serba Usaha Indah Lestari Kota Madya Binjai to develop of members and society.

3. To find out how the influence of Koperasi Serba Usaha Indah Lestari Binjai city to develop community.

The Significances of the Study

1. For writer, as a way to train, to write and to think scientific in the field of cooperative management.
2. For Koperasi Serba Usaha Indah Lestari Binjai city, it is hoped that this research result can be used as input to pay more attention to cooperatives.
3. For other researchers, as a reference in research on the object of the same problem in the future.

II. REVIEW OF LITERATURE

Definition Cooperative based on of Law No.25/1992

Cooperative is a business entity consisting of persons or a body corporate or a co-operative, with the bases activities based on the principles of economic cooperation as well as the people's movement, which is based on a family basis. The purpose Cooperative In Law No.25/1992 regarding cooperatives Article 3 states that , the cooperative aims to promote the welfare of its members in particular and the society in general , as well as help build the national economy , in order to realize an advanced society , just and prosperous based on Pancasila and the 1945 Constitution .

Platform and Cooperative Principles

The foundations of cooperatives in Indonesia are rooted in what is known as Rochdale principles. (Sagimun. MD 1983: 59)

1. The foundation of an idiative Indonesian cooperative is Pancasila. Pancasila is an ideological foundation of the Republic of Indonesia and serves as a guide for the life of all Indonesians. The five principles of Pancasila become the foundation in the life of Indonesian cooperatives.
2. The structural foundation of the Indonesian Cooperative is the 1945 Constitution this is also the case with Pancasila which is nothing but the structural foundation of the Republic of Indonesia is the 1945 Constitution. The Indonesian cooperative movement should be appropriate and should not conflict with Pancasila and the 1945 Constitution.
3. The operational base of Indonesian cooperatives, The operational base of Indonesian cooperatives is as follows:
 - a) Article 33 of the 1945 Constitution and its explanation
 - b) Decree of MPR number II / MPR / 1983 on GBHN

- c) Law No.12 of 1967 on the Principles of Cooperatives
- d) Articles of Association and Bylaws of Cooperatives. Indonesian cooperatives are based on kinship. This is clearly stated in the provisions of Chapter II, the first part, Article 2 of Law No.25 of 1992 on Cooperatives. This principle of kinship is a principle that is in accordance with the soul and personality of the Indonesian nation and has been entrenched in the soul of the Indonesian nation. Cooperative efforts that run cooperatives with the principle of kinship is usually referred to mutual cooperation, which reflects the spirit of togetherness. In cooperatives, what is meant by joint effort here is based on kinship. (Sutantya Rahardjo H. 2000: 39)

Cooperative functions under Law No.25/1992:

1. Build and develop the potential economic viability members in particular and the society at large to improve the economic and social welfare.
2. Play an active role in efforts to enhance the quality of human life and society
3. Strengthen the economy of the people as the basis of the defense forces and the national economy.
4. Trying to establish and develop the national economy which is a joint venture on the basis of the principle of kinship and economic democracy.

Cooperative principles

Cooperative principle by Munker

The cooperative principles are the principles of social science formulated from experience and a major clue in doing something .

Rochdale Principles, among others:

Democratic oversight.

1. Membership is open.
2. Interest on capital is limited.
3. SHU distribution of services to members proportional to each member.
4. Entirely with cash sales.
5. The goods sold must be genuine and not faked.
6. Provide education to the members of the cooperative principle.
7. Neutral to politics and religion.

Principles of Raiffeisen

1. Non
2. Limited working area
3. SHU for backup
4. Responsibility of members is not limited
5. Administrators to work on a voluntary basis
6. Effort only to members
7. Members on the basis of character , not money

The principle of ICA (International Cooperative Alliance)

1. Cooperative membership is open without any restriction made-up.
2. Democratic leadership on the basis of one person one vote.
3. Capital received limited interest, and even then if there is.
4. SHU for public reserves and a portion is returned to the members in accordance with their respective services.
5. All cooperative education should run continuously.
6. Cooperative movement should carry out close cooperation both regionally, nationally and internationally.

Elements of cooperation

1. Cooperatives are business entities
2. Cooperatives are a collection of people and entities cooperative.
3. Indonesian Cooperative is a cooperative work by " cooperative principles
4. Cooperative Indonesia is "economic movement "
5. Indonesian cooperatives based on principle family.

The Role of Cooperatives

Role is closely related to social status. Because every social status is translated into a social role. Both can not be separated, because one depends on the other and vice versa. No status without role and no role without status. That role is very important because it can regulate individual behavior. As William Shakespeare cited by James M. Henslin: The whole world is a stage all men and women are just players ,they came out and went inside in turn someone plays many rolest that the individual provides them "entrance" and "way out" in the stage of his life. In short, the role is very effective for curbing individuals, telling them when they should "go in" and when they should "get out", or what to do between them.

The role of a fence. Roles allow every individual to be free, but for most individuals, that freedom is limited.

Because the role is governed by the prevailing norms. Suppose that a woman or a man decides that she will not wear shoes. In most situations, they cling to their decisions. But when a formal event arrives, like going to school, they will tend to give up on the norms that make them feel over helmed. Roles are essential to social life. When individuals are born, roles, attitudes, obligations, and rights attached to status, have been determined. The role attached to each individual must be distinguished from the social position of society. The position of the individual in society is a static element that shows the place of the individual in society. More role shows the function, adjustment and as a process. It can be said that the individual can occupy a status, but play a role. Since the role is a dynamic aspect of the status, that is, if the individual exercises his / her rights and obligations according to his / her status, then he has performed a role.

A role at least includes three things:

1. Roles include norms associated with the position or place of individuals in society. The role in this sense is the set of rules that guide individuals in the life of society.
2. Role is a concept of what can be done by individuals in society as an organization.
3. Roles can also be regarded as individual behaviors that are important for the social structure of society.

The significance of the role is exposes what is expected of people. For example, a buyer is your status, but your expectation of receiving the item you want from the seller, as well as the salesperson's expectation that you will pay for the goods you buy, is all part of your role.

III. RESEARCH METHODOLOGY**Research Design**

The collected data analyzed through descriptive qualitative method. In descriptive qualitative method, the data were systematically and accurately analyzed based on the theory applied in the study. According Gay and Eurasian (2000), Qualitative approach is based on the collection data and analysis of non numerical data such as observations, interviews, and other more discursive sources of information. Additionally, Moleong stated (2009) "Qualitative research is the research that's means to understand the phenomenon about what is the subject research undergone by using natural method". It means that Qualitative research is the research which understanding the phenomenon based on the collection data and analysis of non-numerical data.that is obsevation to the role undertaken by savings and loan Koperasi in Binjai City to develop of community efforts. As a

research step in this study, the author uses descriptive analysis method.

Place and Time of Research

This research takes place in the Binjai City area. The time of this study was conducted from May to July in 2018.

Population and Sample

Population is used as a sample because the population is relatively small (Sugiyono, 2003: 78). The sampling technique used is the survey where the data of Koperasi Serba Usaha Indah Lestari Binjai city since 2017-2018.

Source of Data

The data were collected based on purposive sampling technique as stated by Sugiyono (2013: 218) "purposive sampling is the technique of collecting data based on certain consideration". In addition, according to James (1999: 76) "purposive sampling is the selection of particularly informative or useful subjects. The research that the authors do is field research and literature research, then data source studied are classified:

- a) Primary Source: data obtained directly from the field through interviews with some leaders of the Multipurpose Business Koperasi Lestari Indah Binjai City.
- b) Secondary source: to support data source and to complete this research is taken from independent bank documentation, literature review in the form of books and other media written by economic experts, especially in the field of cooperatives

IV. FINDINGS AND DISCUSSION

Koperasi Serba Usaha Indah Lestari Binjai always try to comply with all rules and laws that apply especially regarding the rules of lending established by the Office of Cooperatives to prevent the occurrence of sanctions, in addition to the management with integrity and ethical values that have been given a good example for its Personnel by carrying out their duties according to their responsibilities and authority.

This is evident from the inadequacy of internal controls applied that can be seen from the effectiveness of internal control elements, namely: environment control, risk assessment, activities control, information and communication, and monitoring, and achievement of internal control objectives. Despite the limitations of internal controls that do not enable the full effectiveness of the crediting system, there are also other untested factors that also play a role in supporting the effectiveness

of the crediting system, but the internal control of the Koperasi Serba Usaha Indah Lestari Binjai Municipality has supported the effectiveness of small and medium enterprise credit system that is application of healthy crediting principles and procedures, adequate guarantee and collateral, interest and smooth credit repayment, credit giving selectively prioritized in the sectors of small and medium enterprises, and credit has been in accordance with designated. Thus, the internal controls applied to Koperasi Multipurpose Indah Lestari Binjai City has been effective and supporting the effectiveness of small and medium enterprise credit system, which plays a role in encouraging operational efficiency and effectiveness, encourage the reliability of financial statements, and encourage compliance with laws and regulations .

V. CONCLUSION

Based on the research that the authors in the Multipurpose Business Koperasi Indah Lestari Binjai City, the authors can conclude that the internal controls applied to the Multipurpose Business Koperasi Indah Lestari Binjai City and the crediting system has been effective. That derived as follow :

- A. Internal controls implemented have been effective and adequate. with the effectiveness of internal control which consists of the elements:
 1. Control Environment
 - a) The existence of the rules that are applied regarding the personnel procedure in the form of ethics and behavior.
 - b) The existence of adequate organizational structure completed job description, assign responsibility and clear delegation of authority so that each employee can know their respective duties.
 - c) The existence of separation of duties and responsibilities of the crediting system.
 2. Determination of risk management the existence of risk estimates so that it can follow any developments in the event of a change.
 3. Control Activities
 - a) The existence of separation of duties and responsibilities of the crediting system.
 - b) The existence of authorization from the authorized official to the crediting transaction.
 - c) The availability of adequate documents and records.

- d) The existence of physical control of documents / guarantees required for credit files.
4. Information and Communication the existence of the implementation of information and communication systems supported by adequate procedures and documents.
5. Monitoring
 - a) Monitoring is carried out by the Multipurpose Business Koperasi Lestari Binjai city to establish the quality of internal control and follow up to the deviation that happened.
 - b) Has made a branch performance report as a management information tool in monitoring branch operations including the development of loans.
6. The effectiveness and efficiency of operations seen from the caution of savings and credit cooperatives avoids the possibility of demands from customers by controlling strict credit procedures for crediting systems in accordance with applicable regulations.
7. Reliability of financial statements supported by the validity of report data due to proper authorization of each transaction.
8. Compliance with applicable laws and regulations with due regard to guidance from the head office and the board of directors.

B. The crediting system that is applied at Koperasi Serba Usaha Indah Lestari Binjai city has been effective. This is supported by the effectiveness of the crediting system with support from:

- a) The lending system that occurs in the Business Solution of Serba Usaha Indah Lestari Binjai City has been in accordance with the principles and procedures and regulations, so there is no misunderstanding or manipulation of customer data.
- b) The existence of adequate guarantee in accordance with the amount of credit provided to the customer so that it can be used as security guarantee credit.
- c) In every credit given to the customer always provides benefits to the company in the form of interest, and credit repayment from the customer has been in accordance with the

time applied so that the risk of bad loans becomes very small.

- d) Giving credit has been targeted and productive that is prioritized to help the small and medium business sector.
 - e) The use of credit by customers has been in accordance with the original plan in addition to capital.
- C.** The role of internal controls in supporting the effectiveness of the crediting system. This is supported by the questionnaire results related to the role of internal controls to support the effectiveness of the crediting system of 92.97%. And can be seen from:
- a) Effective Internal Control helped maintain the wealth of the Multifunctional Business Koperasi Lestari Binjai City so that security of credit funds is maintained.
 - b) Good internal controls have encouraged the thoroughness and scandal of accounting data so that there will be no case of data engineering.
 - c) Good internal controls have encouraged compliance with management policies, so that there is no violation of the prevailing provisions that have been set up by the Multipurpose Business Koperasi Indah Lestari Binjai City.
 - d) Effective internal control helped operational efficiency. The effectiveness of the crediting system has been achieved by the implementation of the principles and procedures for the provision of sound credit and smooth repayment of principal and interest payable, credit conformity with the allocation also shows that the credit is worth to be disbursed because the debtor uses the existing funds in accordance with the agreement. In addition, the customers are indeed eligible to receive credit supported by the customer's ability and support from the level of business, so that internal controls at Koperasi Multipurpose Indah Lestari Binjai City has been able to prevent abuse of authority, so the credit system is really through analysis and precise calculation so that the credit disbursed can be minimized the risk of stalled.

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A Case Study on Identifying Software Development Lifecycle and Process Framework

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Abstract—This paper analyzes and determines which software development lifecycle and process framework would be appropriate in the following case studies: Microsoft office business unit, Denver Baggage, Avionics development, and Department of Transportation. The analysis for decision takes into consideration the stakeholders involved, the targeted audience, technology, business drivers, culture, time/schedule, resources, scope, and quality.

Keywords—Software process, SDLC, Software framework.

I. INTRODUCTION

Technology is taking over the world at a rapid pace. With the exponential growth of technology across diverse industries, software solutions have become essential in every facet of the business. Because of the size and complexity of current software, there is a need to have a guiding process for development. However, with such diverse applications of software, there is a need to determine the appropriate process in the context of the situation. This paper investigates the following four case studies.

II. CASE STUDY: MICROSOFT OFFICE BUSINESS UNIT (OBU)

Microsoft released Word for Windows word processor in 1989, after five years of development. The product received significant acclaim, and the sales concluded higher than Microsoft's projections, however, the project faced several project management issues in its execution [1]. The project had issues ranging from ill-defined requirements, lack of planning, inadequate project management, and random role assignment [1]. Most of Microsoft's products at that time were among the best available products on the market. Though the product was built in Microsoft's standard style, Office Business Unit project needed a structure - a process framework to guide the development.

Following points were noted before identifying the software process and framework:

Microsoft work culture: The work culture at Microsoft at that time was informal - software engineering staff handled project execution decisions; roles were

interchangeable, and projects were carried out without formal requirements documentation.

Microsoft's release strategy: Microsoft's preferred strategy was to deliver the product in many small releases with short durations.

Time constraint: The initial project was scheduled to be delivered in one year.

Focus on programming: Microsoft's projects at that time relied heavily on programming aka build and demonstrate model. It had always worked for them in the past. Developers and managers were not very concerned with the software architecture or process methodologies.

Small team sizes: Development team size was typically limited to 10 people.

Unclear requirements: The requirements for the project were not well defined. Microsoft wanted to add as many innovative features in the word processor, without defining the project scope.

Based on the above factors and as per [2] an agile process like Extreme Programming (XP) [14] would be a better fit for the OBU project. Below are potential reasons as to why extreme programming would serve the project better: Time criticality / Small releases: The primary focus of Microsoft was to release the product to market as soon as possible. With XP, it could be achieved by releasing an early version of the software and then incrementally adding functionalities to it with later releases. Such incremental deployments are not feasible with traditional software processes like Rational Unified Process (RUP) [11], due to its monolithic development style. With Agile, the product can be built incrementally; particularly with Extreme Programming (XP) process, a simplistic model of the system is released to production and newer versions are released in short cycles.

Undefined requirements: Since the requirements were unclear and volatile, it makes sense to choose an agile process that could quickly respond to changes.

Code-centric development: The nature of the project suggests that it was going to be code intensive (a word processor with many innovative features). Also, at Microsoft, significant emphasis was on programming, rather than on system architecture documentation. In XP, programming forms the core, and it allows programmers to take decisions about the design. This would have worked well with engineers like Hunt - one of the

programmers responsible for deciding on the features for Word.

Informal work culture: Traditional methodologies are rigid and do not work well in informal settings [13], but XP can work very well in such configurations. For example, pair programming, one of the tenets of XP, can be beneficial when developers are comfortable working closely with each other. Small team sizes at Microsoft could support such practices. Furthermore, it is unrealistic for them to use a cumbersome process such as RUP which requires a highly structured and complex team with many roles and requires tool support.

Focus on quality: Bill Gates wanted this to be the “best word processor ever” and much time was to be spent on getting every feature right. Characteristics of XP such as refactoring (restructuring the program to improve quality) and continuous testing (continuously writing unit tests, which must run for the development to continue) would serve this purpose greatly.

Having a working system at all times: Some Microsoft managers were of the opinion that a “shippable” product should be available at all times – after a piece of development is complete, all error and boundary cases should work, and it should successfully integrate with the rest of the system. XP facilitates just that with continuous integration. It says that the system should be built many times a day, every time a task is completed.

User collaboration: Since the market focused on multiple large business corporations and government agencies, the way to elicit requirements should be through user collaboration. An iterative process is required to elicit user requirements and feedback. An agile process like XP best does this.

Extrapolating the engineering culture and project management structure at Microsoft an iterative and incremental lifecycle with a light, agile process like XP would be a good candidate for the MS Word project by providing structure for new requirements, delivery under time constraints, and code-intensive development.

III. CASE STUDY: DENVER BAGGAGE SYSTEM

Before determining what process and framework would be useful for the Denver Baggage System (DBS) [10], notes are taken on the nature of the project. There are several stakeholders on the DBS project, and each has their expectation for the system (see the table below).

Stakeholder	Need
Airport	The project must be completed on time as delays cost money
Airlines	Planes must be loaded as quickly as possible
Passengers	The system must be accurate, so

	bags are not misplaced
Airport Staff	The system must not break since there is no backup in place

The needs of the stakeholder’s lead to the project’s requirements. Based on the date the airport is scheduled to open, the project must be completed within 22 months. It has to be entirely accurate for bags to be delivered to the right place. It cannot have any downtime. It also has to move the bags physically faster than any other system before, which allows planes to have a faster turnaround time. However, the system is far too complex to design and implement within the desired time window. As Neufville pointed out [8], planning the people mover in the Atlanta airport was the subject of two years of research and a doctorate dissertation, and that system was comparatively simple. As the development cannot realistically be completed within the scheduled timeframe, it is assumed the DBS is delivered in increments to have a working system eventually.

By studying the system requirements, of the Denver Baggage System, it seems the creation of the Denver Baggage System would be best handled with a traditional Rational Unified Process (RUP) framework [11]. RUP is appropriate for a variety of reasons:

RUP puts a strong emphasis on the design of a system, this is required as the complexity of the system requires thorough planning.

RUP promotes component-based architecture which enables modeling of real-world systems and integrates well with the development of those systems [2]. This is very important for the DBS project since the physical design of the DBS is constrained by the architectural design of the airport and the physical realities of the conveyor system.

RUP process is designed for delivery in increments. As explained before, it is not possible to deliver the entire system in working condition by the deadline. Delivering some sub-portion of the system should be possible. RUP’s incremental delivery design allows the system to expand as it is developed.

Delivering the system in increments forces the creation of a manual backup system. Some bags would have to be manually transported to the terminal until the entire system is online. This helps maintain system reliability because if the system fails, there is a process and procedure for replacing the lost functionality.

Due to many investors in the DBS project, project accountability is a requirement. The extensive documentation and artifacts produced by RUP provide the accountability mentioned above.

When comparing RUP to other process frameworks, it is apparent why, in this case, it is the superior process. RUP

has advantages over more agile frameworks like XP in that this project is very design heavy. Much planning is needed to ensure that all the parts of the system integrate together successfully.

RUP is better than waterfall-style processes since the DBS project needs incremental deliveries not present in those frameworks.

The DBS project does not need the risk management of a spiral process since the risk is managed by the forced development of a backup system.

IV. CASE STUDY: PENNDOT21

The goal of the PennDOT21 project is to provide on-line vehicle registration services by making a web interface for the PennDOT registration system [12]. This system should be a secure and easily accessible service to all licensed Pennsylvania drivers. The critical factors in determining a lifecycle for this project are as follows:

Stakeholders: The significant stakeholders include the Pennsylvania Department of Transportation, its employees who work with the system, and all licensed Pennsylvania drivers. Because the technical competence of the end users varies, the web interface must provide a highly accessible and intuitive GUI. It suggests an iterative lifecycle with feedback to determine GUI requirements.

Market: We assume that the PennDOT21 system is mostly the first of its kind and therefore may serve as an example system for other states in the future, this suggests a process with clear indicators of progress.

Technology: PennDOT21 to provide an interface with the older PennDOT vehicle registration system. Thus, there must be proper testing to ensure that this integration is secure and robust.

Business Drivers: The business goal of this project is to reduce errors and work required in the existing manual registration process. Because a manual process already exists, this suggests a backup exists for PennDOT21 in case of failure and also that continuous deployment is possible.

Culture: End-users and employees are unaccustomed to using the web interface. Thus, a gradual deployment with training is required for a successful project.

Time/schedule: A time constraint is not a primary requirement of this project because there is already a manual process by which drivers can register their vehicles. Since the interface is dependent on the manual process, any changes in the manual process might affect the schedule.

Scope: The scope listed in the project description only covers an interface for vehicle registration. However, it is feasible that the scope might be extended in future projects by the DOT if the project is successful (since the

DOT covers many more functions than just vehicle registration). Thus, PennDOT21 should be modular and modifiable.

Quality: One of the main concerns for the PennDOT21 is security, as transmitted data might include sensitive information such as registration numbers. Furthermore, the system must provide 24x7 access and thus must be error-free and robust. Concurrency and scalability is an issue, since there may be a large number of users accessing the system at one time.

From the above factors, the most critical project requirements are summarized as follows:

- Robust, secure, scalable, modular and modifiable back-end communication with PennDOT.
- Intuitive and flexible, but secure front-end web interface.
- Clear indicators of project progress.
- Extensive testing to ensure code integrity.

The points above show a dichotomy in the requirements for this project. On the one hand, the robust back-end suggests a traditional process with particular attention to design and architecture. On the other hand, the easy-to-use front-end suggests an iterative, agile process with extensive feedback to make the interface as intuitive as possible. Therefore, the best fit process is a merge of both agile and traditional processes.

ACDM [7] with Rapid Prototyping [9] provides the best fit for this project. ACDM's architecture-centric approach gives the best chance of success in fulfilling the need for a robust, secure, and scalable system. Furthermore, ACDM provides a clear way to track progress by use of the architecture [3], even though rapid prototyping itself may not produce clear progress indicators. Rapid prototyping is used in the production phase because its attitude towards changing requirements and extensive feedback allows it to provide an intuitive and easy-to-use interface. ACDM guides the development, so there is no loss in security or robustness. Furthermore, rapid prototyping's code-centric attitude ensures a minimum of bugs, and this is especially true for PennDOT21 which would be a small or medium software size [2].

ACDM with Rapid Prototyping [9] is the best possible process for this project. Security, scalability, robustness, and modifiability are all attributes that are addressed while examining the architecture of a project. Furthermore, PennDOT21 is not a life-critical system, and has a backup manual registration service (as assumed), so heavyweight processes like Spiral or RUP are not essential to its development. Next, ACDM should be combined with an agile process for development since the exact requirements for an intuitive web interface cannot be well-defined early in the project. In this case, Rapid prototyping is the best agile process to combine

with ACDM because of Rapid prototyping's code-centric approach and attitude towards changing requirements. Another approach like scrum might focus on the management side, which may not be necessary for this project (depending on the specifics of the development team).

V. CASE STUDY: FLIGHT CONTROL SYSTEM

The aircraft flight control system (FCS) is a high-risk flight system that controls every aspect of an airplane operation to ensure safer, smoother flight; it consists of the flight control surfaces, cockpit controls, and the necessary mechanism to control the aircraft's direction in flight.

FCS requires:

- Good aircraft handling properties
- Low pilot workload
- Model simulation or prototyping is required to analyze whether digital processing signals represent the desired implementation, to avoid any mishap during the ground or flight testing[4].
- Backup or failover plan in case of software or hardware fault.
- The system developed should be comprehensively tested for an extensive set of faults and have thorough ground-based testing. The system and its inherent functional design should be free from errors.

Additionally, FCS requires adherence to the highest level of quality standards. Any failure in the system can cause loss of aircraft and human lives; the probability of success should be very close to 100%. However, a test to prove 100 percent correctness is almost impossible. Thus, a trade-off is done by deploying many reliable, redundant artifacts, a thorough design and development process, and test-cases under all possible combinations of inputs. Redundant artifacts would be used as backup during any software fault.

The project is high risk, safety-critical, and requires zero defect deliverables along with continuous risk assessment. Thus, a spiral model is proposed as the software development process along with six sigma business management strategy. This gives a combination of prototyping, continuous refinement and near-zero defects.

Here are all of the factors taken into consideration:

Stakeholders:

- Pilots, Passenger
- FAA (Federal Aviation Administration)
- Airlines
- Market:

- Private and military avionics industry

Technology:

- Real-time, Embedded
- Communication between each device has to be near real-time

Business drivers:

- Early generations of FCS were mechanically based, so pilots had to physically steer and control the aircraft, which was limited by the physical capabilities of the pilot [4].
- Development of digital FCS would automate the process.
- Increase in safety as the pilot can concentrate on high-level tasks rather than routine control tasks.

Culture(s):

The spiral model [5] along with Six Sigma strategy is a good fit for the project. The project would consist of interactions between software engineers, embedded systems developers, six sigma black belt members (to aid high quality and defect free deliverables), testers, change management group (risk, impact analysis and versioning), analysts and pilots (for live testing of the system).

Time/schedule, resources, scope, and quality:

This project, being safety critical, requires thorough testing, simulation, high-quality standards, zero defects, and adequate documentation. The spiral model incorporates the above requirements with a fast-iterative approach, and a team of six sigma competent members would work on quality, risk management, cost, and estimation in sync with spiral model phases. Hence, the spiral model fits the project well.

Six Sigma:

Due to the lack of emphasis on documentation with the spiral model, its weakness is strengthened by combining it with Six Sigma strategy. Six Sigma [6] improves the quality of process outputs by identifying and removing the causes of defects and minimizing variability in manufacturing [7]. In a Six Sigma process, 99.99966% of the product is expected to be bug-free. The five phases of six sigma process are defined, measure (identifying critical to quality and risks), analyze (high-level design), design (simulate and optimize) and verify (set up pilot runs). This along with the spiral model would provide a thoroughly tested, well documented, bug-free, high-quality deliverable.

Considering that the key for developing aircraft flight control is safety, we have concluded that the Spiral process is the excellent fit for this project. Spiral model encapsulates iterative development with prototyping, verification and validation, and a waterfall approach in

incremental order. Finally, six sigma provides the documentation that the spiral model lacks, as well as ensure further quality control to the highest level.

VI CONCLUSION

We have seen in the above four cases that different circumstances can call for very different development models. High-risk applications such as the Flight Control System require traditional models with features such as risk assessment and thorough testing or simulation. On the other hand, products in a highly competitive market, such as MS Word, might require a more agile process for faster time to market. Many factors such as stakeholders, business culture, technology, and risk must be considered for selecting the most appropriate model, and a full analysis of any project should be carried out before selecting a process.

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Policy, Institutional and Legal Guidelines for Sustainable Use of Constructed Wetlands in Tanzania

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Abstract— *The guidelines will provide all stakeholders especially planners, designers and constructors as well as funding agencies in the Tanzania with an easy guidance in policy, institutional and legal aspects required to be considered for proper planning, designing, construction and sustainable use of constructed wetlands technology. These guidelines will contribute towards improving sanitation delivery services in areas without access to conventional sanitation systems and hence will improve the environmental protection against pollution. In Tanzania, the need for guidance in policy, institutional and legal aspects during planning, designing, construction and implementation of constructed wetlands technology is paramount important due to poor institutional arrangement pertaining to issues of sanitation and due to unsuccessful stories given for some of the implemented constructed wetlands in some parts of the country. It is hoped that when these guidelines are properly followed and adhered to, it will yield a positive results in terms of proper planning, designing construction and implementation of the technology. The methodologies used were documents review and interview.*

Keywords—*Constructed wetland, Guidelines, Sustainable use, Policy, wastewater treatment.*

I. INTRODUCTION

Constructed wetlands (CWs) are planned systems designed and constructed to employ wetland vegetation to assist in treating wastewater in a more controlled environment than occurring in natural wetlands. Hammer (1989) defines CW as a designed, manmade complex of saturated substrate, emergent and submerged vegetation, animal life, and water that simulate natural wetlands for human uses and benefits. CW are “eco-friendly” alternatives for secondary and tertiary treatment of municipal and industrial wastewater. The pollutants removed by CW’s include organic materials, suspended solids, nutrients, pathogens, heavy metals and

other toxic or hazardous pollutants. Different types of CWs can effectively treat secondary or tertiary treated wastewaters. However, they should not be used to treat raw sewage and, in industrial situations, the wastes may need to be pre-treated so that the biological elements of the CW system can function effectively with the effluent. CW’s are practical alternatives to conventional treatment of domestic sewage, industrial and agricultural wastes, storm water runoff, and acid mine drainage.

There is not even a single city or town in Tanzania with adequate sewage treatment facilities (Mohammed, 2002). Under normal circumstances, urban centres would be served by wastewater treatment plants and regulated septic disposal facilities, while peri urban areas would experience unregulated waste dumping and burial. In Tanzania however, a very small portion of the urban centres is served with adequate wastewater treatment facilities. Coverage by sewerage services in major cities such as Dar es Salaam, Arusha and Mwanza is less than 15%, with an exception of Moshi at 40% (Mihayo and Njiru, 2005). About 60-70% of the urban population (Mato, 2002), in Tanzania, lives in unplanned peri-urban areas, relying mostly on pit latrines and septic tank soak away systems for sanitation. Major problems with pit latrines and septic tanks in Tanzania are leakages caused by poor construction, flooding of low lying areas, and lack of maintenance. Soak away pits fill up due to poor infiltration when built in clay soil areas. Possibility of conventional systems polluting drinking water sources is high due to close proximity to shallow water wells and surface water sources. Additionally, there is generally lack of adequate wastewater treatment due to lack of funds to install centralized wastewater treatment systems and lack of commitment among policy makers to seriously deal with the problem.

To tackle these problems, good solutions for improving sanitation systems in Tanzania have to be identified. A sustainable low cost solution for hygienic sanitation identified is engineered wetland systems, also known as Constructed Wetlands (CW). The use of constructed wetlands for domestic wastewater treatment in Tanzania has gained much popularity over the last fifteen years since the early pioneering works by Mwegoha et al. (2001), Mwegoha et al. (2002), Kimwaga et al. (2002a, 2002b), Njau et al. (2002), Senzia et al. (2002a, 2002b), Haule et al. (2002), Kaseva et al. (2002), Kimwaga et al. (2004) and Senzia et al. (2003).

The long operational experience and research results have shown greater treatment efficiency, greater nutrient reclamation as compared to other natural biological treatment systems. These systems are low energy-consuming and use natural processes, in contrast to the complex conventional treatment systems that are high energy and high-maintenance demanding. Other advantages include: simplicity, low construction, operation, and maintenance costs, use renewable energy, use locally available materials and robustness. Although they have been found to be commonly used for treating domestic wastewaters, they can also be used for treating industrial wastewater, including water that contains agro-industrial wastes.

Another potential advantage of using sub-surface flow constructed wetlands is that they do not allow mosquitoes to breed. Also, the systems can be designed in clay soils by which septic tank systems cannot fit, they can be designed in areas with high water table because the maximum depth below the ground surface is 0.6 m, they can fit for decentralized wastewater treatment as it can be designed in small, medium and large scales.

Developing these guidelines followed the introduction of economic development frameworks such as sustainable Development Goals (SDGs), MKAKATI WA KUKUZA UCHUMI NA KUPUNGUZA UMASIKINI TANZANIA - Strategy for raising economy and reducing poverty in Tanzania (MKUKUTA), with the guidelines providing a platform for proper planning, designing, construction and sustainable use of constructed wetlands technology hence improving sanitation delivery services in areas without access to conventional sanitation systems and consequently contribute towards improving the environmental protection.

Overall Objectives

The overall objective is to provide Policy, Institutional and Legal guidelines in order to increase access, affordability, and sustainability of constructed wetland technology in urban, peri-urban and rural area of Tanzania.

The specific objectives are:

- (a) To provide policy, institutional and legal requirements in planning phase of constructed wetlands,
- (b) To provide policy, institutional and legal requirements in design phase of constructed wetlands,
- (c) To provide policy, institutional and legal requirements in construction phase of constructed wetlands, and
- (d) To provide policy, institutional and legal requirements in implementation phase of constructed wetlands.

II. METHODOLOGY

The methodologies used were documents review and interview. Relevant research reports on constructed wetland technologies in Tanzania were reviewed. Different researchers who researched on constructed wetland technologies in Tanzania were interviewed.

III. POLICY, INSTITUTIONAL AND LEGAL GUIDELINES IN PLANNING, DESIGN, CONSTRUCTION AND IMPLEMENTATION PHASES

Planning Phase

During the planning phase for the construction wetland project, the following are required.

Land Title Deed

A Developer must hold either a title deed issued by the Ministry responsible for land matters or any other documentation evidencing ownership for the land upon which the CW shall be located.

Environmental and Social Clearances

An Environmental and Social Impact Assessment (ESIA) is a process pursuant to which a development proposal (including its alternatives) and its effects on physical environment and human life, including the mitigation and management of effects is evaluated. An ESIA is carried out in order to ensure that the likely effects of new developments are taken fully into account before the development is allowed to go ahead.

The EIA process covers the period commencing at the initial concept of the proposal and run through implementation to completion and, where appropriate, decommissioning. An EIA is conducted under the provisions of the Environmental Management Act, Cap. 119, which is managed by the National Environmental Management Council. As provided in the Environmental Management Act, Cap. 119 and depending on size and potential for impact, some projects may not require a full EIA.

Wastewater Analysis

The developer should analyze the wastewater design parameters in authorized institutions such as Ardhi University, University of Dar es Salaam e.t.c.

Design Phase

The design of a CW should be carried by qualified and registered engineers by engineer's registration board (ERB) and should be designed by following manuals, standards and code of practice. The design should meet the recommended effluents discharge standards

Construction Phase

At this stage a building permit is required. The construction of any major installation must be authorized by relevant authorities responsible for town and country planning. The authorities that issue building permits include district, municipal and city councils (local government authorities). The authority issues a permit to the developer or proprietor after checking the designs and engineering drawings if they correspond with best engineering practices and also, after checking the design and construction site if comply with master plan. Then the proprietor should find the registered construction company by Engineers Registration Board (ERB) for the construction and should find the qualified and registered consultants for regular check of the construction process.

Implementation Phase (Operation and Maintenance)

CW effluent quality should be monitored by the proprietor for checking if they comply with allowable effluent discharge standards (Tanzania Standards or WHO standards). Institutional such as primary, secondary schools should arrange environmental unit/club for Operation & Maintenance of CW. The operation and maintenance manual for constructed wetlands in Tanzania should be used with this guideline.

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Geoepidemiological Profile of Leprosy in Rondônia, Brazil

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Abstract— The research aimed to evaluate the geoepidemiological profile of leprosy and its spatially uneven production in the state of Rondonia in the period from 2011 to 2014, from the perspective of medical geography, identifying and performing mapping of critical areas of the spatial production of leprosy. The study it is quantitative, descriptive and retrospective research. Information System Diseases and Reportable - the database SINAN (Sistema de Informação de Agravos e Notificáveis) was used. For the clothing of thematic maps was used ArcGIS program. The research universe was created by the registration of all new cases of leprosy reported in the period from 2011 to 2014, living in Rondonia. The State of Rondonia had 2,972 (two thousand nine hundred seventy-two) new cases of leprosy in the period studied, respectively 827 new cases in 2011, 779 in 2012, 2013 686 and 2014 680, which corresponds to 5.24 detection rate in 2011 4.93 2012 3.96 3.88 2013 and 2014 and are classified as hyperendemic area with detection rate/average incidence of 4.50 per 10,000 inhabitants. Leprosy is present in virtually 100% of the municipalities of Rondonia.

Keywords— *Geoepidemiological Profile, Epidemiology, Medical Geography and Leprosy.*

I. INTRODUCTION

The epidemiology of leprosy, particularly their geographical distribution remains with numerous gaps and puzzles. Several major areas - historically - endemic in the world are under tropical climate, high temperatures and rainfall¹. In temperate and cold regions, however, leprosy has also presented high incidences, nevertheless were eliminated without a definitive explanation².

According to the World Health Organization³ (1982) currently, 80% of new cases are concentrated in countries located in the intertropical band: India; Brazil; Myamar; Madagascar; Nepal; and Mozambique.

Some leprosy medical geography works discuss the role of the occupation in the history of the territories as a foundation for maintenance of outbreaks^{4,5}. On the other hand, usually is accepted the association of leprosy with unfavorable living conditions, considering economic, hygienic and sanitary and biological^{4,5}.

Brazil maintains, in recent decades, the most unfavorable situation in America and the diagnosis of the second largest number of cases in the world after India. Leprosy among Brazilians is therefore a public health problem whose elimination program is among the priority actions of the Ministry of Health.

The geographical distribution of the disease in Brazil is studied, usually for its macro-regions and states, it does not have a systematic knowledge of their spatial distribution. With the implementation of Notifiable Diseases Information System (SINAN) by the Ministry of Health (MS), co-administered by the Department of Health Surveillance (SVS/MS) and Department of the Unified Health System (Datusus/MS) in a gradual improvement process it is currently possible to develop detailed explorations of disease in different geographical scales¹.

Factors associated with spatial distribution of leprosy, in general, can be grouped into natural and social. Among the natural assumptions, the weather are, relief, vegetation types and particular ecosystems. Among the social premises, it highlights unfavorable living conditions, malnutrition, migration and others.

Few investigations of leprosy infection focus on non-human sources. The *Mycobacterium leprae* can survive for months outside the human body and favorable moisture conditions. Thus, wet soils, low temperatures and high environmental humidity favor the survival of the bacillus; Beyond these more known environmental sources, should be considered, also, vegetation, water, some arthropods and monkeys^{6,7}.

According to the work of Fine *et al*⁸ the most important source of infection are probably non-treated patients multibacillar where multibacillar contacts of patients had a risk of illness five to ten times higher than the general population; however, there are few multibacillary patients in certain areas indicates other sources of infection⁹.

In this line of research, we discuss about the meaning of armadillo in the incidence of leprosy since the beginning of the 70s Opromola¹⁰ states that, although not proved leprosy a zoonotic disease, the presence of bacilli in wild animals would have serious implications for the control and eradication program of the disease in humans.

Among the social assumptions associated with the geographic distribution of the disease, reaffirm to poverty, malnutrition or some nutritional deficiencies, as well as unfavorable hygienic conditions and migration. The disease often relates to indicators such as low income or *per capita*, low education and lack of basic health conditions, among others. Nevertheless, historical documents about the factors associated with the transmission of leprosy suggest that its great spread and rapid decline in medieval Europe are due to the existence of some unknown epidemic factor.

As knowledge popularized leprosy is still a serious health problem in the world. Besides being a disease aggravated inherent to socioeconomic and cultural borne diseases, it is also marked by the psychological impact generated by deformities, disabilities, stigma causes and people's isolation in society. This fact contributes to decreased self-esteem and self-segregation of leprosy carrier. Precisely for this reason, its sufferers hide their problem in order not to be discriminated against by society¹¹.

According to Cunha¹¹ leprosy is known for millennia, in the biblical account was cited as an impurity of mind and their carriers were isolated from society. Hence arose the prejudices about the disease. A public health problem already was considered as caused mutilations, disabilities and that deformed his face and body, with the loss of body parts, has long been known as leprosy until the change of nomenclature for leprosy, through Law Brazilian Federal No. 9010 of March 29, 1995.

Leprosy is simple to diagnose, treat and can be cured provided it is diagnosed early because their injuries can lead to physical disabilities.

The *M. leprae* has an interesting feature, has high infectivity and low pathogenicity, it means that many are infected, but few get sick¹².

The production and distribution of leprosy in the state of Rondonia deserve special attention by high detection rates presented, ranking third in the national ranking in reported cases of the disease. The study of the spatial behavior of this indicator can be an important tool to assist in planning, monitoring and evaluation of health actions by directing interventions to reduce the high rates of the disease. So geoepidemiological characterize the pattern of leprosy in the State of Rondonia, means contributing to spatial visualization of leprosy, for applying control measures in places considered risk areas. The research aims to evaluate the geoepidemiológico pattern of leprosy and its spatially uneven production in the state of Rondonia in the period from 2011 to 2014, from the perspective of medical geography and specific objectives, describe the geoepidemiológico pattern of leprosy; identify the spatially uneven production; perform mapping of critical areas of the spatial production of leprosy in the state of Rondonia.

II. METHODS

2.1 Type of study

The study is conducted by quantitative, descriptive and retrospective study. Seeks to identify events (...), or even describe how certain phenomena are distributed in the population, or part of, or their sample quantitatively measuring the problem will contribute to a spatial analysis of leprosy in the state of Rondonia in the 2011 period 2014.

2.2 Data collection instruments

Data were requested from ANVISA - National Agency of Sanitary Vigilance, by application, in which it sent the information SINAN database - Notifiable Diseases and Information Service.

The SINAN-NET was developed by SVS / MS together to DATASUS, it aims to modify the information production logic for the analysis on levels of increasingly decentralized health system. Subsidizes the construction of epidemiological surveillance systems of territorial base, to be aware of what happens to the Internet, the transmission of data from reporting daily to the other levels of government, so that these data are available in a timely manner, the three spheres government.

The systematic use of data generated by the system from outside decentralized, contributes to the democratization of information, allowing all health professionals have access to information and make available to the community. It is therefore an important tool to assist the planning of health, set intervention properties, in addition to enabling that evaluate the impact of interventions.

The System for Notifiable Diseases Information System (SINAN) is an important system for epidemiological surveillance, was created in 1990 by the Ministry of Health (MOH) in order to collect, process and transmit data on notification of diseases throughout the country, providing information for the analysis of

morbidity profile, as well as carry out the process of data collection and transfer related to diseases and reportable diseases. Leprosy is the object of this system, which enables therefore get consolidated information on the disease and the SINAN was the main data for this work¹³. With possession of information obtained ANVISA, the database was done in ArcGIS program for later preparation of thematic maps with spatial distribution of leprosy in the state of Rondonia, containing new cases of distribution map.

Because it is study used secondary data there was no need for project submission to a Research Ethics Committee meeting the provisions of Resolution 196 of the CNS/CES. - National Health Council/Committee Ethics and Health Still, It has officially requested authorization from the primary data holders, by application to ANVISA.

It was created by the registration of all new cases of leprosy reported in the period from 2011 to 2014, living in Rondonia.

The selection of variables to study based on the relationship of those variables used for the construction of epidemiological and operational indicators officially used by the Ministry of Health. In order to analyze the evolution of leprosy and describe their geographical distribution in Rondonia the following variables were selected, and their categorizations:

Table.1: Main variable: overall case detection coefficient

COEFFICIENT	PARAMETERS
Low	<0,2/10.000 inhabitants
Medium:	0,2 1,0/10.000 inhabitants
High	1,0 2,0/10.000 inhabitants
Very High	2,0 4,0/10.000 inhabitants
Hiperendemic	≥4,0 /10.000 inhabitants

Table.2: Independent Variables

GENRE	MALE	FEMALE			
Age	0-14 years	15-44 years	45 e years		
Race/Color	White	Black	Brown	Yellow	Indigenous
Clinical form of the Disease	Indeterminate	Tuberculoid	Dimorphic	Virchowian	Not Rated
Operational Rating	Multibacillary	Paucibacillar	Not Rated		

The state of Rondonia is located in northern Brazil, located between parallels 7°58' and 13°43' south latitude and the meridians 59° 50' and 66° 48' west longitude from Greenwich. It has an area of 238,512.80 square kilometers and includes 52 municipalities. (National Atlas of Brazil, IBGE 2010).

III. RESULTS AND DISCUSSIONS

As SINAN data, the state of Rondonia had 2,972 (two thousand nine hundred seventy-two) new cases of leprosy in the period studied, respectively 827 new cases in 2011, 779 in 2012, 686 in 2013 and 680 in 2014, which corresponds to detection rate of 5.24 2011 4.93 2012 3.96

3.88 2013 and 2014 and are classified as hyperendemic area with detection rate / average incidence of 10 thousand 4.50 (table 3). Figures 1, 2, 3 and 4 illustrate the distribution of new cases of leprosy by the municipality. Leprosy is present in virtually 100% of the municipalities of Rondonia. The municipalities that were

not reported new cases are probably devoid of the actions of the control program of the disease or lack of health professionals to diagnose the disease. In the period studied leprosy remains hyperendemic or very high incidence in most municipalities, regardless of their socioeconomic characteristics, social, environmental organization, hygiene, health, lifestyles, genetic pool, urban or rural characteristics. Detection rates / incidence of the production and distribution of leprosy does not follow a pattern in the territory, building its own configuration with their arrangements in geographic space.

However the municipalities that have the highest new cases numbers are the most urbanized, with the highest population index and the 1st generation of municipal units, geographically spread from north to south of the

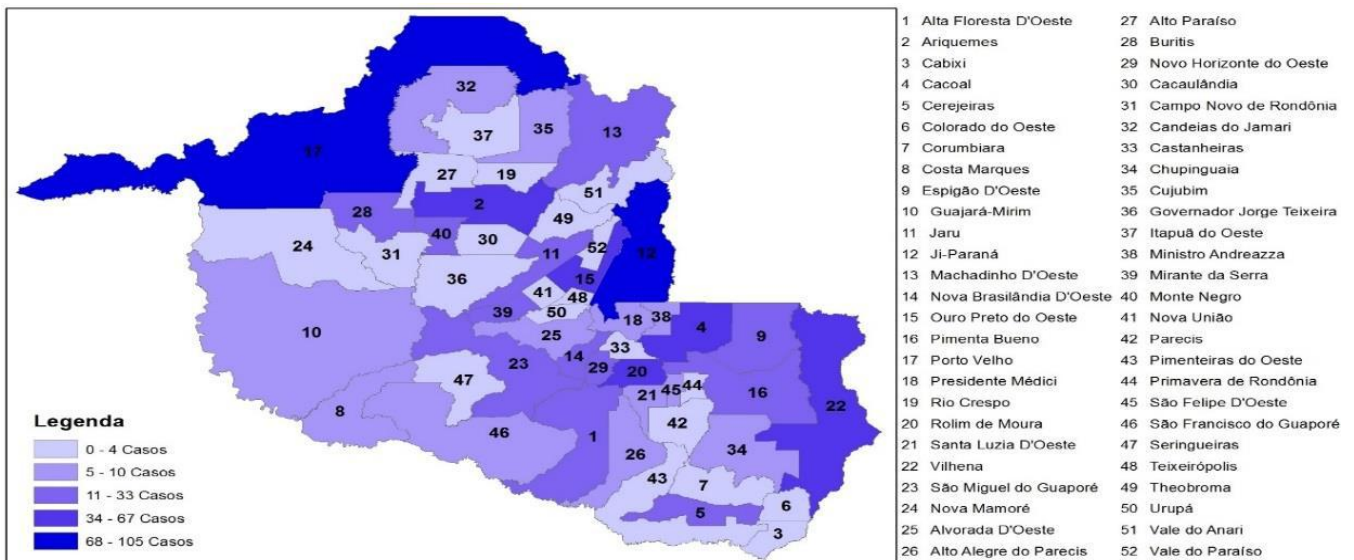
state, located on the axis of BR 364: Old Port with 105, 135, 117 and 78 respectively in the years 2011, 2012, 2013 and 2014 has the highest number of new cases, following the Ji-Parana municipalities with respectively 101, 97, 76 and 64, Cacoal 67, 49, 37 and 59, Rolim Moura 60, 53, 42 and 68; Velho 44, 45, 34 and 53, and Vilhena 44, 37, 30 and 29 new cases studied for years respectively.

Because the distribution rate per 10,000 inhabitants detection, the towns of Ariquemes, Cacoal, Ji-Parana, Rolim de Moura and Vilhena are classified as hyperendemic, with the exception of Porto Velho with very high parameter. All other hyperendemic municipal units have different characteristics as to population issues, urbanization, socioeconomic, hygienic-sanitary and others.

Table.3: New Cases Reported in Study Period

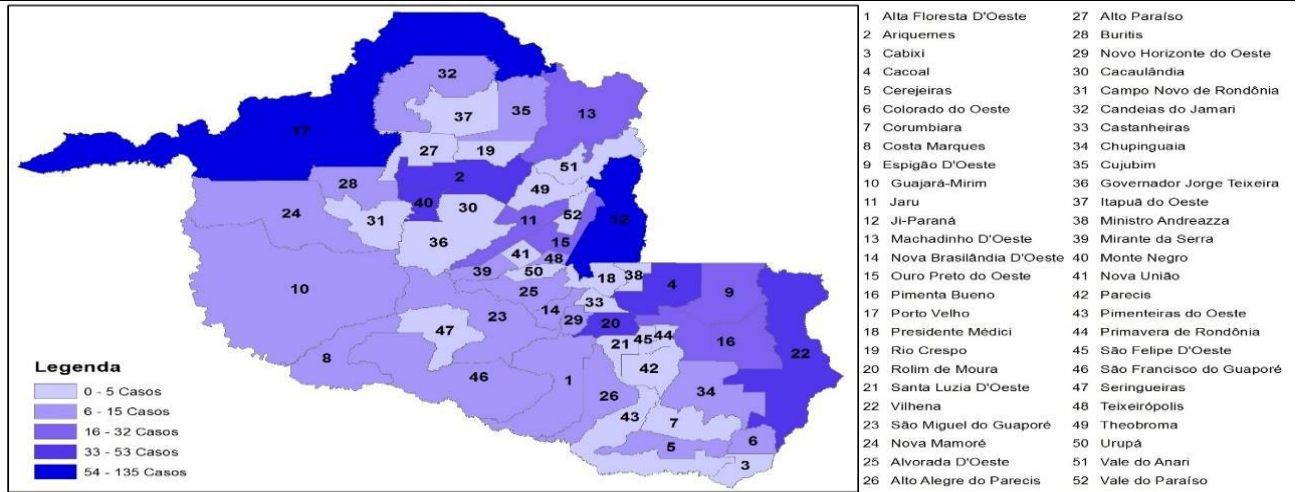
Year	New Cases	Detection Rate/Impact
2011	827	5, 24
2012	779	4,93
2013	686	3,96
2014	680	3,88
Total	2972	4,50

Source: SINAN / MS, 2015.



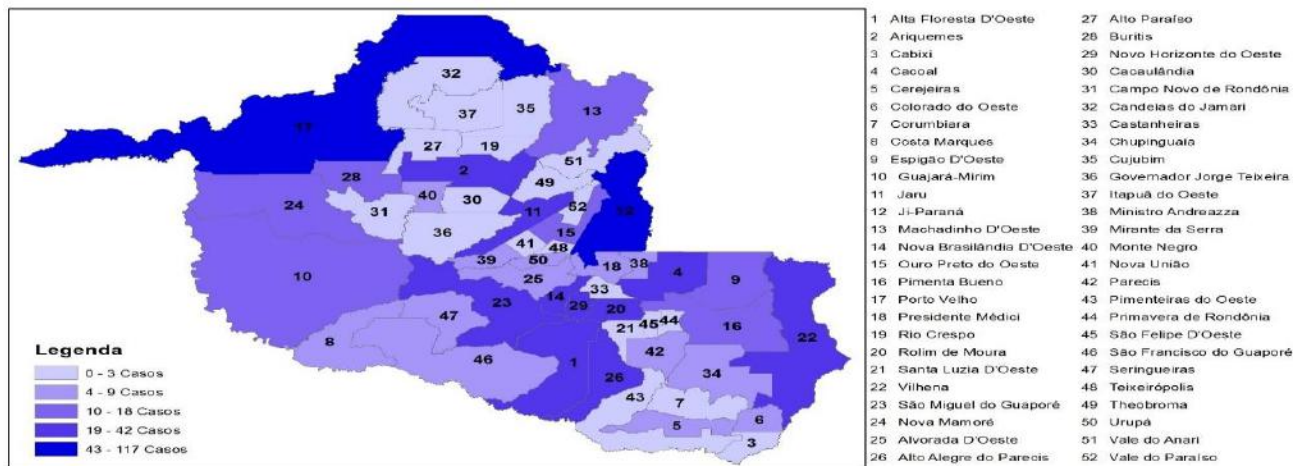
Source: Edited image in ArcGIS program

Fig.1: Production Map and Leprosy Distribution by County in 2011



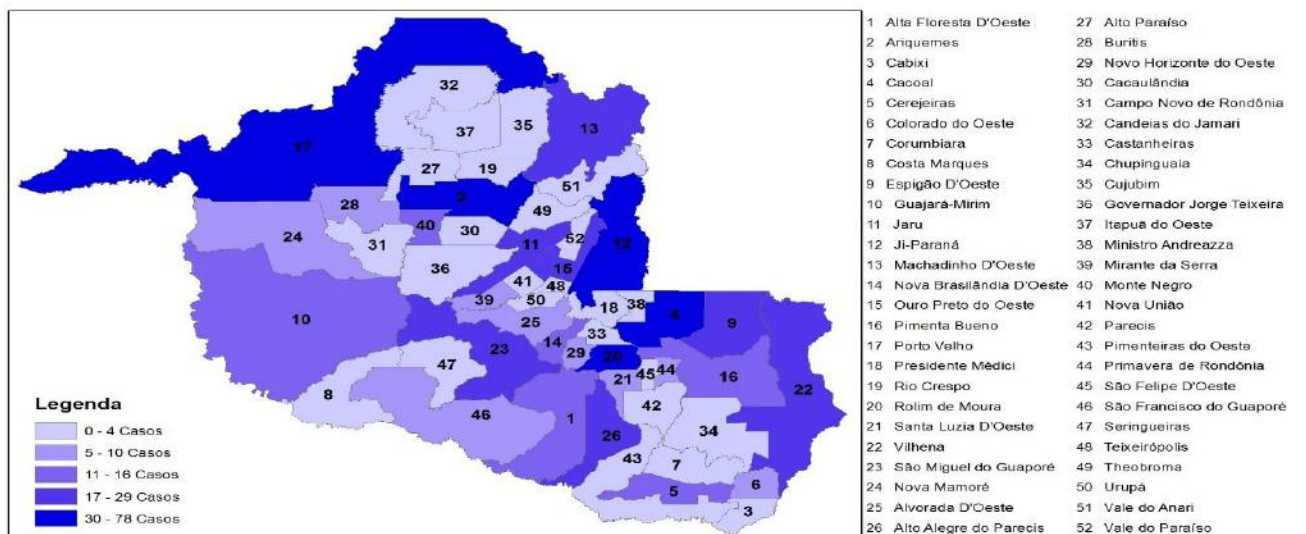
Source: Edited image in ArcGIS program

Fig.2: Production Map and Leprosy Distribution by County in 2012



Source: Edited image in ArcGIS program

Fig.3: Production Map and Leprosy Distribution by County in 2013



Source: Edited image in ArcGIS program

Fig.4: Production Map and Leprosy Distribution by County in 2014

Table.4: Detection Rate/incidence per 10,000 inhabitants. by municipalities of Rondonia

Municipalities	2014	2013	2012	2011
Alta Floresta D'Oeste	6,23	8,93	3,73	9,0
Alto Alegre dos Parecis	15,84	19,52	10,9	3,9
Alto Paraíso	11,0	0,5	1,12	1,7
Alvorada D'Oeste	3,48	2,87	3,65	3,0
Ariquemes	5,15	3,35	4,85	4,0
Buritis	2,68	3,28	4,49	4,9
Cabixi	0,0	0,0	3,26	0,0
Cacaulândia	1,58	1,59	6,17	6,9
Cacoal	6,8	4,3	0,77	8,48
Campo Novo de Rondonia	0,7	0,7	3,36	0,78
Candeias do Jamari	0,4	0,87	0,0	3,44
Castanheiras	8,2	0,0	4,15	0,0
Cerejeiras	7,2	2,77	9,0	10,0
Chupinguaia	0,0	5,0	5,52	9,39
Colorado do Oeste	4,7	3,0	2,34	2,18
Corumbiara	2,23	0,0	8,35	3,36
Costa Marques	2,46	2,52	6,37	3,56
Cujubim	0,49	1,54	6,5	6,0
Espigão D'Oeste	6,55	4,4	0,99	5,86
Governador Jorge Teixeira	0,0	0,0	0,0	0,97
Guajará-Mirim	2,59	3,0	1,42	1,19
Itapuã do Oeste	2,0	0,0	2,26	3,44
Jaru	3,77	4,49	4,24	3,27
Ji-Paraná	4,95	5,93	8,2	8,6
Machadinho D'Oeste	7,14	3,0	8,33	4,72
Ministro Andreazza	1,08	7,34	3,9	4,86

Source: SINAN / MS, 2015.

Classification of case detection rates per 10,000 inhabitants: **low** (<0.2); **average** (0.2-0.9); **high** (1.0-1.9); **very high** (2.0 to 3.9); **hyperendemic situation** ($\geq 4,0$)

In 2011, 27 (twenty seven) municipalities are presented hyperendemic, implying say that more than 50% of the

Municipalities	2014	2013	2012	2011
Mirante da Serra	7,24	5,6	11,68	12,7
Monte Negro	7,63	5,79	27,24	10,56
Nova Brasilândia D'Oeste	6,0	12,6	6,53	16,59
Nova Mamoré	2,59	5,7	2,9	1,72
Nova União	3,82	2,53	4,0	2,68
Novo Horizonte do Oeste	8,65	22,82	6,0	16,85
Ouro Preto do Oeste	6,24	4,48	8,5	13,79
Parecis	5,36	3,65	4,0	8,16
Pimenta Bueno	4,0	3,79	4,98	6,17
Pimenteiras do Oeste	0,0	0,0	4,38	0,0
Porto Velho	1,57	2,4	3,0	2,4
Presidente Médici	0,87	2,17	2,3	4,0
Primavera de Rondonia	16,91	2,78	14,67	2,88
Rio Crespo	0,0	2,72	0,0	2,98
Rolim de Moura	3,79	7,58	10,36	11,78
Santa Luzia D'Oeste	8,0	3,37	4,7	6,91
São Felipe D'Oeste	1,62	3,2	3,4	16,84
São Francisco do Guaporé	4,82	2,1	6,0	4,28
São Miguel do Guaporé	8,4	13,52	3,64	10,96
Seringueiras	2,39	6,39	0,86	3,44
Teixeirópolis	3,96	0,0	12,55	6,2
Theobroma	0,0	0,0	0,0	0,94
Urupá	2,24	4,44	1,57	1,55
Vale do Anari	0,0	0,95	0,0	0,0
Vale do Paraíso	1,2	0,0	3,76	3,15
Vilhena	3,22	3,4	4,64	5,64

municipalities of Rondonia are presented in hyperendemic situation. This independent hyperendemic situation of social, demographic, economic, urban, urban or rural, environmental characteristics, among others, the example of Ariquemes municipalities with an incidence rate of 4.0; Ji Parana at a rate of 8.6; Pimenta Bueno with

6.17 rate; Ouro Preto do Oeste with 13.79 rate; Rolim de Moura with a rate of 11.78 and Vilhena with 5.64 rate per 10,000 inhabitants. All with the highest rates of urbanization and concentration of population in urban areas and all situated in the range of federal highway BR 364, with the exception of Rolim de Moura. The municipalities of San Felipe D'Oeste with an incidence rate of 16.84 per 10,000 inhabitants; Novo Horizonte do Oeste with 16.85; Nova Brasilândia D'Oeste with 16.59; Mirante da Serra 12.7; Alta Floresta D'Oeste with 9.0; Buritis 4.9; Cacaulândia to 6.9; Cacoal to 8.48; Cherry with 10.0; Chupinguaia to 9.39; Cujubim to 6.0; Espigão D'Oeste with 5.86; Machadinho D'Oeste with 4.72; Ministro Andreazza with 4.86; Monte Negro with 10.56; Parecis to 8.16; Presidente Medici with 4.0; Santa Luzia D'Oeste with 6.91; São Francisco do Guaporé with 4.28; São Miguel do Guaporé with 10.96 and Teixeiraópolis with 6.2 per 10,000 inhabitants with different characteristics spread across all areas and state geographic regions. Chupinguaia to 9.39; Cujubim to 6.0; Espigão D'Oeste with 5.86; Machadinho D'Oeste with 4.72; Ministro Andreazza with 4.86; Monte Negro with 10.56; Parecis to 8.16; Presidente Medici with 4.0; Santa Luzia D'Oeste with 6.91; São Francisco do Guaporé with 4.28; São Miguel do Guaporé with 10.96 and Teixeiraópolis with 6.2 per 10,000 inhabitants with different characteristics spread across all areas and state geographic regions. Chupinguaia to 9.39; Cujubim to 6.0; Espigão D'Oeste with 5.86; Machadinho D'Oeste with 4.72; Ministro Andreazza with 4.86; Monte Negro with 10.56; Parexcis to 8.16; Presidente Medici with 4.0; Santa Luzia D'Oeste with 6.91; São Francisco do Guaporé with 4.28; São Miguel do Guaporé with 10.96 and Teixeiraópolis with 6.2 per 10,000 inhabitants with different characteristics spread across all areas and state geographic regions.

In 2012 incidence rates remains highly endemic in 28 (twenty-eight) of the 52 municipalities of Rondonia. Ariquemes, with an incidence rate of 10 thousand 4.85; Ji-Parana, 8.2; Jaru, 4.24; Ouro Preto do Oeste, 8.5; Pimenta Bueno, 4.98; Rolim de Moura, 10.36 and Vilhena, 4.64 configure on the most urbanized municipalities and higher population number, while the municipalities of Alto Alegre dos Parecis, 10.9; Buritis, 4.49; Cacaulândia, 6.17; Chestnut, 4.15; Cherry, 9.0; Chupinguaia, 5.52; Corumbiara, 8.35; Costa Marques, 6.37; Cujubim, 6.5; Jaru, 4.24; Machadinho D'Oeste, 8.33; Mirante da Serra, 11.68; Monte Negro, 27.24; Nova Brasilândia D'Oeste, 6.53; New Union, 4.0; Novo Horizonte do Oeste, 6.0; Parecis, 4.0; Pimenteiros do Oeste, 5.38; Primavera de Rondonia, 14.67; Guaporé San Francisco, 6.0; Teixeiraópolis, 12,

In 2013 the number of municipalities with charges hyperendemic decreases to 17 (seventeen). Municipalities Jaru, with an incidence rate of 4.49 for 10 thousand; Ji-Parana to 5.94; Ouro Preto do Oeste, with 4.48 and Rolim de Moura, with 7.58 are the ones with urban characteristics. Alta Floresta D'Oeste with an incidence of **8.93**; Alto Alegre dos Parecis, with 19.52; Chupinguaia with 5.0; Spike Western, with 4.4; Minister Andreazza with 7.34; Mirante da Serra, with 5.6; Monte Negro, 5.79; New Brasilândia D'Oeste, 12.6; Nova Mamoré, with 5.7; Novo Horizonte do Oeste, with 22.82; São Miguel do Guaporé, with 13.52; Seringueiras with 6.39 and Urupá, with 4.44 municipalities are hiperendemic rates.

In 2014 the number of municipalities with hyperendemic rates to grow back to 22 (twenty-two). Ariquemes, with an incidence rate of 5.15 per 10,000 inhabitants; Cacoal, with 6.8; Ji-Parana to 4.95; Ouro Preto do Oeste, with 6.24 and Pimenta Bueno, with 4.0 are hierperendemics municipalities in leprosy considered the most populous and urbanized. Alta Floresta D'Oeste, with 6.23 fee for 10 people; Alto Alegre dos Parecis, with 15.84; Alto Paraiso, 11.0; Castenheiras with 8.2; Cerejeiras with 7.2; Colorado do Oeste, with 4.7; Espigão D'Oeste, with 6.55; Machadinho D'Oeste with 7.14; Mirante da Serra, with 7.24; Monte Negro, with 7.63; Nova Brasilândia D'Oeste, with 6.0; New Horizon West, with 8.65; Parecis, with 5.36; Primavera de Rondonia, with 16.91; Santa Luzia D'Oeste, with 8.0; São Francisco do Guaporé, with 4.82 and São Miguel do Guaporé, with 8.4 being the hyperendemic municipalities distributed geographically throughout the territory of the State of Rondonia.

The municipalities with the highest leprosy incidence rates during the study period corresponding to the years 2011 to 2014 are: Alta Floresta D'Oeste with 6.97 incidence rate per 10,000 inhabitants; Alto Alegre dos Parecis with 12.54 rate; Ariquemes with 4.33 rate; Cacaulândia with 4.06 rate; Cacoal with 5.08 rate; Cerejeiras with 7.24 rate; Chupinguaia with 4.97 rate; Espigão D'Oeste with a rate of 4.45; Ji-Parana with 6.92 rate; Machadinho D'Oeste 5.79 rate; Ministro Andreazza with 4.29 rate; Mirante da Serra with 9.30 rate; Monte Negro with a rate of 12.0; Nova Brasilândia D'Oeste with 10.43 rate; Novo Horizonte do Oeste with 13.58 rate; Ouro Preto do Oeste with 8.25 rate; Parecis with 5.29 rate; Pimenta Bueno with 4.73 rate; Primavera de Rondonia with 9.31 rate; Rolim de Moura with 8.37 rate; Santa Luzia D'Oeste with 5.74 rate; São Felipe D'Oeste with 6.26 rate; São Francisco do Guaporé with a rate of 4.3; São Miguel do Guaporé with 9.13 rate; Teixeiraópolis with a rate of 5.67 and 4.22 with Vilhena rate.

Among the reported cases, it was found that most of them, 1728 (57.7%) occurred in males and 1269 (42.3%) in female persons (Table 5). The distribution of new cases

followed a certain similarity in each period with respect to gender, no significant differences ($\chi^2 = 3.0900$, $p = 0.0787$).

Table.5: Distribution of new cases of leprosy in the years 2011 to 2014 by gender / sex

Year	Male	%	Female	%	Total
2011	484	58,5	343	41,5	827
2012	462	59,3	317	40,7	779
2013	420	59,0	291	41,0	711
2014	362	53,2	318	46,8	680
Total	1728	57,7	1269	42,3	2997

Source: SINAN / MS, 2015.

As for the color classification considerations (inferring ethnicity) specified by the Health's Ministry of Brazil, the analysis of people who contracted leprosy revealed that there was a higher prevalence in brown color with 1600 new cases (54.2%), followed by white with 1015 (34.4%) of cases. So also in other color categories showed statistically significant differences ($\chi^2 = 61.6750$ $p = 0.000$).

Table.6: Characterization of people reported with new cases of leprosy in the period studied, according to the color

Year	White	Black	Yellow	Brown	Indigenous	Total
2011	288	92	4	425	2	811
2012	274	88	2	405	1	770
2013	240	58	12	388	3	701
2014	213	67	5	382	1	668
Total	1015 (34,4%)	305	23	1600 (54,2%)	7	2950

Source: SINAN / MS, 2015.

With regard to the area of residence, most in 2042 (68.2%) of leprosy reported individuals living in urban areas, especially those who reported residing in the more

urbanized cities. In the distribution by place of residence differences were significant in relation to areas of subspaces residences ($\chi^2 = 21.6104$; $p = 0.0000$).

Table.7: Place of residence and distribution of people reported with new cases of leprosy in the years 2011-2014.

Year	Unknown	Urban	Rural	Peri	Total
2011	15	580	231	1	827
2012	14	549	213	3	779
2013	17	456	227	11	711
2014	12	457	208	3	680
Total	58 (1,9%)	2042 (68,2%)	879 (29,3)	18 (0,6)	2997

Source: SINAN / MS, 2015.

It was found that age of the subjects reported leprosy, ranged from less <15 years greater than 80 years old. The new cases were more prevalent in the age group of 20 to 59 years, 2220 (74%) of cases. Among the new cases that

arouse attention, are the <15 years with 6.27%. However, the distribution of new cases with respect to age showed significant differences for the years studied.

Table.8: Age range and distribution of people reported with new cases of leprosy in the years 2011-2014.

Year	< 15 years old	20 a 59 years old	60 years old or more	Total
2011	43	644	140	827
2012	46	596	137	779
2013	59	501	151	711
2014	40	479	161	680
Total	188 (6,27%)	2220 (74%)	589	2997

Source: SINAN / MS, 2015.

As for the operational classification of the disease, there was the wide prevalence of Multibacillary way with 1924 new cases during the study period representing 64.2% of the total cases in all municipalities of Rondonia. Leprosy

Multibacillary does not appear different when related between the municipalities. There is also no difference in the distribution of paucibacillary between the municipalities of Rondonia.

Table.9: Confirmed cases Leprosy by the Operational Classification of Disease in the years 2011 to 2014

Year	Paucibacillary	Multibacillary	Total
2011	321	505	826
2012	284	495	779
2013	254	457	711
2014	213	467	680
Total	1072(35,8%)	1924(64,2%)	2996

Source: SINAN / MS, 2015.

The clinical form notified met distribution of 4 forms, with the prevalence Diforma representing nearly 50% of cases, followed by tuberculoid with 21% Undefined

15.9% and Virchowian 13.3%. It does not appear different as their distribution by municipalities.

Table.10: - Reported cases by Form Clinic in the years 2011-2014.

Year	Indeterminate	Tuberculoid	Dimorphic	Virchowian	Unclassified	Total
2011	138	186	391	97	9	821
2012	115	172	366	108	7	768
2013	108	154	361	81	3	707
2014	111	113	333	111	10	678
Total	472 (15,9)	625 (21%)	1451 (48,8%)	397 (13,3)	29	2974

Source: SINAN, 2015.

The treatment scheme was adopted PCT/MB/12 doses 56.6% of cases, followed PCT/PB/less than 12 doses. But two situations arouses much attention, the considerable number adoption of patients who underwent the treatment

regimen with more than 24 doses and the record in 2014 when 31.2% of patients did not undergo the treatment (128 cases no dose).

Table.11: Treatment scheme: PCT / PB / 6 doses; PCT / MB / 12 doses; Other Leprosy Treatment Schemes

Year	No Dose	Less than 12 doses	12 Doses	13 to 23 Doses	Doses greater than 24	Total
2011		307	489	29		825
2012	18	28	362	24 + 4 (24 doses)	17	456
2013	25	40	350	26	27	468
2014	128 (31,2%)	86	21	66	109	410
Total	171	461 (21,3)	1222 (56,6%)	145	153	2159

Source: SINAN, 2015.

Of the 2534 new cases that underwent treatment prevailed

healing with 2062 cases (81.4%). 3% abandoned treatment and 1.2% died.

Table.12: Leprosy treatment Output Mode in the years 2011-2014.

Year	Not filled	Cure	Transferred to the same municipality	Transferred to another municipality	Transferred to another State	Transferred to another country	Death	Abandonment	Total
2011	43	703	14	19	13	0	5	30	827
2012	26	666	8	18	15	0	14	32	779
2013	136	619	10	23	16	1	9	15	829
2014	0	74	3	15	4	0	3	0	99
Total	205	2062 (81,4%)	35	75	48	1	31	77	2534

Source: SINAN, 2015.

3.1 DISCUSSION

Leprosy detection rates, the overall population of the municipalities of the State of Rondonia, point to a hyperendemicity situation. The high coefficients in the four years examined, a pattern consistent with maintaining stability of hyperendemic level.

According Meima *et al*¹⁴ the global trend detection of new leprosy cases between 1985 and 2000 showed no decline and points out that trends in transmission and incidence of leprosy are still not completely clear, requiring further research.

In India in the 1984-2002 period, although there has been substantial decline in prevalence, the detection rate remained constant during this period¹⁵. This study reports that the seven countries with the highest detection rates in three time periods, the detection rate remained stable or increased and, although this may be explained by the improved operating performance, when considering together the detection rate cases, the proportion of new cases treated with Multidrug/Multibacillary and the high rate among children, these data are indicative that leprosy continues to be transmitted in the community.

Richardus and Habbema¹⁶ report that in the past 25 years, the case detection has been determined in many countries by operational factors and mentions the fall of 75% in detecting new cases occurred in India from 2000 to 2006 and 24% occurred in Brazil from 2004 to 2005.

Reports that such falls, sudden, have biological credibility considering the long period of incubation leprosy as well as the absence preventive intervention such as vaccination in the decade that preceded the sudden drop.

Mathematical models developed for studies of transmission and control of leprosy were used to analyze the impact of the current strategy for the elimination of leprosy on its incidence and project future incidence considering various scenarios. The annual incidence prediction of decline ranged from 2% to 12%, concluding

that the elimination strategy reduces transmission, but in a slow¹⁶.

Penna and Penna¹⁷ show a downward trend in the detection rate for Brazil is only predicted after 2010, attributing the fall occurred on operational factors such as a possible decline in the diagnostic coverage, or likely change in the notification process and registration of cases.

The aggregate data from all municipalities of Rondonia, Brazil, show relative stability of detection rates in the last four years. There is evidence that leprosy does not always play in smaller geographical units or in spaces smaller epidemiological heterogeneity, due to the many variables involved in the health-disease, it is scattered with greater or lesser extent throughout the territory of the state.

Magalhães¹⁸, when analyzing the evolution of leprosy in different regions of Brazil, found growth trends of endemic ranging, for example, an increase of 9% in the Northeast and 0.7% in the South. In Brazil in 2002, while the case detection rate was 2.62/10,000 inhab, in the northern region this rate was 7.73/10,000 inhab. and in the South region was 0.75/10,000 inhab. which shows an uneven inter-regional development, intra-regional and interstate endemic in the country and suggests the existence of geographical contexts of different vulnerability to the social production of leprosy.

To corroborate the existence of producers geographical contexts of the disease, cite the study by Rodrigues *et al*¹⁹ in São Paulo, which points to the decline of endemic disease, but allows you to view regions with different magnitudes of the disease, with detection rates higher in the more northern regions of the state.

A study conducted in the city of Sobral, Ceará, Brazil, showed that the new case detection rate increased in the 1997-2003 period, rising by over 100% in the last three years of the study²⁰.

During the study period in the State of Rondonia, the 2972 (two thousand nine hundred seventy-two) new cases

of leprosy have tended to decline, without, however, show significant differences, ranking as hyperendemic area with detection rate / average incidence of 4.50 per 10,000 inhabitants. Leprosy is present in virtually 100% of the municipalities of Rondonia.

Leprosy is considered one of the public health problems in different regions of the world. In the state of Rondonia - Brazil, it is one of the major endemic problems related to health. Recognize the different aspects related to the disease can aid in characterizing different areas of the region, contributing to the changes related to the welfare of the population.

Among the reported cases, it was found that most of them, 1728 (57.7%) occurred in males and gender in 1269 (42.3%) in female people. In Mato Grosso, Brazil, from 1996 to 2007, higher detection rates for males were observed in all regional groups. Magalhães and Rojas²¹ found higher rates for males in all the states of the North and Midwest. Increase in detection rates for males was observed in the endemic declining situation²². Leprosy notification data in Portugal²³ showed a peak incidence for males aged 25 to 29 years. A study conducted in Fernandópolis²⁴ to characterize the contacts of leprosy profile who became ill reported a percentage of 59.7% of cases among men.

The Barro study (2005) showed that for males increased incidence occurred in the age group 35-44 years, while for females this increase was in the range 45-54 years. Another study in Coari in Amazonas state, Brazil, showed percentage of 70.8% of cases for males²⁵.

Study by Queiroz²⁶ in relation to the distribution of cases by sex is observed that the detection rates for males are shown higher in all regional state of Mato Grosso. In the state, the evolution of the detection rate for both sexes plays that observed for the set of data. However, the first to the last period, reducing the detection rate among men was lower (1.4%) than in women (6.7%).

For the detection by age, Mato Grosso, it is noted that the coefficients are higher in older age groups, especially in the ages 15 to 44 and 45 years and older, observing increase in these two age groups and reducing the intermediate period during the last period²⁶.

Considered trend indicator of the leprosy endemic the detection rate in children under 15 years has shown a slight decrease.

In the study by Magalhães and Rojas²¹ in Mato Grosso, the analysis shows that by age stratum under 15 years detection coefficients are within hyperendemicity parameter, and only in group I showed reduced. Considered a trend indicator of endemic disease, which reflects early exposure to *M. leprae*, this indicator had a wide variation in the first period in the various regional. The 2007 data published by WHO in its latest

annual report also show the same variation in this age group in the various regions of the world and between regions within the same continent. In Africa, for example, proportions were found 2.89% in Togo to 37.96% in Comoros. In the Americas 0.32% proportions in Argentina to 14.02 in the Dominican Republic²⁷.

Variations of this indicator in several Brazilian regions were also observed by Magalhães and Rojas²¹ (2005), which reported increases of 335% in the Northeast to negative in the South and North. The authors also report that in the Midwest state of Mato Grosso stands out among the other states with an increase of 421% in the detection of cases of children under 15 years.

Studies show that in the endemic declining situation, the age of new cases detected shifts to older age groups².

For Queiroz²⁶ the highest coefficients are concentrated in the older age groups, the detection of leprosy in the state of Mato Grosso, remained stable among the population 45 years or more. In the same study the rise of the coefficients among children under 15 years points to a worsening of the epidemiological situation in the period.

As for the distribution by race / color, it was observed that there was a predominance over the whole period and in all municipalities for the mulatto (54.2%) except for the municipalities of the southern region of the state where prevails the white population.

However, there were no significant differences when compared to the municipalities as ethnic/predominant color. Maybe justifies this frequency considering that for the state of Rondonia predominant brown color.

Name *et al*²⁸ for analysis of the University Hospital data BSB observed that the patients reported, 57% were brown, white and 27% black 13.2%, East Indian corresponded to 2% of the cases. Given these diverging in relation to white and brown observed in studies and in the IBGE (2000). Thus, one of the factors that may be related is on the migratory process of the population or disabled in the settings for skin color observed by the people, for the color record is defined by the declarant of the concept itself, and may thus have influenced the data from this survey.

For Queiroz²⁶ leprosy can occur in all races (OPS, 1983). In a recently published study, Santos *et al*²⁹ found in 76.7% proportion of non - whites (brown and black) and Thomas *et al*³⁰. (2003) found a rate of 82.1% among non - whites. Both figures suggest that, even in populations they evaluated the detection rate among non - whites should be greater than among whites.

According to Queiroz²⁶ there is still a poor record of race/color variable. In their study only 1% of leprosy cases records had information "Race / Color," and in the second period only 58%.

The distribution of the detection rate by race / color showed that the detection rate among non -whites is higher in all groups except in places influenced by the composition of the population. The distribution of leprosy by race / color depends on the regional peculiarities in the formation and or mixing of the population²⁶.

In the study Queiroz²⁶, virtually the entire period predominated multibacillary (64.2%). In the report published by WHO²⁷ (WHO, 2008) a wide variation is reported between countries regarding the proportion of multibacillary and paucibacillary among new cases detected. In the region of Africa was found a proportion of cases with multibacillary 40.7% in Comoros, and 92.9% in Ethiopia. In the Americas, the proportion was 53.5% in Brazil, 78.7% in Paraguay.

In Brazil, a study by Sanchez *et al*³¹ in Prudentópolis-PR predominated multibacillar forms, the same in the fields of study *et al*²⁰, the city of Sobral-CE. Vásques to²⁵, in a study in Coari-AM showed that the 10 - year period the multibacillary amounted, and last year they came to represent 75% of cases²⁵.

One possibility to be detecting a higher proportion of paucibacillary cases could be the type of information, communication and health education to the community is addressed. Signs and symptoms of paucibacillary forms are more easily assimilated by the community. Also during the campaigning for the detection of cases, paucibacillary cases may be more easily detected.

Cunha *et al*³² reported an increase in paucibacillary forms in the Duque de Caxias municipality three times after having been relevant role in patient care which were: an increase in the number of doctors in attendance, decentralization of treatment for other health units and after decentralization for PSF units starting local campaigns.

A gradual increase in the proportion may indicate clinical form Borderline difficulties classification by clinical form or even because the regimen for dimorphic forms and virchowianas is longer. In this case physicians may be more likely to conduct which in case of doubt it takes a longer duration of therapeutic regimen³³.

Although there was an increase in the proportion of dimorphic forms the state in regional group I and Rondonópolis can still observe a predominance of tuberculoid forms. This form would be a trend indicator of the disease.

Magalhães and Rojas²¹ reiterate that in some areas in Mato Grosso, Brazil, high detection paucibacillary, the endemic is expanding.

The increase in frequency of tuberculoid forms detection, especially in the Midwest and Northeast Brazil has been reported by Motta and Zuniga³⁴, who completed pointing strong possibility of increase in the transmission of

leprosy in Brazil, warning of a major concern situation to the Public Health authorities of Brazil.

The degree of disability II at the time of diagnosis can be used to estimate the effectiveness of the measures for early detection³⁵. Cases with disabilities account for loss in the workforce in endemic regions and makes them sick individuals unable to support themselves and their family. Moreover deformities are closely associated with the stigma related to the disease.

Kerr-Pontes *et al*³⁶ showed that in the state of Ceará, leprosy is associated with a high level of poverty and rapid, uncontrolled urbanization.

Magalhães and Rojas²¹ also indicate that the focal distribution of leprosy, the association with unfavorable living conditions, mainly socioeconomic, and the relationship between poverty and leprosy, confirm the role of social deterioration in the production of this disease. They emphasize, however, that although the relationship between poverty and the disease is not questionable, does not mean that everywhere under these conditions are endemic, with, according to the authors, the need for micro environments favorable to the existence and survival of the pathogen, as well as other factors favorable to its transmission.

In relation to clinical forms of leprosy, there was a gradual increase in the proportions of dimorphic forms in all population strata in Mato Grosso and, albeit with some fluctuations, a reduction in the proportion of tuberculoid forms, except for regional Rondonópolis, where the reverse was observed²⁶.

In Mato Grosso, there is a stabilization of indeterminate forms the three periods, a gradual reduction in the proportion of tuberculoid and virchowianas and 64% increase in dimorphic proportions throughout the period²⁶. In regional Rondonópolis prevailed Indeterminate and Tuberculoid forms, but in the last period there was a slight reduction in the latter, also noting it is an increase of over 100% in dimorphic proportions throughout the period.

The patient Multibacillary is the main source of infection as it has a high bacterial load in the dermis and mucous membranes and can eliminate bacilli in the external environment. It is assumed that leprosy is transmitted by the respiratory tract which needs further studies.

However, there is no conclusive evidence that the transmission is exclusively by respiratory tract, can occur through the skin when there are ulcerated or traumatic skin lesions. The properties of an ecological study does not enable individual risk check, but enable the analysis of the risk of variability in ecological terms. This type of study is of fundamental importance for the understanding of the social and environmental determinants of the health-disease, in which the socioeconomic status of the

population groups have an important role in explaining health conditions.

The clinical Dimorphic Forms accounted for nearly 50% of cases, followed by Tuberculoid Form with 21% Indefined Form 15.9% and 13.3% Virchowian or Lepromatous Form.

A gradual increase in the proportion may indicate clinical form Borderline difficulties classification by clinical form or even because the regimen for dimorphic forms and virchowianas is longer. In this case physicians may be more likely to conduct which in case of doubt it takes a longer duration of therapeutic regimen³³.

Although he maintained throughout the period prevalence of borderline forms in the state, one can observe a predominance of tuberculoid forms. This form would be a trend indicator of the disease.

The increase in the frequency of detection of tuberculoid forms, especially in the Midwest and Northeast has already been reported by Motta and Zuniga³⁴, who completed pointing strong possibility of increase in the transmission of leprosy in Brazil, warning of a major concern situation for Public Health authorities.

IV. FINAL CONSIDERATIONS

During the study period were reported 2,972 new cases of leprosy, with an average detection rate of 4.50, hyperendemic situation. Predominant male with 57.7%, brown ethnicity with 54.2%, in the urban area 68.2% and in the age group 20 to 59 years with 74%. As for operational classification of the disease was predominant Multibacillary with 64.2%. There were 48.2% of the dimorphic form, tuberculoid 21%, 15.9% Undefined and 13.3% virchowian. Prevailed treatment PQT/MB/12 doses to 56.6%, with the output mode of treatment with 81.4% cure and only 3% of withdrawal. In 2014, the 52 districts of Rondonia, 42% have hyperendemic detection rates, very high 27% to about 10% high. The production and distribution of leprosy not follow a spatial pattern in Rondonia, reflecting social and different environmental conditions, *Mycobacterium leprae* and identifying critical subespacialidades the territory.

Throughout the period studied leprosy remained hyperendemic and still no signs of exhaustion cases, whether it be analyzed by reference to the whole of the State of Rondonia population.

The identification of the leprosy carrier profile enables the creation of policies in health, more planned and targeted manner to the risk group. In this sense, they are essential to information campaigns about the disease and its early symptoms are promoted. Also important is the disclosure about the care facilities, since the carrier of this disease should go to health facilities to receive the dose of medication supervised.

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Design and Fabrication of Garlic Peeler

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Abstract— Garlic is an important and economical plant. It has many uses in medicinal, culinary and ayurvedic purposes. Garlic peeling is a tedious, time consuming and laborious work. So far, traditional peeling methods are used for garlic peeling. These methods are observed to be unhygienic, laborious and caused high damage to garlic segments. Mechanical peelers available are costly and not affordable to small scale industries. Since, the traditional methods are laborious and mechanical methods are costly there is a need to develop low cost, mechanical peeler that will reduce the drudgery.

Angular iron and flat iron was used for main frame and supporting the main units. A food grade rubber and mild steel pipe was used for rubber roller. Iron bar was used for shaft. A wire mesh was used as screen. Dimensions of garlic segments were measured using digital vernier callipers and weight of each garlic segment was measured using electronic balance. Moisture content, orthogonal dimensions, weight, geometric mean diameter, sphericity, equivalent mean diameter, shape factor, terminal velocity and drag coefficient of garlic segments were found.

Moisture content of garlic segments was $59.36 \pm 0.87\%$ (w.b). At this moisture content, average length, width and thickness of garlic segments were found to be 25.818 3.743 mm, 10.116 2.209 mm and 7.34 1.638 mm, respectively. Average weight of individual garlic segments were found to be 1.159 g. Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of garlic segments were found out to be 12.422 mm, 0.481, 13.03 mm and 0.218, respectively. The terminal velocity and drag coefficient were 18.941 m/s and 0.416 at moisture content of $59.08 \pm 0.82\%$ (w.b). Cost of peeler was estimated to be about ₹ 10,005/-.

Keywords— Garlic, peeler, cylinder-conclave.

I. INTRODUCTION

Garlic (*Allium sativum* L.), an underground perennial bulb, is an important vegetable spice belonging to the family of Liliaceae. The bulb is a cluster of 12 or more segments called cloves, which are swollen leaf bases. Cloves, as well as, whole bulb are surrounded by a thin papery white skin. Cloves are the economical and edible part of garlic plant. Garlic is widely used for culinary and medicinal purposes. It is a strong source of phenolic compounds, phosphorous, sulphur, zinc, selenium and vitamin A and C and also low levels of calcium, sodium, ferrous, manganese and vitamin B (Grégrová *et al.*, 2013).

Garlic is cultivated for centuries all over the world including Asia. India is one of the leading producers of garlic with an area of 238.760 thousand hectares producing 3221.380 thousand tons during the year 2013-14 (Spice Board of India, 2014). As per Spice Board of India, Gujarat stood first by producing 277.455 thousand tons of garlic during the year 2011-12. Madhya Pradesh, Uttar Pradesh, Rajasthan, Assam, Punjab and Maharashtra are other leading garlic producers in the country.

Garlic is consumed as green, as well as dried in the spice form and as an ingredient to flavour the vegetarian, non-vegetarian dishes and pickles. Good tasty pickles, chutneys, curry powders are prepared from garlic cloves. It is also used to disguise the smell and flavour of salted meat and fish. Dehydrated garlic in powdered or granulated form is being used in place of fresh bulbs in many countries (Mishra *et al.*, 2014).

Garlic processing involves bulb breaking, peeling, dehydration, grinding and other unit operations. Garlic peeling is one of the most important and essential key unit operations prior to any subsequent processing activity. During garlic peeling, the thin membranous skin, inedible part is to be removed off from the segments. Typical size of the cloves makes the peeling to be very tedious and time consuming operation. Traditional peeling methods,

including hand peeling, flame peeling, oven peeling and chemical peeling (Dhananjay *et al.*, 2015).

An efficient peeling device is, therefore, required to gently peel off the skin from garlic clove without any adverse effect on its shape, structure and aroma. Many researches had worked on development of machine operated garlic peeler. Manjunatha *et al.* (2012) developed machine operated garlic peeler by using cylinder and concave concepts. The machine is power consuming, heavy and costly to consumer acceptability. To overcome these problems and cater the needs of garlic peeling in an easier manner, this study was undertaken with the main objective of development of a garlic peeler. Small capacity, hand operated, operator friendly garlic peelers are very much essential to consumers. To meet this objective, work has been undertaken to fabricate hand operated garlic peeler and to a) Study of physical characteristics of garlic segments or cloves b) Selection of engineering materials for fabrication of garlic peeler and c) Design of hand operated garlic peeler. The proposed development of a garlic peeler could alleviate the problems faced by traditional garlic peeling methods and aid in boosting the processing and export of garlic and its products. The machine will be reducing the time of peeling of garlic.

II. MATERIALS AND METHODS

Materials used were garlic segments, angular and flat iron, galvanized iron sheets, iron rods, bearings, wire mesh, blower, handle and pulley.

Fresh, well matured and cured garlic were procured from local market of Bapatla, Guntur Dist., A.P. Bulbs were broken by hand and uniform sized segments are graded manually after blowing the thin papery skin of segment. Materials used for fabrication of peeler were procured from local hardware stores of Bapatla, Guntur Dist., A.P.

Moisture content of garlic segments was measured by hot air oven method. Three samples of garlic segments of 15 g each were taken into moisture boxes and placed in hot air oven (Yorco, Model: YSI-431) at 100-105°C with lid open for 2h which was cooled in a desiccator with closed lid for 15 min later. Weight of the sample was taken when weight remained constant (AOAC, 2000). And calculated by using formula

$$MC = \frac{\text{Initial Weight of Sample} - \text{Final weight of sample}}{\text{Initial weight}} \times 100$$

Dimensions of garlic segments were useful in designing peeling machine as size affects the cylinder-

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concave clearance. To determine these dimensions, ten groups of samples consisting of 100 garlic segments were randomly selected. Ten segments were selected from each group and the three principal dimensions (length, width and thickness of garlic segments) were measured using digital vernier callipers with an accuracy of 0.1 mm.

The Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of the garlic segments were calculated using the following formulae.

$$\text{Geometric mean diameter } (D_g) = (\text{LWT})^{1/3}$$

$$\text{Sphericity } (\phi) = \frac{(\text{LWT})^{1/3}}{L}$$

$$\text{Equivalent mean diameter } (D_e) = \frac{(6 V_{\text{single}})^{1/3}}{\pi^{1/3}}$$

$$V_{\text{single}} = \frac{100 \text{ grain weight}}{PD \times 100} \times 10^6$$

$$\text{Shape factor } (Z) = \frac{\pi}{6} \frac{D_g^3}{D_e^3} \phi$$

Where

D_g = Geometric mean diameter (mm)

L = Longest intercept (mm)

W = Longest intercept normal to L (mm)

T = Longest intercept normal and W (mm)

D_e = Equivalent mean diameter (mm)

V_{single} = Volume of single particle (mm³)

PD = Particle density (kg/ m³)

φ = Sphericity

Z = Shape factor

The terminal velocity of garlic segments was measured in wind tunnel using a vertical column duct. This method produced air current in a vertical duct of diameter 39.07 mm, using centrifugal pump, for garlic segments to be floated. A tube of diameter 82.97 mm was attached at axis of centrifugal pump. The vertical duct has the provision for varying air stream. For each test, a small sample was placed in the duct and air velocity was increased gradually till the segments get suspended. Then the velocity of air in the tube at the point of suction was measured using digital anemometer. Velocity of air in the vertical duct was measured using

$$A_1 V_1 = A_2 V_2$$

where,

A_1 = cross sectional area of tube (m²)

V_1 = velocity of air in the tube (m/s)

A_2 = cross sectional area of vertical duct (m²)

V_t = terminal velocity of air in the vertical duct (m/s)

Drag coefficient was calculated using the following formula

$$C_d = \frac{2mg(\rho_p - \rho_a)}{V_t^2 \rho_a \rho_p A_p}$$

where,

m = Mass of single particle (kg)

g = Acceleration due to gravity (m/s²)

V_t = Terminal velocity (m/s)

ρ = Particle density (kg/m³)

a = Density of air (kg/ m³)

A_p = Projected area of particle (m²) = $\frac{\pi}{4} D_e^2$

D_e = Equivalent mean diameter (m)

III. MATERIALS USED IN FABRICATION OF GARLIC PEELER

Hand operated garlic peeler consisted of hopper, cylinder-concave unit and blower. Peeler works on the principle of the cylinder-concave mechanism. The cylinder surface covered with rubber and it was called as rubber roller. Rubber roller (cylinder) rotated against a fixed screen

which was attached to the fixed concave as a result of which the garlic segment got peeled off primarily due to shearing action with slight compression.

Hopper, a rectangular box with one side vertical and other, tapered towards the bottom was designed to facilitate easy flow. The feed hopper was made from 1mm galvanised iron sheet. Length of hopper was 180 mm, breadth 100 mm and a height of 170 mm and 100 mm on either sides of hopper. Bottom opening was 50 mm wide with a length of 180 mm. This arrangement will uniformly spread segments on cylinder to rub against concave. Hopper was facilitated with a galvanized iron sheet was facilitated to regulate flow of segments into cylinder.

Rubber roller consisted of a hollow mild steel tube with both sides closed with caps. Total length of tube was 220 mm with a diameter of 62.5 mm. A food grade silicon rubber of 180 mm length and 6 mm thick was covered on the tube. Thin wires of 1 mm thickness were glued along the length of rubber at a distance of 10 mm apart as shown in fig.1

Iron shaft was welded to caps of cylinder to attach on frame using bearings. Shaft was designed to fit the requirements of different drives. One end was facilitated with provision for attaching handle for imparting drive. Other end was made to 20 mm diameter to attach pulley to transfer drive to blower.



Fig.1: Rubber roller and shaft

Concave was made up of flat iron of 25mm width and 3mm thick rods. A frame of dimensions 225mm length and 200mm breadth was made using flat iron and rods were welded across the frame at a distance of 10mm. The frame was bent on anvil to match the curvature of rubber roller.

A wire mesh of thickness 1 mm with an opening size of 1 mm² was used as screen for abrasion surface. It was cut into 230 × 200 mm and fastened on concave.

Main frame of the garlic peeler was a trapezoidal structure made of angular iron. Height of the main frame was 580mm. The bottom rectangular frame of main frame was 400 × 470mm. The upper frame was 300 × 370mm.

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The frame was designed by looking into convenience of operator and to accommodate exit chutes and blower.

Blower used was a smithy blower made of cast iron. The blower had a circular mouth outlet. The drive to it was taken from shaft of cylinder. The pulley of blower was 25 mm in diameter where as shaft was 50 mm.

IV. FABRICATION OF MACHINE

Main frame of garlic peeler supported three units, i.e, feeding unit, concave-cylinder unit and blower. Angular iron was arc welded according to the said dimensions to

main frame. Angle frame of 80 mm height and 200 mm length bent in C-shape was welded to two opposite sides of top face of frame. This angle frame was welded such that, leaving horizontal face for fitting bearings by fasteners.

Feeding unit consists of hopper that was spot welded to a side of cylinder- concave unit. A feed regulator of thin flat sheet was provided to manage and avoid spillage of segments. It was a 1mm thick galvanized iron sheet that could be moved up or down to open or close the hopper opening upon feed requirement. A small galvanized iron plate was placed slanted between hopper opening and concave. This provision allowed flow of segments into the clearance between concave and rubber roller. It prevented jumping of segments off the roller. Hopper was placed slightly to a side in slanting position.

Cylinder-concave (Fig.2) unit consisted of rubber roller, concave, wire mesh and cylinder. A shaft passed through the rubber roller and extended from caps of roller for other provisions. This shaft was passes through 32mm diameter bearings (Fig.3) situated on either side on angle frames. Wire mesh was fastened on to the concave. Concave-screen was placed beneath rubber roller. The clearance between roller and concave was fixed as 20mm on the feeding side and at the outlet side it can be adjustable from 8 to 12mm by the nut and screw mechanism provided beneath the concave. Clearance between concave and rubber roller was fixed using two wooden pieces of thickness 8mm and 20mm. A 20mm wooden piece was placed on the roller near inlet of cylinder while 8mm was placed on the roller near the bottom outlet. These pieces were then tied with a rope to keep them in place. Concave was then adjusted and arc welded at that position on the top side. At the bottom screw and nut arrangement was provided so as to vary the clearance between concave and roller. The clearance could be decreased by rotating the screw clockwise and increased by rotating the screw anti-clockwise. The concave and nut-screw mechanism was supported by two rings made of flat iron placed on either side of rubber roller.



Fig.2: Cylinder-concave unit



Fig.3: Bearing

One side of shaft was facilitated for handle attachment to give drive, whereas, other side was for pulley. The whole concave and rubber roller unit was housed inside a cylinder of diameter 210mm and 270mm length. To support and hold the cylinder in place, flat iron was bent to cylinder shape and arc welded to main frame.

Blower was placed at a height of 120 mm from the bottom frame. Chutes were made of 1 mm thick galvanized iron sheet. A chute was spot welded to cylinder at the outlet, with a dimension of 170×50 mm at the top and then, it was tapered to 80×50 mm. This chute was attached to another chute coming from blower of $420 \times 50 \times 50$ mm. At a distance of 80 mm from blower another chute of $130 \times 80 \times 50$ mm was welded.

Garlic segments were fed into hopper, which flow through the clearance between concave and rubber roller. After undergoing abrasion, peeled and unpeeled segments along with peel flow through the chute into the chute from blower. Here the peel was blown away by air while peeled and unpeeled segments roll down into the outlet chute. Unpeeled garlic segments were manually separated from peeled segments and were fed again into the hopper. Fig. (4) and Fig. (5) are the front and side views of peeler, respectively.



Fig.4: Garlic Peeler (Front view)



Fig.5: Garlic peeler (Side view)

V. RESULTS AND DISCUSSION

Moisture content of garlic segments was found to be $59.36 \pm 0.87\%$ (w.b.). Average length, width and thickness of garlic segments were found to be 25.818 3.743, 10.116 2.209 and 7.34 1.638 mm, respectively, at moisture

content $59.36 \pm 0.87\%$ (w.b.). This helped in determining the clearance space between concave and rubber roller. Average weights of individual garlic segments were found to be 1.159 g at a moisture content of $59.36 \pm 0.87\%$ (w.b.).

Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of garlic segments were found out to be 12.422 mm, 0.481, 13.03 mm and 0.218, respectively, at moisture content of $59.36 \pm 0.87\%$ (w.b.). At moisture content $59.08 \pm 0.82\%$ (w.b.), terminal velocity and drag coefficient were calculated to be 18.941 m/s and 0.416, respectively. The terminal velocity is useful parameter in designing blowers for aeration and separation of lighter materials like peel, husk etc.

Cost of Peeler

Cost of peeler was ₹ 10,005/- The cost of each material used is given in

Sl. No	Material	Cost (₹)
1	Shaft	260
2	Mild steel cylinder	430
3	Caps	330
4	Handle	200
5	Pulley	150
8	Bearings	900
9	Angular Iron	750
10	Flat Iron	750
11	Galvanized iron sheet	1,500
12	Wire (3 mm)	250
13	Wire mesh	515
14	Fastners	200
15	Blower	650
16	Rubber	1,000
17	V-Belt	120
18	Fabrication labor charges	2,000
Total		10,005/-

VI. SUMMARY AND CONCLUSIONS

Moisture content of garlic segments was $59.36 \pm 0.87\%$ (w.b.). At this moisture content, dimensions of garlic segments were measured using digital vernier callipers and weight of each garlic segment was measured using electronic balance. Average length, width and thickness of garlic segments were found to be 25.818 3.743, 10.116 2.209 and 7.34 1.638 mm, respectively. Average weight of individual garlic segments were found to be 1.159 g. Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of garlic segments were found out to be 12.422 mm, 0.481, 13.03 mm and 0.218, respectively. The terminal velocity and drag coefficient were 18.941 m/s

and 0.416 at moisture content $59.08 \pm 0.82\%$ (w.b). Cost of peeler was estimated to be around ₹ 10,005/-.

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Comparison of Pre-Cooling and Storage Processes for Fuji Apple Quality Maintenance using the Decision Support Method

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Abstract— In Brazil the fruit growing is becoming more and more technified, obtaining with this better quality and productivity. As fruit varieties are regionalized and harvested at different times of the year, they need post-harvest conservation techniques to be offered in different regions of the country during the off-season. For these reasons, management of the Cold Chain (CC) logistic process in post-harvest refrigeration and preservation of fruits is the way to overcome these problems. In this context, the research aimed to analyze how the TODIM Method of Multicriteria Decision Support contributes to the process of comparing forced air pre-cooling (24hs) and cold storage (30 Days and 60 Days, CAT1 - 80 and CAT1 - 198) in Normal Atmosphere (NA) and Controlled Atmosphere (CA) 24hs. The methodological procedures adopted were: exploratory and descriptive research, with qualitative approach and field research. In the field research carried out at the Cooperserra cooperative, the following results were identified: (1) feasibility of the implantation of the rapid precooling process to the hydrocooling by immersion proving to be efficient in the application of the system, in relation to the precooling for forced-air cooling in the chamber combined with storage; (2) the management of the Cold Chain (CC) logistic process in the pre-cooling and storage stages maintains the quality of the Fuji apple (*Malus Communis*). In addition to contributing to academic research, the study corroborated the development of best practices in the management of the Cold Chain (CC) logistics process and commercialization, providing elements for companies to plan the logistics processes incorporating the precooling and storage stages of the Fuji apple (*Malus Communis*). It was concluded that in the pre-cooling to the cold water, it does not need that the apple stays for 24 hours in the cold chamber to reach the appropriate temperature of 2° C, it was verified that in 25 minutes of cooling the fruit reaches

the temperature of 5°C, maintaining the quality of the fruit and optimizing the energy expenditure of the cold room.

Keywords— *Fruticulture, Precooling, Storage.*

I. INTRODUCTION

In Brazil, the fruit growing is becoming more and more technified, obtaining high productivity and quality. According to Vitti (2008), the production of each fruit has characteristics regionalized in different countries as well as at different times of the year, so it is necessary to improve the techniques of post-harvest conservation of these fruits, so that they can be offered in different regions of the country. country in the offspring of culture. For these reasons, the use of refrigeration in post-harvest conservation has become the primary means of overcoming these problems.

Fruit-growing is among the main sectors that generate income, employment and rural development for the national agribusiness (KoseraNeto, 2015). The productivity indexes and the commercial results obtained in the last harvests are factors that demonstrate the vitality as well as the potential of this productive segment.

Brazilian apple production has expanded significantly in the last two decades. In addition to the tradition of more than 30 years in the commercial cultivation of fruit, factors such as the production of modern varieties, availability of land, regions with favorable climatic conditions, as well as concerns about productivity, packaging infrastructure and conservation, have transformed Brazil into a world producer of apples (Bittencourt et al., 2011).

In this context, refrigeration has benefits to maintain the quality of the fruit, since its principle is to reduce the metabolism of the vegetable by reducing the temperature, also reducing the microbial growth rate (Degaspere, 2004).

Rapid cooling technologies are part of Cold Chain (CC), which Cold Chain Management (2004) defines as

consistency in maintaining adequate cooling of the environment for products that require special treatments, properly controlled during the accomplishment of the logistic steps, ensuring the quality of the fruit.

According to Cário and Seabra (2010), in the region of São Joaquim, the production is concentrated in the apple cultivars Fuji (*Malus Communis*) and Gala. The apple Gala (*Malus Domestica Bork*) harvests in the months of February and March each year, while the harvest of the Fuji apple (*Malus Communis*) occurs in the months of April and May. With this difference of harvest period, the fact that the production of the region is divided in the two cultivars, favors the optimization of resources in the harvest and post-harvest stages.

After the harvest, the rapid precooling process, understood as the rapid removal of the field heat from the products, should be one of the first steps to guarantee advantages such as: the consumption of a better quality product, reduction of losses for the merchant, increased storage and marketing time, profit maximization and cost minimization. In this research the Multicriteria Analysis Methodology (AMD) was used, the TODIM method was applied to compare the results.

II. MULTICRITERIA METHODS OF SUPPORT FOR THE DECISION

According to Vieira (1999, p.12), "multicriteria methods try to represent the preferences of the decision maker in the best possible way, even when those preferences present some inconsistency." Moreover, one can say that the purpose of these methods is not to find solutions, but rather to recommend actions considered satisfactory, in the context of the problem being analyzed.

To Gomes, Gomes and Almeida (2006, p. 36) "The Multiple Criteria Decision Support (AMD) is a set of methods and techniques to assist or support people and organizations to make decisions under the influence of a variety of criteria," the application of any method of multicriteria analysis presupposes the need of previous specification on what objective the decision maker intends to achieve, when the comparison is proposed among several decision alternatives, using multiple criteria.

AMD methods are tools to support decision making in complex situations, when there are several potential actions (not necessarily alternatives) to be analyzed in the light of several criteria (Vieira, 1999).

Multicriteria Decision Support can be seen as a set of methods that lend themselves to clarifying a problem in which alternatives are evaluated by multiple criteria, which are conflicting in most cases (Oliveira et al., 2016). Multicriteria methods have been developed to support and guide decision-makers in the evaluation and choice of solution alternatives in different spaces.

According to Gomes, Gomes and Almeida (2006).

The space of decision variables, in particular, consists of the set of feasible and non-feasible decisions for a given problem. The decision-making process is highly complex in a company since a decision may involve several alternatives with different consequences and numerous criteria to analyze. The purpose of the Multicriteria approach is to help decision makers organize and synthesize information in the way they can feel confident about decision making. (Belton & Stewart, 2002).

In group decisions, individual preferences can be combined to result in a group decision. Actions are linked to the decision variables that must be decided and communicated, the decision of the group is the consequence of an exchange of decisions (Eissmann et al., 2017).

There are two large families of multicriteria methods, whose origins refer to the American and European (notably French) schools of Multicriteria Decision Support. The American school is characterized by the decomposition of the problem of decision in hierarchical levels and also by the comparison of the alternatives, pair by pair, whereas the methods of the French School do not require the decomposition of the problem in hierarchical levels and also do not require the comparison of the alternatives at the same time (Vieira, 1999).

The main method of the American School is the AHP method - "Analytic Hierarchy Process". One of the methods of the French School is the Promethean method. In this research there is a special interest in the TODIM method "Multicriteria Interactive Decision Making", conceived by Professor Luiz Flávio Autran Monteiro Gomes, from the Fluminense Federal University.

TODIM Method (Multicriteria Interactive Decision Making)

For Vieira (1999), "in its initial stage the TODIM (Multicriteria Interactive Decision Making) method consists of comparing pairs of alternatives, in light of each of the analysis criteria, by means of a function that represents dominance) of one alternative over another." We can present some characteristics TODIM Method:

- a) good levels of transparency and intelligibility;
- b) adequacy to the discrete problem of ordering potential actions;
- c) minimization of the possibility of occurrence of order reversal;
- d) adequacy to the solution of hierarchically structured problems;
- e) incorporation of the concepts of Perspective Theory.

The multicriteria TODIM method, which, besides the advantage of trying to model the patterns of preference

when risk decisions are made, using the Prospective Theory (Kahneman&Tversky, 1979) allows both quantitative and qualitative criteria to be worked on. has a satisfactory degree of intelligibility compared to other discrete methods (Gomes and Duarte, 1998).

According to Gonzalez, Gomes and Rangel (2012) to perform the application of this model to a database derived from calculations and value judgments, the TODIM method must evaluate characteristic forms of the functions of losses and gains. These will serve to construct the additive difference function of the method, which equips measures of dominance of each alternative in relation to the other alternatives.

Although it seems complex to have to test that adaptation of the paradigm to the database, which could eventually force the decision analyst to use other forms of the functions of losses and gains, in fact it is not since the first uses of the TODIM method, in the early nineties of

the last century, the same mathematical forms have been successfully employed (Oliveira et al., 2017a; Oliveira et al., 2017b; Oliveira et al., 2017c).

Gomes and Duarte (1998) consider the "TODIM method a set of n alternatives to be ordered in the presence of m, quantitative and qualitative criteria". While the valuations of the alternatives against the quantitative criteria are obtained by, for example, some measure, as in the case of the criterion "prevalence of the disease in question", the valuations of the alternatives according to the qualitative criteria are obtained through value judgments read on a cardinal scale or on a verbal scale.

These scales are used to order alternatives to the criteria and also to weigh the criteria. Using verbal scales, value judgments are converted to numerical values read on the corresponding cardinal scale. An example of such a scale is shown in the following table:

Table.1: Correspondence between cardinal and verbal scales

Intensidade da importância	Definição	Alternativas x Critérios (c)
1	muito pouca importância	alternativa i-muito pouca importância para c
2	pouca importância	alternativa i-pouca importância para c
3	alguma importância	alternativa i-alguma importância para c
4	grande importância	alternativa i-grande importância para c
5	Importância absoluta	alternativa i-absoluta importância para c

Source: Gomes and Duarte (1998).

or each of the qualitative criteria c, a specialist should estimate the contribution of each alternative i to the objective associated with criterion c. Thus, if w_{ic} is an estimate of the contribution of alternative i to the maximization of criterion c, this estimate is expressed by a weight on a cardinal scale or by means of a reading on the corresponding verbal scale. Since there is a correspondence between the readings on the verbal scale and the cardinal scale, the performance matrix of the alternatives will contain only numerical values in their cells.

The following additive difference function is used to determine the dominance of one alternative over the other:

$$\delta(i,j) = \sum_{c=1}^m \phi_c(i,j)$$

where $\phi_c(i,j)$ is called the partial dominance function of

alternative i over j and its expression:

$$\phi_c(i,j) = \begin{cases} \sqrt{\frac{a_c(w_{ic} - w_{jc})}{\sum_c a_c}} \\ -\sqrt{\frac{(\sum_c a_c)(w_{jc} - w_{ic})}{a_c}} \end{cases}$$

being $\delta(i,j)$ is the measure of dominance of alternative i over alternative j. If $\delta(i,j) > 0$, the alternative i dominates the alternative j, that is the alternative i is preferable the alternative j; if $\delta(i,j) = 0$ the alternatives i and j are equal.

m = number of criteria;

c = any criterion, c = 1, ..., m;

a_c = weight of criterion c normalized;

$W_{ic}W_{jc}$ = weights of the alternatives i and j , respectively, in relation to the criterion c .

It should be noted that $W_{ic} \cdot W_{jc} > 0$ represents a relative gain, while $W_{ic} \cdot W_{jc} < 0$ represents a relative loss. The total values of the various alternatives are combined to produce an ordering using the expression 1.3.

$$\xi_i = \frac{\sum_{j=1}^n \delta(i,j) - \text{Min}_i \sum_{j=1}^n \delta(i,j)}{\text{Max}_i \sum_{j=1}^n \delta(i,j) - \text{Min}_i \sum_{j=1}^n \delta(i,j)}$$

After the calculation of the several matrices of partial dominances, one for each criterion, the final dominance matrix is obtained, through the sum of the elements of the several matrices.

Table.2: Matrix of final dominance

Alternativa	1	2	3		i			n
1	$\delta(1,1)$	$\delta(1,2)$	$\delta(1,3)$		$\delta(1,i)$			$\delta(1,n)$
2	$\delta(2,1)$	$\delta(2,2)$	$\delta(2,2)$		$\delta(2,i)$			$\delta(2,n)$
3	$\delta(3,1)$	$\delta(3,2)$	$\delta(3,3)$		$\delta(3,i)$			$\delta(3,n)$

Source: Gomes and Duarte (1998).

This matrix will be normalized using the expression (1.3) to obtain the global values of the alternatives. Each number calculated by expression (1.3) above is to be interpreted as the measure of the overall desirability or utility or simply value of a given alternative.

The formulation of the TODIM Method

Consider a set of n alternatives to be ordered in the presence of m , quantitative and qualitative criteria. The contributions of alternatives i and j to the maximization (or minimization) of criterion c , are $w_{i,c}$ and $w_{j,c}$, respectively. These contributions, when the criterion c is quantitative, are obtained, for example, by means of a measure - average area of housing in the segment, for example. The contributions of alternatives i and j when the criterion c is qualitative are obtained by value judgments read directly on a cardinal scale or on a verbal scale - when using the latter, it will always be related to the first. The mentioned scales are also used to weigh criterion c - and the other criteria. Consider also that a_c is the weight assigned to criterion c . In the multicriteria environment, the gains and losses in the comparison of alternatives i and j , according to criterion c , are perceived by analyzing the difference between $w_{i,c}$ and $w_{j,c}$. Thus, the partial (preference) dominance of alternatives i over the alternative j according to criterion c , is given by:

$$\phi_c(i,j) = a_c \cdot \text{arctg}(w_{i,c} - w_{j,c}) \quad , \quad \text{se } w_{i,c} > w_{j,c}$$

In this case it is said that alternative i dominates (or is preferred in relation to ...) alternative j . The function $\phi_c(i,j)$ is an arc-tangent function since, as described above, this is the function to be used in the earnings field.

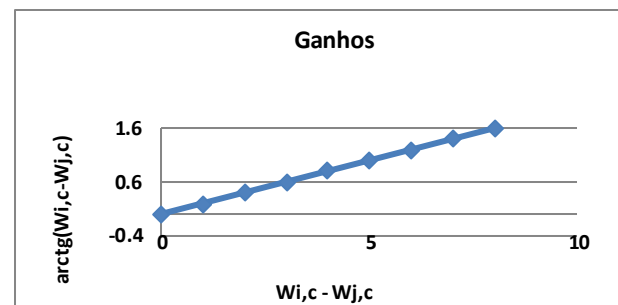


Fig.1: Gains represented by the Arc-tangent Function

Source: Vieira (1999).

If, on the other hand, alternative i is dominated by alternative j according to criterion c , the partial dominance function is given by:

$$\phi_c(i,j) = -a_c \cdot \sqrt{-(w_{i,c} - w_{j,c})}, \text{ if } w_{i,c} < w_{j,c}$$

The function $\phi_c(i,j)$ is a square root function, because as described above, this is the function to be used in the loss terrain.

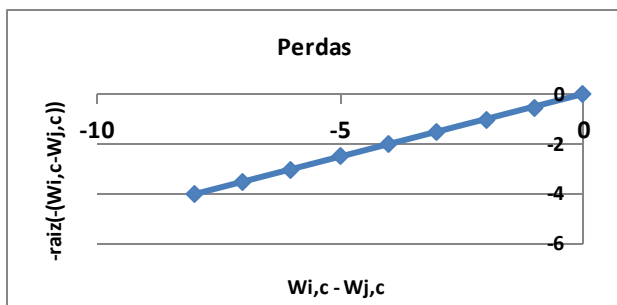


Fig.2: Losses represented by the Square Root Function
 Source: Vieira (1999).

Of course, if alternative *i* is equivalent to alternative *j* according to criterion *c*, the partial dominance function is given by:

$$\phi_c(i,j) = 0, \text{ if } w_{i,c} = w_{j,c}$$

Once the matrices are calculated $\phi_c(i,j)$ for each of the *m* criteria, the second step of the TODIM method consists of aggregating the partial preferences (dominances) calculated in a matrix of final preferences, which is given by:

$$\delta(i,j) = \sum_{c=1}^m \phi_c(i,j) \quad , \quad \forall (i,j).$$

The final step of the TODIM method consists of calculating the final preference of each of the alternatives,

so that it is possible to identify from the best to the worst alternative. The final preference (dominance) of alternative *i* is given by:

$$\xi_i = \left(\sum_{j=1}^n \delta(i,j) \right) - \text{Min}_i \sum_{j=1}^n \delta(i,j) / \left(\text{Max}_i \sum_{j=1}^n \delta(i,j) \right) - \text{Min}_i \sum_{j=1}^n \delta(i,j)$$

In fact, the first member of the previous expression, $\sum_{j=1}^n \delta(i,j)$, already represents the final preference of alternative *i*, insofar as it aggregates the comparisons of alternative *i*, pair by pair, with all other alternatives. What the expression does is a scale change, so that all preferences are in the range [0 , 1].

MATERIALS AND METHODS

Setting the Study Scenario

The proposed scenario of the study will be defined based on two important attributes: pre-cooling and storage (conventional and controlled atmosphere), shown in Figure 3.

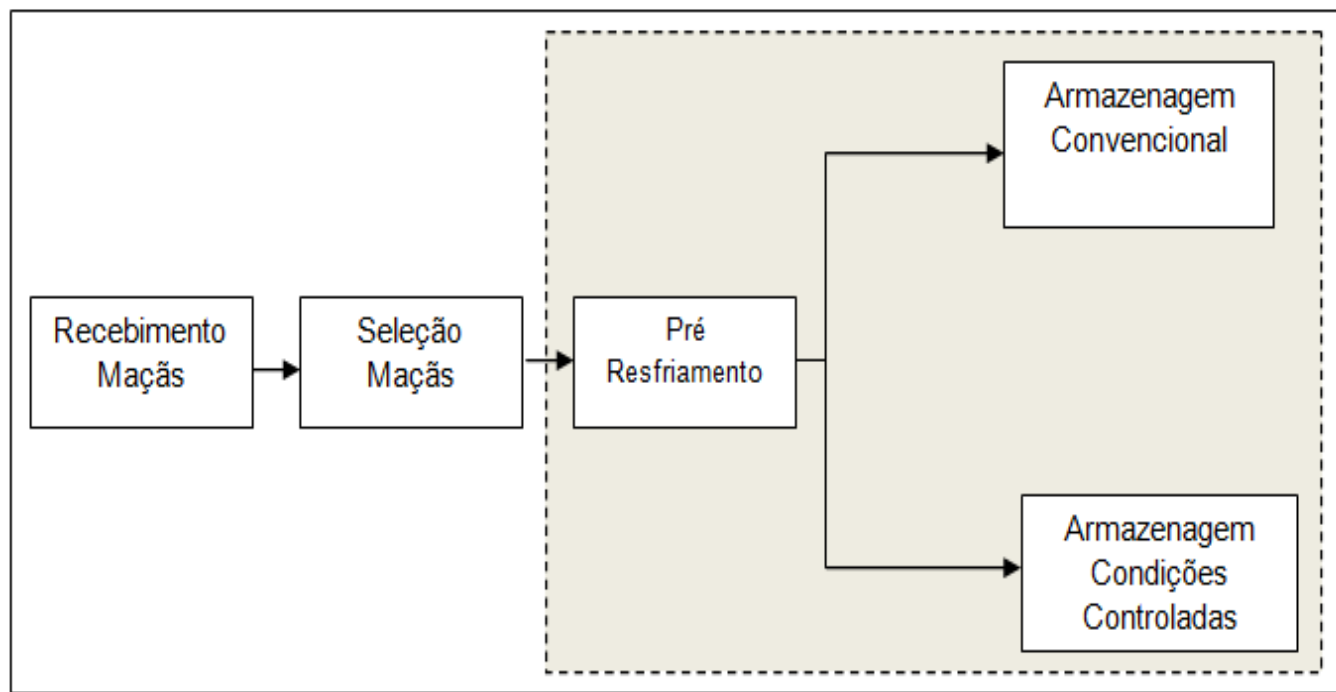


Fig.3: Study Scenario

The simulation in the study scenario involved the processes of precooling the hydrocooling and pre-cooling by forced air in the storage chamber, with the objective of rapidly reducing breathing and perspiration processes in function temperature and time, constituting the first stage of the cold chain and conventional storage under controlled conditions (Pacheco Costa, et al., 2017).

According to Teruel et al. (2001) both systems, forced air and water, guarantee low cooling times. Even so, the forced air circulation system usually cools 1/4 to 1/10 of the time required in conventional chambers, but is still two to three times slower than cooling with ice water. The relationship between time and temperature is what characterizes the cooling efficiency, so the lower the cooling time, the greater the efficiency of the system, which translates into products that maintain their quality and a shelf life of larger shelf.

Conducting Research

The research was conducted at the Cooperserra cooperative in São Joaquim/SC. In the first stage, seventy experiments were carried out with five Fuji (Malus Communis) 80 CAT1 and 198 CAT1 samples from orchards located in the municipality of São Joaquim/SC. The fruits harvested in commercial maturation in the harvest of April 2017. After the harvest, the fruits were transported to the Packing House of the cooperative.

The fruits were selected for size and maturation stage, eliminating those with physical defects and physiological disorders. They were then washed in running water and treated with 1% aqueous chlorine solution. Subsequently, they were packed in cardboard boxes and transported by truck, without refrigeration to the chemistry laboratory of the Universidade do Planalto Catarinense - UNIPLAC in Lages/SC.

The treatments evaluated were: Pre-forced air cooling (24hs) and cold storage (30 Days and 60 Days, CAT1 - 80 and CAT1 - 198) in Atmospheric Normal and Controlled Atmosphere 24hs.

Pre-cooling and storage process (30 days and 60 days, CAT1 - 80 and CAT1 - 198) by forced - air cooling in the cold room

On 06/26/2017, the experiments for pre-cooling by forced air (forced-air cooling) and storage in the cold room for 24 hours at 1°C were sent to the cooperative in São Joaquim/SC denominated: Atmosphere Normal (60 Days - CAT 1 - 80), (30 Days - CAT 1 - 198) and (60 Days - CAT 1 - 198) Controlled Atmosphere (30 Days - CAT 1 - 80), (60 Days - CAT 1 - 80), (30 Days - CAT 1 - 198) and (60 Days - CAT 1 - 198).

Fruits denominated (30 days - CAT 1 - 80), (60 Days - CAT 1 - 80), Normal Atmosphere and Controlled Atmosphere

The fruits were pre-cooled in the chamber for 24 hours at 1°C and later stored 30 and 60 days in Normal Atmosphere. On July 28, 2017 the second stage of the research was started, the fruits stored in the period of 30 days (CAT1 - 80) in Normal Atmosphere were separated, the experiments 1 and 3 were separated called Shelf (7 Days and 14 Dias), were placed in ambient conditions, remaining seven days and fourteen days of exposure under the same conditions of commercialization.

The analysis of the samples of the experiments 2, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity. On the same date, the fruits stored in the Controlled Atmosphere (CA) were stored for 30 days (CAT1 - 80), the experiments 1 and 2 were separated, called Shelf (7 Days and 14 Days), placed under ambient conditions, remaining seven days and fourteen days of exposure under equal conditions of commercialization. The analysis of the samples of the experiments 3, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity.

On 30/08/2017 the third stage of the research was started, the fruits stored in the period of 60 days (CAT1 - 80) in Normal Atmosphere were separated, the experiments 1 and 2 denominated Shelf were separated (7 Days and 14 Days), were placed in ambient conditions, remaining seven days and fourteen days of exposure under the same conditions of commercialization. The analysis of the samples of the experiments 3, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity.

On the same date, the fruits stored in the Controlled Atmosphere were stored at 60 days (CAT1-80), the experiments 1 and 2 were separated, called Shelf (7 Days and 14 Days), placed at ambient conditions, remaining seven days and fourteen days of exposure under equal conditions of commercialization. The analysis of the samples of the experiments 3, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity.

On August 8, 2017, samples of the Shelf Stable (7 Days, CAT1 - 80) Normal Atmosphere of the Experiment

2 were analyzed. The experiment was carried out in the cooperative laboratory. the color of the epidermis and the rot of the fruits, and the analysis of °Brix, Pressure (firmness of the pulp) and titratable acidity. At the same time, the samples were analyzed (7 Days, CAT1 - 80) Controlled Atmosphere of the experiment 2, carried out in the laboratory of the Cooperative, started with the measurement of the temperature of the pulp in the sequence. color of the epidermis and fruit rot, and the analysis of °Brix, Pressure (pulp firmness) and titratable acidity.

On 08/08/2017, samples of the Experimental 1 Shelf (14 Days, CAT1 - 80) Normal Atmosphere were analyzed and the temperature of the pulp was measured. the color of the epidermis and the rot of the fruits, and the analysis of °Brix, Pressure (firmness of the pulp) and titratable acidity. On the same date, the samples called the Shelf (14 Days, CAT1 - 80) Controlled Atmosphere of experiment 1, carried out in the laboratory of the Cooperative, were analyzed by the measurement of the temperature of the pulp in the sequence. color of the epidermis and fruit rot, and the analysis of °Brix, Pressure (firmness of the pulp) and titratable acidity. The research data was presented in Chapter 5, item 4.

Fruits denominated (30 Dias - CAT 1 – 198), (60 Dias - CAT 1 – 198), Normal Atmosphere (NA) and Controlled Atmosphere

The fruits were pre-cooled in the chamber for 24 hours at 1°C and later stored 30 and 60 days in Normal Atmosphere. On July 28, 2017 the second stage of the research was started, the fruits stored in the period of 30 days (CAT1 - 198) in Normal Atmosphere were separated, the experiments 1 and 2 were separated, called the Shelf (7 Days and 14 Days), were placed in ambient conditions, remaining seven days and fourteen days of exposure under the same conditions of commercialization.

The analysis of the samples of the experiments 3, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity (TA).

On the same date, the fruits stored in the Controlled Atmosphere (CA) were stored for 30 days (CAT1 - 198), the experiments 1 and 2 were separated, called Shelf (7 Days and 14 Days), placed under ambient conditions, remaining seven days and fourteen days of exposure under equal conditions of commercialization.

The analysis of the samples of the experiments 3, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity (TA).

On August 30, 2017 the third stage of the research was started, the fruits stored in the period of 60 days (CAT1 - 198) in Normal Atmosphere were removed, the experiments 1 and 2 denominated Shelf were separated and 14 days), were placed in ambient conditions, remaining seven days and fourteen days of exposure under the same conditions of commercialization.

The analysis of the samples of the experiments 3, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity (TA).

On the same date the fruits stored in the Controlled Atmosphere (CA) were stored at 60 days (CAT1 - 198), the experiments 1 and 2 denominated Shelf were separated (7 days and 14 days), placed under ambient conditions, remaining seven days and fourteen days of exposure under equal conditions of commercialization.

The analysis of the samples of the experiments 3, 4 and 5, started with the measurement of the temperature of the pulp in the sequence was observed the color of the epidermis and the rot of the fruit, and the analysis of °Brix, Pressure (firmness of the pulp) and Titlutable acidity.

COMPARISON OF FRUIT PROCESSES (CAT1 - 80 AND CAT1 - 198) - TODIM METHOD

In the second stage, results obtained by means of the multicriteria modeling of forced-air pre-cooling parameters on the quality of the fruit during the storage period in the cold room were evaluated. The following evaluation and comparison parameters are as follows:

- Pulp temperature;
- °Brix;
- Pressure (Firmness of Pulp); and,
- Tit Titratable Acids.

We used the TODRI multicriteria method that, besides the advantage of trying to model the patterns of preference when risk decisions are made, using the Prospective Theory (Kahneman & Tversky, 1979), allows to work with both quantitative and qualitative criteria and has a satisfactory degree of intelligibility compared to other discrete methods (Gomes and Duarte, 1998). In the multicriteria environment, the gains and losses in the comparison of alternatives i and j , according to criterion c , are perceived by analyzing the difference between $w_{i,c}$ and $w_{j,c}$.

Thus, the partial (preference) dominance of alternatives i over the alternative j according to criterion c , is given by:

$$\phi_c(i,j) = a_c \cdot \arctg(w_{i,c} - w_{j,c}) \quad , \quad \text{if } w_{i,c} > w_{j,c}$$

If, on the other hand, alternative i is dominated by alternative j according to criterion c, the partial dominance function is given by:

$$\phi_c(i,j) = -a_c \cdot \sqrt{-(w_{i,c} e w_{j,c})}, \text{ if } w_{i,c} < w_{j,c}.$$

The function $\phi_c(i,j)$ is a square root function, because as described above, this is the function to be used in the loss terrain. The comparison between the Pre-cooling and Storage processes of the following treatments:

- Camera 24hs (30 days NA);
- Chamber 24hs (30 days BC);
- Camera 24hs (60 days NA); and,

House 24hs (60 days BC).
 Parameters used for evaluation and comparison are as follows:

- Pulp temperature;
- °Brix;
- Pressure (Firmness of Pulp); and,
- Tit Titrateable Acids (TA).

Comparison Pulp Temperature - CAT1 – 80

Table 5 shows the application of the TODIM data comparison method, presenting the gains and losses, Temperature of the pulp fruits CAT1 – 80.

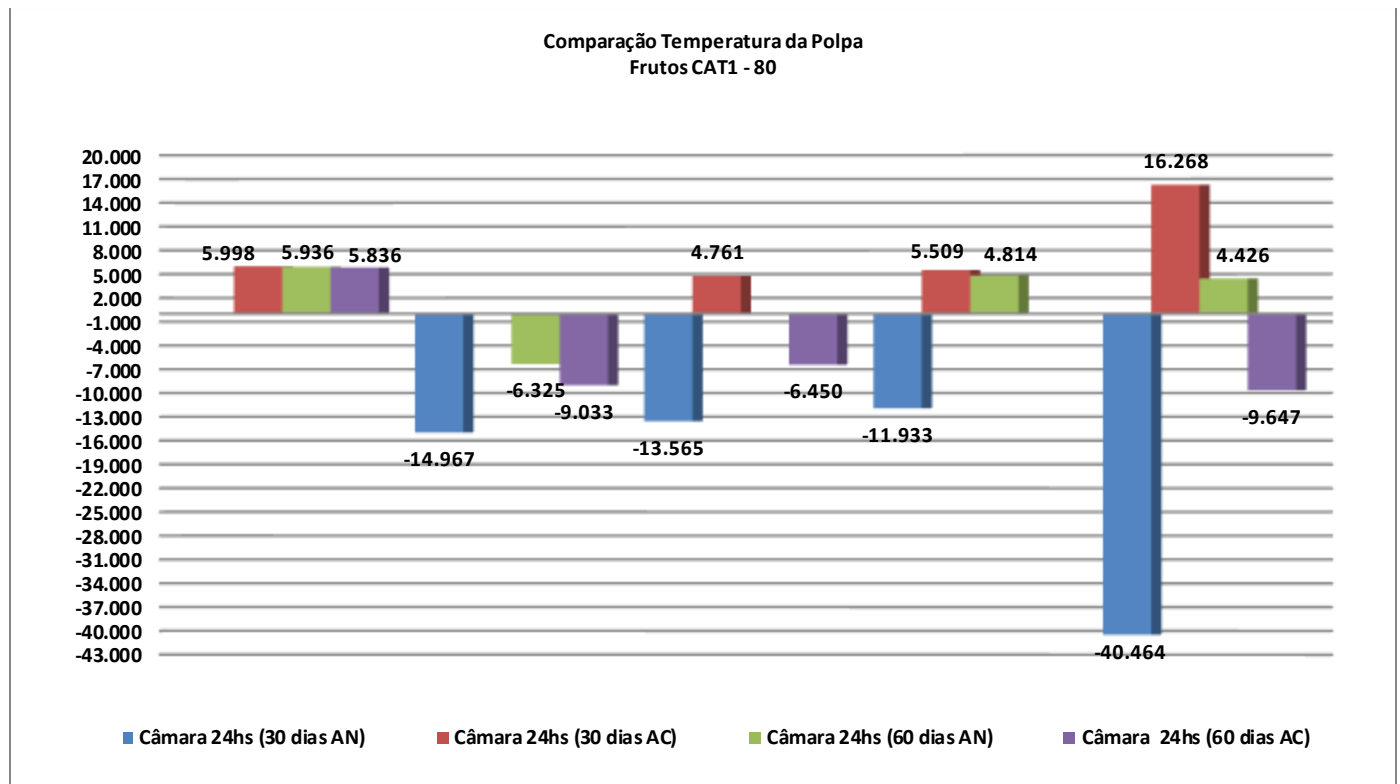


Fig.10: Temperature Comparison of Fruit Pulp CAT1 - 80

It was compared the temperature of the pulp between the treatments of 30 and 60 days NA and CA, it was concluded with the application of the TODIM method that the best treatment was Chamber 24hs (30 days CA) where it showed a gain of 16,268 as shown in table 12.

Comparison °Brix - Fruits CAT1 – 80

Table 6 shows the data already applied to the TODIM Method, presenting the gains and losses, °Brix fruits CAT1 - 80.

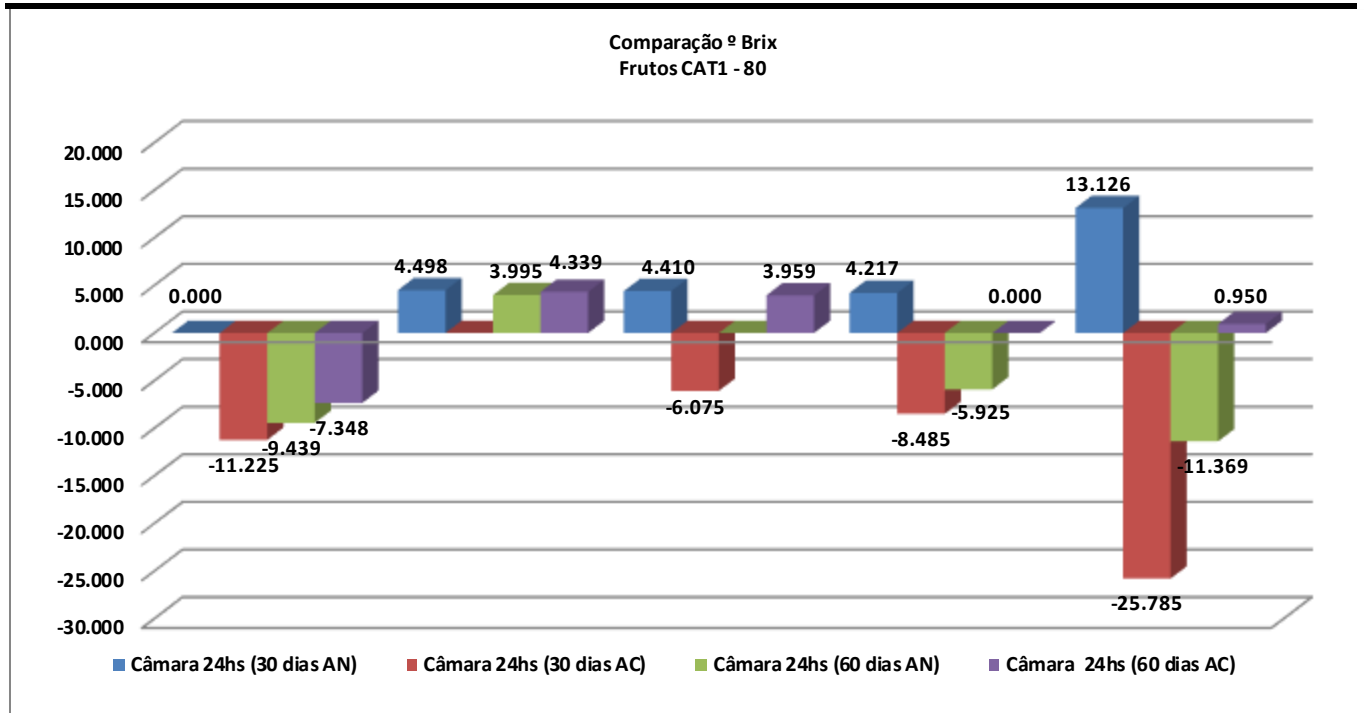


Fig.11: Comparison °Brix - FruitsCAT1 - 80

It was compared the °Brix between treatments of 30 and 60 days NA and CA, it was concluded with the application of the TODIM method that the best treatment was Chamber 24hs (30 days NA) where it showed a gain of 13,126 as presented in table 13.

Comparison Pressure (Firmness of Pulp) Fruits CAT1 – 80

Table 7 shows the data already applied the TODIM Method, presenting the gains and losses, Pressure (Firmness of the Pulp) fruits CAT1 - 80.

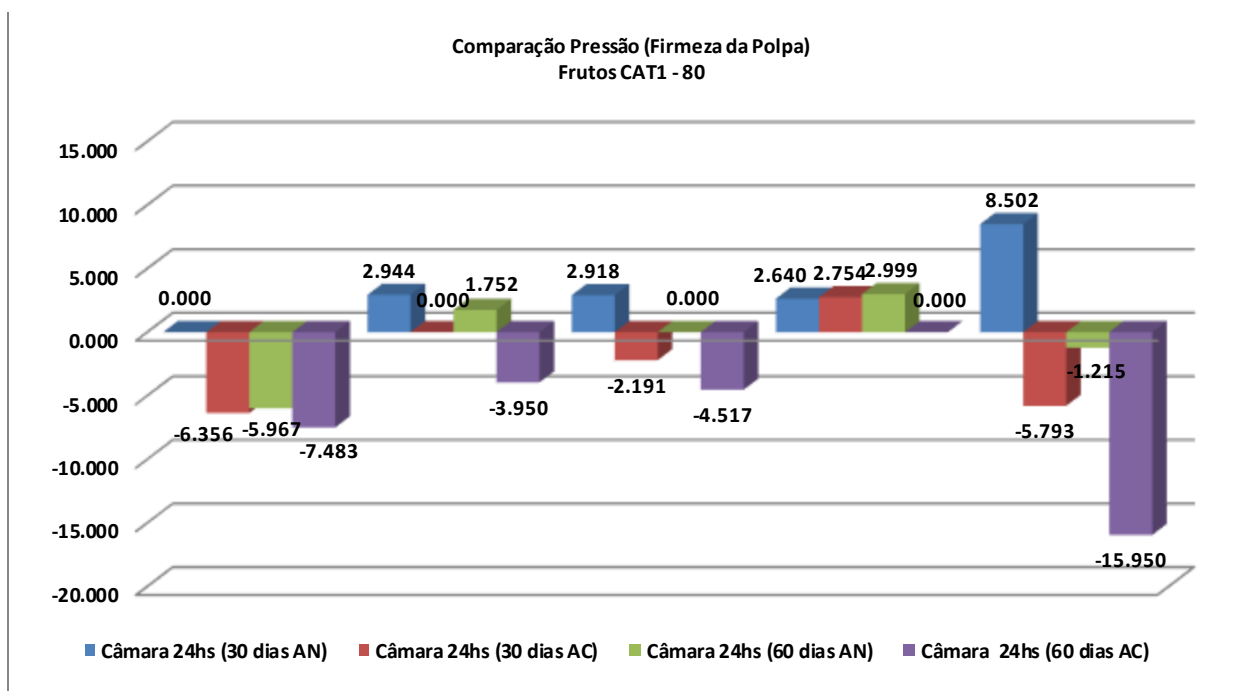


Fig.12: Comparison Pressure (Firmness of Pulp) - FruitsCAT1 - 80

It was compared the pressure (firmness of the pulp) between treatments of 30 and 60 days NA and CA, it was

concluded with the application of the TODIM method that the best treatment was Chamber 24hs (30 days NA) where

it showed a gain of 8,502 as presented in table 14.

TODIM, apresentando os ganhos e perdas, Acidez Titulável (AT) frutos CAT1 – 80.

Comparison Titratable Acidity–CAT1 - 80

O quadro 8 apresenta os dados já aplicado o Método

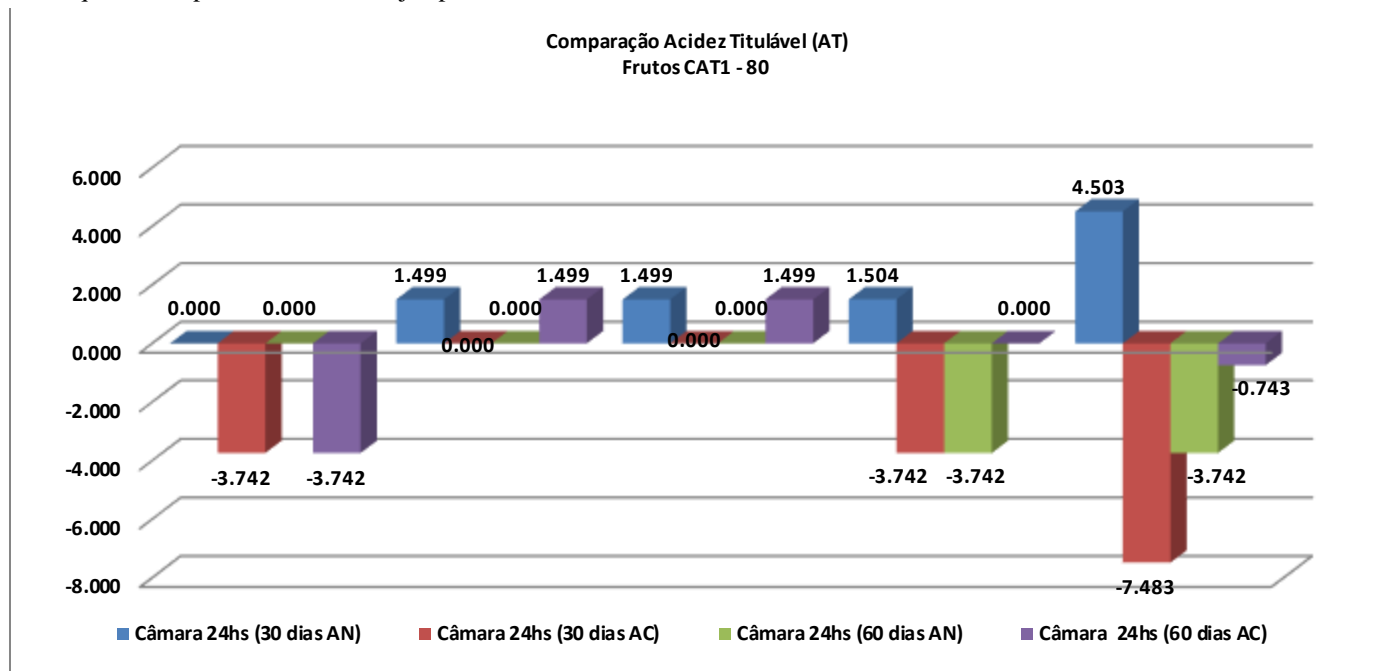


Fig.13: Comparação Acidez Titulável (AT) - Frutos CAT1 - 80

Fonte: Dados da pesquisa

In the comparison of titratable acidity (TA) between the treatments of 30 and 60 days NA and CA, it was concluded with the application of the TODIM method that the best treatment was Chamber 24hs (30 days NA) where it showed a gain of 4.503 as presented in the table 15.

Comparison Pulp Temperature - CAT1 – 198

Table 9 shows the data already applied to the TODIM Method, presenting the gains and losses, Temperature of the pulp fruits CAT1 - 198.

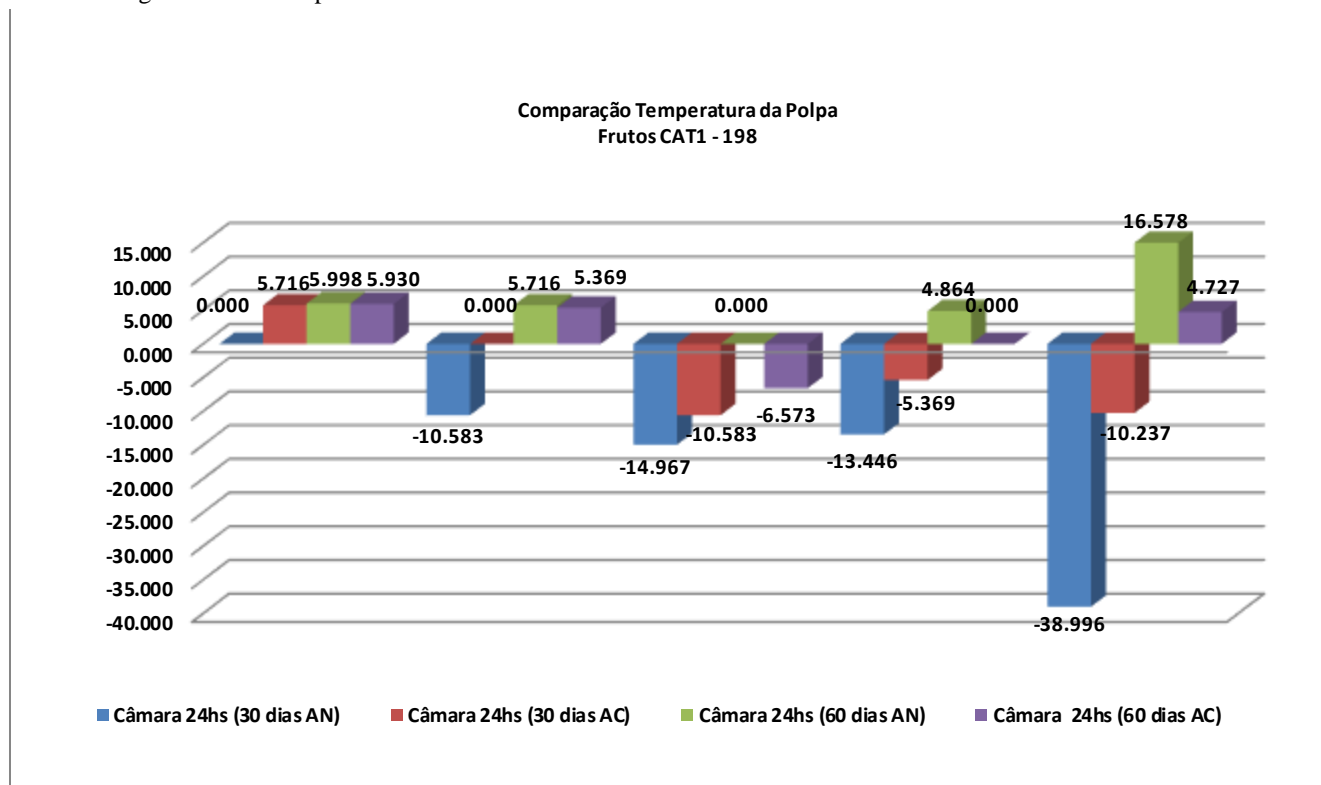


Fig.14: Temperature Comparison of Fruit Pulp CAT1 - 198

The comparison of the pulp temperature between the treatments of 30 and 60 days NA and CA, was concluded with the application of the TODIM method that the best treatment was Chamber 24hs (60 days NA) showing a gain

of 16,578 as presented in table 10.

Comparação °Brix - Frutos CAT1 - 198

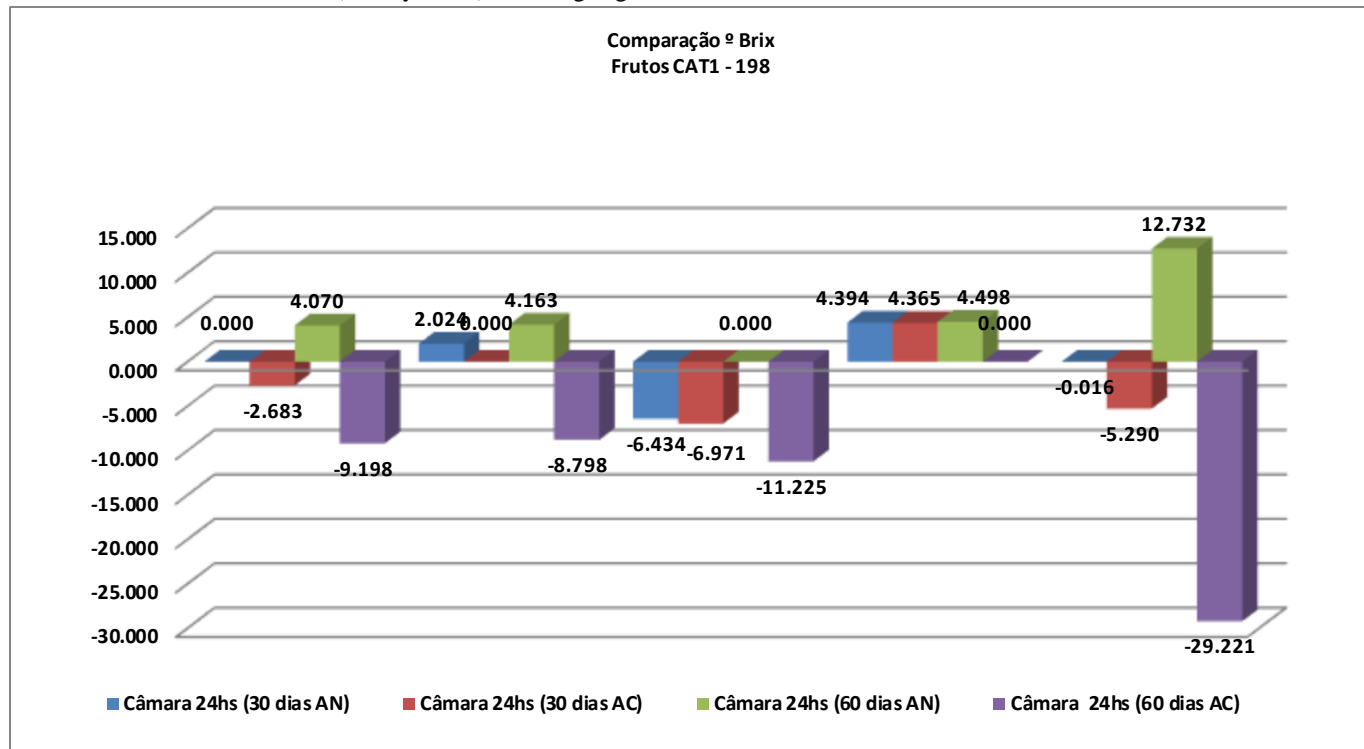


Fig.15: Comparação °Brix - Frutos CAT1 - 198

It was compared the Brix between treatments of 30 and 60 days NA and CA, it was concluded with the application of the TODIM method that the best treatment was Camera

24hs (60 daysNA) where it showed a gain of 12,732 as shown in table 11.

Comparison Pressure CAT1 - 198

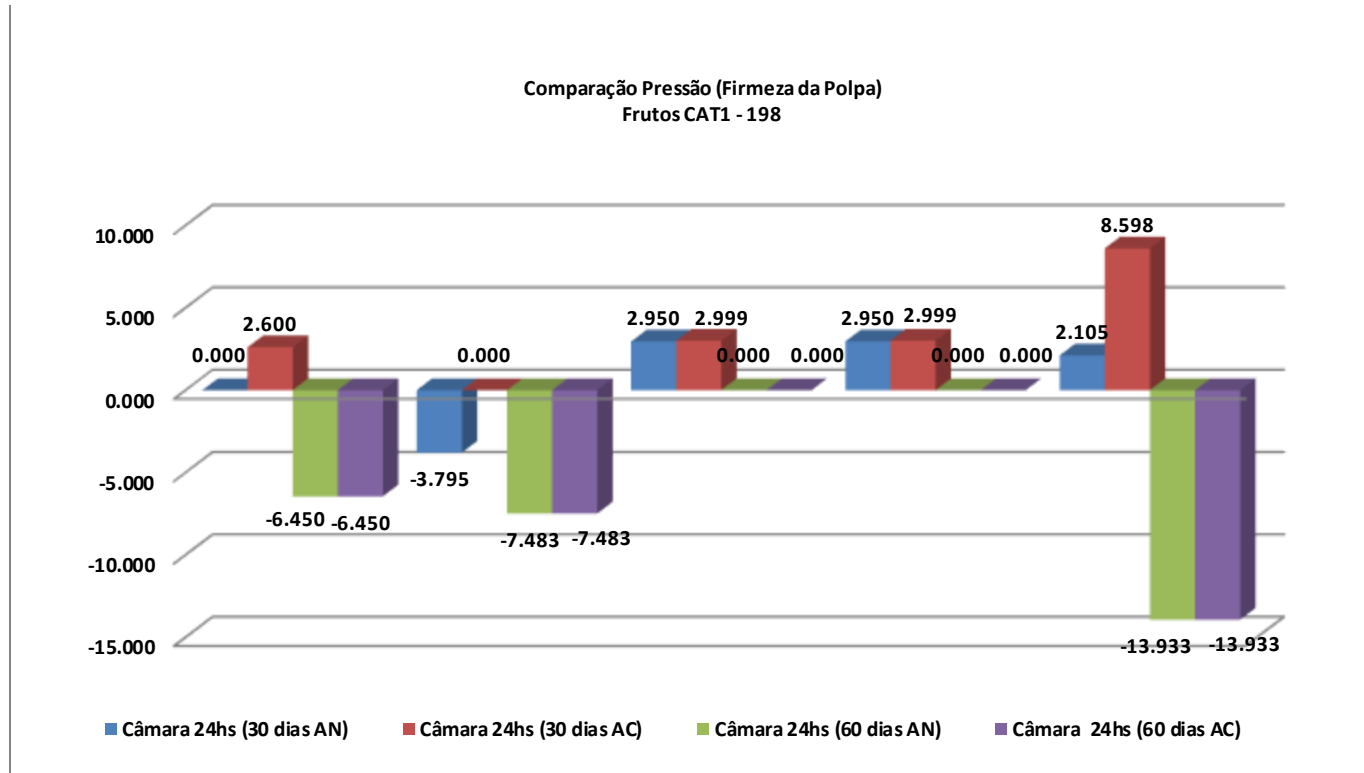


Fig.16: Comparison Pressure (Firmness of Pulp) - Frutos CAT1 - 198

It was compared the pressure (firmness of the pulp) between treatments of 30 and 60 days NA and CA, it was concluded with the application of the TODIM method that

the best treatment was Chamber 24hs (30 days CA) where it showed a gain of 8,598 as presented in table 12.

Comparison Titratable Acidity(AT) CAT1 - 198

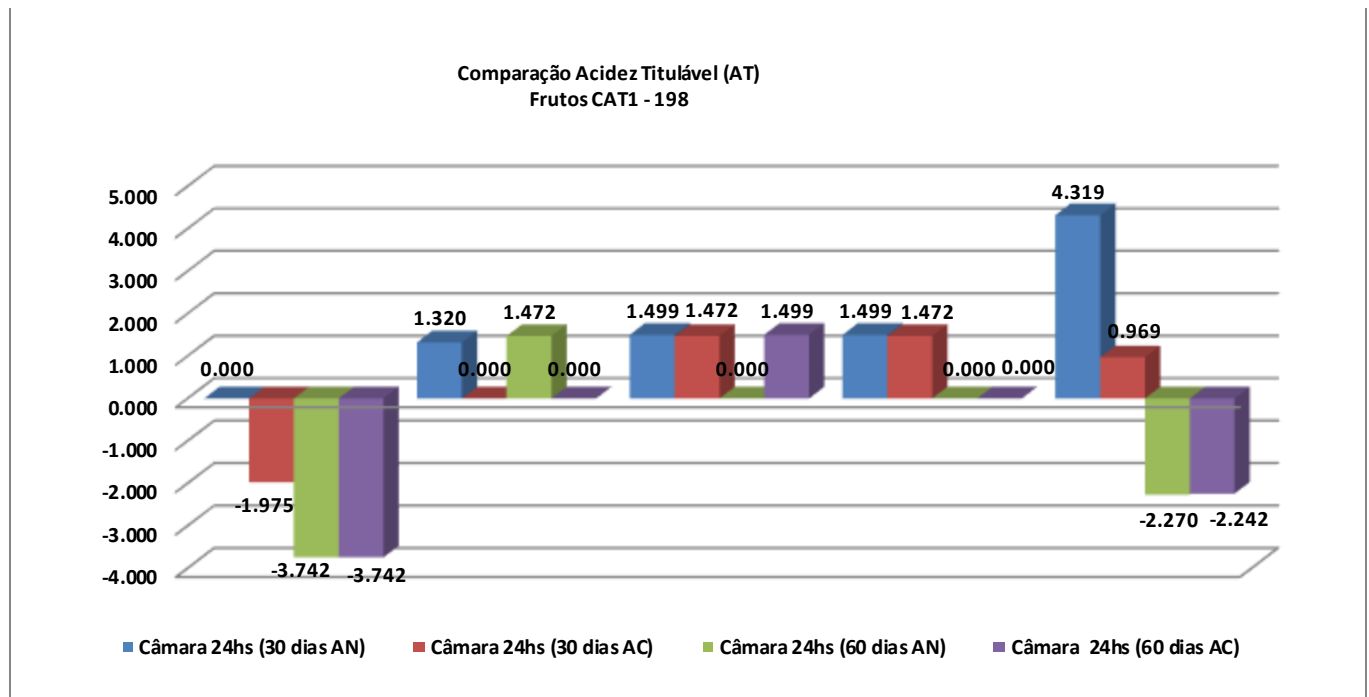


Fig.17: Comparison Titratable Acidity (AT) - Fruits CAT1 – 80

A titratable acidity (TA) was compared between the treatments of 30 and 60 days NA and CA, it was concluded with the application of the TODIM method that the best treatment was Chamber 24hs (30 days NA) where it showed a gain of 4,319 as presented in the table 12.

III. CONCLUSION

The question raised at the beginning of this research was: How do we use the pre-cooling and storage processes to maintain the quality of the Fuji apple (*Malus Communis*)? The answer to the research question, based on the scope adopted is as follows:

The aim of this research was to analyze how the TODIM Method of Multicriteria Decision Support contributes to the precooling process in a fast system to the cold water by immersion in relation to the forced air precooling method to maintain the quality of the Fuji apple (*Malus Communis*).

The methodology was structured in four steps: definition of the study scenario, description of the research in the different conditions in the pre-cooling and storage processes, presentation of the results of the research in the proposed scenario and comparison of results between processes and precooling and storage using multicriteria modeling - AMD, Method - TODIM. The application of this methodology to the hypothetical

scenario made possible the analysis of the involved processes.

With this analysis it was possible to perform the data collection of the treatments involved and to obtain the results for the comparison between the processes.

In the field research carried out at the Cooperserra cooperative, the following results were identified: (1) feasibility of the implantation of the rapid precooling process to the hydrocooling by immersion proving to be efficient in the application of the system, in relation to the precooling for forced-air cooling in the chamber combined with storage; (2) the management of the Cold Chain (CC) logistic process in the pre-cooling and storage stages maintains the quality of the Fuji apple (*Malus Communis*).

In addition to contributing to academic research in the areas of logistics and fruit growing, the research corroborated the development of best practices in the management of the Cold Chain (CC) logistics process and commercialization, providing elements for companies to plan logistics processes incorporating the stages of pre-cooling and storage of fujiapple (*Malus Communis*).

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Approach of economic-emission load dispatch using Ant Lion Optimizer

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Abstract— To solve the problem of the economic emission load dispatch (EELD) is necessary minimize the total cost of fuel consumption and carbon emission. In this study is applied the ant lion optimizer (ALO) to this problem. The cost function and emission function with their respective restrictions are being using. To present the results this proposal is applied in IEEE 30 bus system that consists of six thermal units. The results for this case study with the application of ant lion with all generators on with demand being met, the total fuel cost is 48915.36652 (\$/h). The results this method can be compared with another metaheuristic algorithms and helps the plant operators in the decision making of preventive maintenance.

Keywords— Ant lion Optimizer, EELD, Power Plants.

I. INTRODUCTION

The Thermal Power Plant (TPP) operation is dependent upon incineration of fossil fuel which generates sulfur dioxide (SO₂), carbon dioxide (CO₂) and nitrogen oxides (NO_x) which create atmospheric pollution. Reduce the emission level and total cost of generation and at the same time accomplishing the demand for electricity from the power plant is the goal of economic emission load dispatch (EELD). To solve the EELD problem is necessary minimize the total cost of fuel consumption and carbon emissions (De, Das, Mandal, & Mandal, 2018; Moraes, Bezerra, Moya Rodríguez, Nascimento, & Leite, 2018). The problem is formulated as a multiobjective economic emission load dispatch (EELD) problem in which both the objectives (emission and economy) have

to be minimized (Chopra, Kumar, & Mehta, 2016). This is a complex problem to solve because of its large size, a nonlinear objective function and a wide number of restrictions (Bhattacharya & Chattopadhyay, 2010).

Various evolutionary, heuristic and meta-heuristics optimization algorithms have been developed such as: Grey Wolf Optimization (GWO) (Chopra et al., 2016; Hong, MH, & Mohd Rusllim, 2014), non-dominated sorting genetic algorithm (NSGA-II) (Basu, 2008; Moraes et al., 2018), hybrid genetic algorithm (Thenmozhi & Mary, 2004), Tabu Search Algorithm (Li, Yang, Tseng, Wang, & Lim, 2018), Simulated annealing (Júnior, Nunes, Nascimento, Rodríguez, & Leite, 2017; Ziane, Benhamida, & Graa, 2017), Neural Networks (Deng, He, & Zeng, 2017), Harmony Search Algorithm (El Ela, El-Sehiemy, Shaheen, & Shalaby, 2017), particle swarm optimization (De et al., 2018), Differential Evolution (Jebaraj, Venkatesan, Soubache, & Rajan, 2017), Ant Colony Optimization (Zhou et al., 2017), Biogeography-Based Optimization (Ma, Yang, You, & Fei, 2017), genetic algorithm controlled by fuzzy logic (Song, Wang, Wang, & Johns, 1997).

This research use the emission function and economic function in the multiobjective optimization ALO, with restrictions.

II. MATERIAL AND METHODS

To solve a problem of EELD, two important objectives in an electrical power system must be considered; they are: environmental, and economy impacts (Basu, 2014).

2.1 Economic Load Dispatch

The fuel cost is considered as an essential criterion for economics analysis in ELD. The most simplified cost function of each generator can be assumed to be approximated by a quadratic function of generator power output P_i (Ghosh, Chakraborty, Bhowmik, & Bhattacharya, 2017; Jebaraj et al., 2017):

$$F1(P_i) = \sum_{i=1}^N (a_i + b_i P_i + c_i P_i^2) \text{ \$/h} \quad (1)$$

where a_i , b_i and c_i are the fuel cost coefficients of the i th unit generating, N the number of generators and P_i the active power of each generator. Fig. 1 illustrates the fuel cost curve without valve-point effects and emissions.

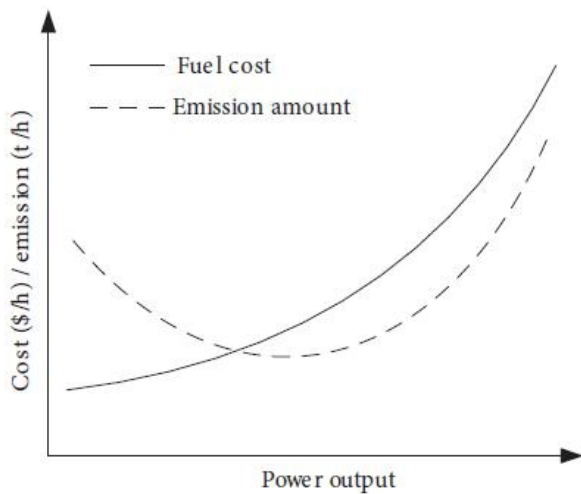


Fig.1: Fuel cost and emission function of the thermal generator.

Source: (Gitizadeh & Ghavidel, 2014)

2.2 Economic Emission Dispatch

Emissions can be represented by a function, that links emissions with power generated by each unit. The emission function in kg/h, which normally represents the emission of SO₂ and NO_x, is a function of the power output of the generator, and it can be expressed as follows (Swain, Sarkar, Meher, & Chanda, 2017):

$$F2(P_i) = \sum_{i=1}^N (d_i + e_i P_i + f_i P_i^2) \text{ kg/h} \quad (2)$$

Where d_i , e_i and f_i are the emission coefficients of the i th unit generating, N the number of generators and P_i the active power of each generator, from the TPP.

2.3 Economical load dispatch constrains

2.3.1 Equality power balance constraint

The real power of each generator is limited by the lower and upper limits. The following equation is the equality restriction of power balance (Rizk-Allah, El-Sehiemy, & Wang, 2018).

$$\sum_{i=1}^n P_i - P^D - P^L \quad (2)$$

where P_i is the output power of each i generator, P^D is the load demand and P^L are transmission losses, in other words, the total power generation has to meet the total demand P^D and the actual power losses in transmission lines P^L (Dewangan, Jain, & Huddar, 2015).

$$\sum_{i=1}^n P_i = P^D - P^L \quad (3)$$

The calculation of power losses P^L involves the solution of the load flow problem, which has equality constraints in the active and reactive power on each bar as follows (Nwulu & Xia, 2015):

$$P^L = \sum_{i=1}^n B_i P_i^2 \quad (4)$$

A simplification is applied to model the transmission losses, setting them as a function of the generator output through Kron's loss coefficient derivatives of the Kron formula for losses (Huang et al., 2018).

$$P^L = \sum_{i=1}^n \sum_{j=1}^n P_i B_{ij} P_j + \sum_{i=1}^n B_{0i} P_i + B_{00} \quad (5)$$

where B_{ij} , B_{0i} and B_{00} are the energy loss coefficients in the transmission network and n is the number of generators. A reasonable accuracy can be obtained when the actual operating conditions are close to the base case, where the B coefficients were obtained (Gitizadeh & Ghavidel, 2014).

2.3.2 Production Capacity Constraint

The power capacity total generated from each generator is restricted by the lower limit and by the upper limit, so the constrain is (De et al., 2018):

$$P_{min,i} \leq P_i \leq P_{max,i} \quad (6)$$

where P_i is the output power of the i generator, $P_{min,i}$, is the minimal power of the i generator and $P_{max,i}$, the maximal power of the i generator.

2.3.3 Fuel Delivery Constraint

At each time interval, the amount of fuel supplied to all units must be less than or equal to the fuel supplied by the seller, i.e. the fuel delivered to each unit in each interval should be within its lower limit $F_{min,i}$ and its upper limit $F_{max,i}$ so that (Qu et al., 2018):

$$F_{min,i} \leq F_{im} \leq F_{max,i}, i \in N, m \in M, \quad (7)$$

where $F_{i,m}$ is the fuel supplied to the engine i at the interval m , $F_{i,min}$ is the minimum amount of fuel supplied to i generator and $F_{max,i}$ is the maximum amount of fuel supplied to i generator.

2.3.4 Optimization problem

The multi-objective optimization problem is defined as follow:

$$\text{Minimize } (P) = [F_1(P), F_2(P)] \quad (8)$$

where $F_1(P)$, $F_2(P)$ are the objective functions to be minimized over the set of permissible decision vector P .

2.3.5 Incremental fuel cost method

The incremental fuel cost can be obtained from the following equation (Tiwari, Dave, & Dwivedi, 2017):

$$IC_i = (2 \cdot a_i \cdot P_{gi} + b_i) \text{ \$/MWh} \quad (9)$$

where IC_i is the incremental fuel cost a_i are the values of the different points of the actual curve of the incremental cost and b_i are the values of the points on the approximated curve (linear) of incremental cost. P_{gi} is the total power generation. The curve of incremental fuel cost is show in the following Figure. 2:

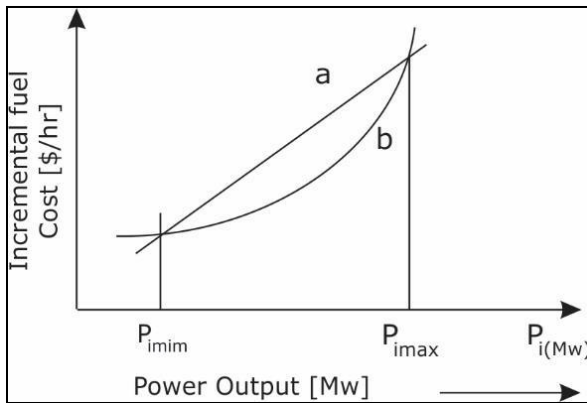


Fig.2: Incremental Cost Curve of Power Generator.

Source:(Nascimento, Nunes, Rodríguez, Leite, & Junior, 2016)

2.4 Ant lion optimization

The Ant Lion Optimizer (ALO) is a algorithm inspired by nature (Mirjalili, 2015). The ALO algorithm mimics interaction between antlions and ants in the trap. To model such interactions, ants are required to move over the search space, and antlions are allowed to hunt them and become fitter using traps. Since ants move stochastically in nature when searching for food, a random walk is chosen for modelling ants' movement as follows [28]:

$$X(t) = [0, \text{cumsum}(2r(t_1) - 1), \text{cumsum}(2r(t_2) - 1), \dots, \text{cumsum}(2r(t_n) - 1)] \quad (10)$$

where cumsum calculates the cumulative sum, n is the maximum number of iteration, t shows the step of random walk (iteration in this study), and $r(t)$ is a stochastic function defined as follows (Trivedi, Jangir, & Parmar, 2016):

$$r(t) = \begin{cases} 1 & \text{if } rand > 0.5 \\ 0 & \text{if otherwise} \end{cases} \quad (11)$$

where t shows the step of random walk (iteration in this study) and $rand$ is a random number generated with uniform distribution in the interval of [0, 1].

To keep the random walk in the boundaries of the search space and prevent the ants from overshooting, the random walks should be normalized using the following equation (Yao & Wang, 2017):

$$X_i^t = \frac{(X_i^t - a_i) \times (d_i^t - c_i^t)}{(b_i - a_i)} + c_i^t \quad (12)$$

where c_i^t is the minimum of i -th variable at t -th iteration, d_i^t indicates the maximum of i -th variable at t -th iteration, a_i is the minimum of random walk of i -th variable, and b_i is the maximum of random walk in i -th variable.

To simulate the trapping of ants the mathematical expression of the trapping of the ants to the ant lion's pits is given by following equations (Trivedi et al., 2016):

$$c_m^t = Ant - lion_n^t - c^t \quad (13)$$

$$d_m^t = Ant - lion_n^t - d^t \quad (14)$$

To construction of trap, the fittest ant lion is selected using the roulette wheel method.

To simulate the sliding ants towards ant lions, the boundaries of random walks should be reduced adaptively as follows (Mirjalili, 2015):

$$c^t = \frac{c^t}{I} \quad (15)$$

$$d^t = \frac{d^t}{I} \quad (16)$$

where $I = 10^w \frac{t}{S}$, t is current iteration, S is the maximum number of iterations and w is a constant whose value is given by (Raju, Saikia, & Sinha, 2016):

$$w = \begin{cases} 2 & \text{if } t > 0.1S \\ 3 & \text{if } t > 0.5S \\ 4 & \text{if } t > 0.75S \\ 5 & \text{if } t > 0.9S \\ 6 & \text{if } t > 0.95S \end{cases} \quad (17)$$

To catching the ants by ant lion and re-building the pit can be mathematically described as [28]:

$$Antlion_j^t = Ant_i^t, \text{ if } f(Ant_i^t) > f(Antlion_j^t) \quad (18)$$

where $Antlion_j^t$ indicates the position of selected j th ant lion at t th iteration and Ant_i^t shows the position of i th ant at t th iteration. t shows the current iteration.

Finally the last operator in ALO, that is elitism, calculated using roulette wheel as follows equation (Trivedi et al., 2016):

$$Ant_i^t = \frac{R_A^t + R_E^t}{2} \quad (19)$$

where, R_A^t = the random walk nearby the ant lion chose by means of the roulette wheel at t th iteration, R_E^t = the random walk nearby the elite at t th iteration, Ant_i^t = the location of i th ant at t th iteration.

2.5 ALO applied to EELD

Initialize random walks on ants using Eq (10) and save generation scheduling of generating units as ant position using Eq (20) described below:

$$M_{Ant} = \begin{bmatrix} Ant_{1,1} & Ant_{1,2} & Ant_{1,3} & \dots & Ant_{1,d} \\ Ant_{2,1} & Ant_{2,2} & Ant_{2,3} & \dots & Ant_{2,d} \\ \dots & \dots & \dots & \dots & \dots \\ Ant_{n,1} & \dots & \dots & \dots & Ant_{n,d} \end{bmatrix}_{n \times d} \quad (20)$$

where M_{Ant} is the matrix for saving the position of each ant, $Ant_{i,j}$ shows the value of the j th variable (dimension) of i th ant, n is the number of ants, and d is the number of variables.

For evaluating each ant (i.e., generating units), the following objective functions described in Eq. (1) and Eq (2) are utilized during optimization and following matrix stores the fitness value of all ants:

$$M_{OA} = \begin{bmatrix} f([Ant_{1,1}, Ant_{1,2}, \dots, Ant_{1,d}]) \\ f([Ant_{2,1}, Ant_{2,2}, \dots, Ant_{2,d}]) \\ \vdots \\ f([Ant_{n,1}, Ant_{n,2}, \dots, Ant_{n,d}]) \end{bmatrix} \quad (21)$$

where M_{OA} is the matrix for saving the fitness of each ant, $Ant_{i,j}$ shows the value of j th dimension of i th ant, n is the number of ants, and f is the objective function.

Save the optimal cost and generation scheduling using Eqs. (22) and (23) described below:

$$M_{OAL} = \begin{bmatrix} f([AL_{1,1}, AL_{1,2}, \dots, AL_{1,d}]) \\ f([AL_{2,1}, AL_{2,2}, \dots, AL_{2,d}]) \\ \vdots \\ f([AL_{n,1}, AL_{n,2}, \dots, AL_{n,d}]) \end{bmatrix} \quad (23)$$

where M_{OAL} is the matrix for saving the fitness of each ant lion, $AL_{i,j}$ shows the j th dimension's value of i th ant lion, n is the number of ant lions, and f is the objective function.

This solution comprises the number of generations of the system that will be optimized, which results in minimization of cost and emissions described in Eq (8) by fulfilling all constraints described in Eq (3), Eq (6) and Eq (7).

Equation (8) are applied in the performance evaluation of the EELD until the optimum cost and emission is achieved. For inequality constraints, similar to any other techniques, when the solutions obtained for any iteration are out of boundaries, ALO chooses the boundaries values, while for equality constraint, when it is violated, the penalty factor of 1000 is implemented and embedded in the cost function as per Eq. (8). The algorithm will continue until the maximum iteration is met, and the optimum results are obtained.

III. SIMULATION TESTS AND RESULTS

The power plant selected for the case study consists of six generating units with a load demand of 900 MW where generation limits, fuel cost and emission coefficients for case study is take from Ref (Lee & Darwish, 2008; Manteaw & Odero, 2012).

The EELD problem simulated with the ALO algorithm, the systems of standard IEEE 30 bus systems have been taken into consideration (figure 3).

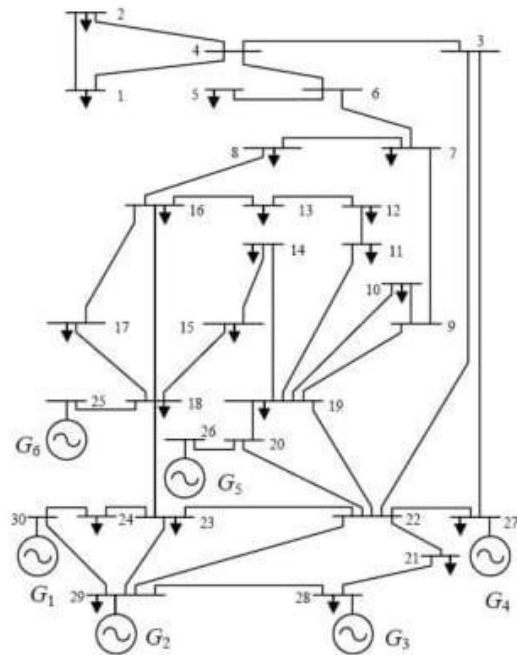


Fig.3: Diagram of IEEE 30-bus test system.
 Source: (Lee & Darwish, 2008)

The data of IEEE 30 bus test system to apply in ALO optimizer is presented in table 1, table 2 and table 3.

Table.1: Characteristic data of the generators from the case study power plants.

Gen	c_i (\$/MW ² h)	b_i (\$/MWh)	a_i (\$/h)	P_{min} (MW)	P_{max} (MW)
G1	0.1524	38.539	756.79	10	125
	7	73	886		
G2	0.1058	46.159	451.32	10	150
	7	16	513		
G3	0.0280	40.396	1049.3	40	250
	3	55	2513		
G4	0.0354	38.305	1243.5	35	210
	6	53	311		
G5	0.0211	36.327	1658.5	130	325
	1	82	696		
G6	0.0179	38.270	1376.2	125	315
	9	41	7041		

Source: (Manteaw & Odero, 2012)

Table.2: Coefficients of emission of the 6 generating unit.

Unit	d_i	e_i	f_i
G1	0.00419	0.32767	13.85932
G2	0.00419	0.32767	13.85932

Source: Authors.

G3	0.00683	-0.54551	40.2669
G4	0.00683	-0.54551	40.2669
G5	0.00461	-0.51116	42.89553
G6	0.00461	-0.51116	42.89553

Source: (Manteaw & Odero, 2012)

Table.3: Loss coefficients ($\times 10^{-6}$).

2022	-286	-534	-565	-454	-103
-286	3243	16	-307	-422	-147
-535	16	2085	831	23	-270
-565	-307	831	1129	113	-295
-454	-422	23	113	460	-153
-103	-147	-270	-295	-153	898

Source: (Manteaw & Odero, 2012)

The results after running the simulation of the proposed ALO algorithm, are displayed in Tables 4. The simulation of the proposed ALO algorithm is tested in MATLAB R2016 to meet the demand of 900MW.

Table.4: Coefficients of emission of the 6 generating unit.

Generator	Power of each generator in Mw	Emission of each engine in Kg/h	Cost of each engine in \$/h
G1	125	8238.41182	7956.60886
G2	92.7026704	3382.26922	5640.22656
G3	86.4365762	4403.87432	4750.48463
G4	151.819543	23857.7694	7876.38287
G5	240.571054	64104.5546	11619.7208
G6	229.179195	55417.1514	11071.9428
Total	925.709039	159404.0308	48915.36652

Source: Authors

The graphics with pareto front of costs versus emissions and the using all generators is presented in fig. 4.

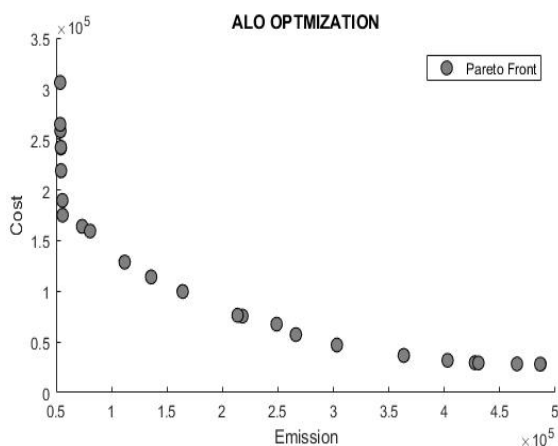


Fig.4: Pareto front of cost vs emission.

The graphics with power, emission and cost are presented in figure 5, 6 and 7 respectively.

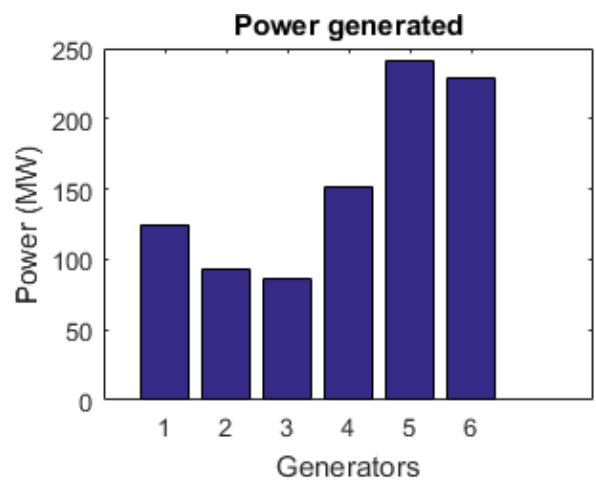


Fig.5: Power generated in each generator.

Source: Authors.

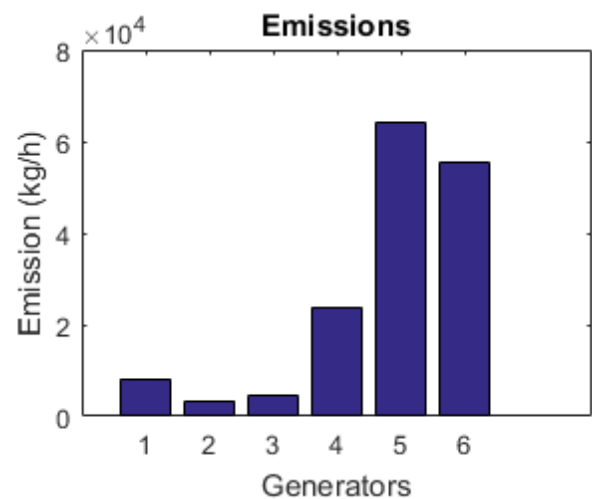


Fig.6: Emission in each generator.

Source: Authors.

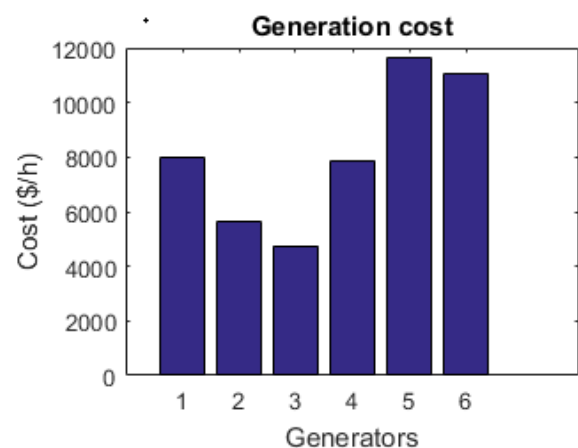


Fig.7: Cost of each generator.

Source: Authors.

IV. CONCLUSION

The ant lion optimizer is successfully applied to a 30 bus test system, to solve the EELD problem, so now it is possible to use these results to compare with other techniques that apply to this same IEEE bus test system. This application can also help workers to operate more efficiently the generators in a power plant.

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Teaching Sciences in Virtual Worlds with Mastery Learning: A Case of Study in Elementary School

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Abstract— *Virtual worlds are 3D environments that provide a feeling of immersion and a high degree of interaction, collaboration, communication between users. Its applicability can be focused on the educational scope, in which theories can be integrated as the basis to didactic activities carried out in the 3D environment, being its area of interdisciplinary comprehension. In this context, this article presents the use of a Virtual World built to assist in the teaching of Science for students of the middle school, whose articulation of the activities performed in the course are based on the precepts of the educational theory Mastery Learning. Tests were carried out in the subject of science, being divided into two periods with different groups for comparative purposes and realized evaluations during the period of the experiments. Kruskal-Wallis and Wilcoxon-Mann-Whitney non-parametric test were applied to the results of the assessments to ascertain the performance of each group. It was verified in the general analysis that the participants who used the Virtual World had a growing performance, with high medians and adequate distribution of the results, being predominant of a smaller variability and amplitude. Thus, was possible to conclude that the results obtained with the approach were positive, which led to the validation of this research and presented a clear contribution to the academic environment.*

Keywords— *Virtual Worlds; Mastery Learning; Science; Educational Theory; 3D environment.*

I. INTRODUCTION

Increasing technological evolution of tridimensional virtual environments (3D) and techniques for virtualization of real-life elements provided a significant advance in the use of these environments for leisure, education, and entertainment. Especially in the educational context, challenges are concentrated in the

creation of alternatives and adaptation of methods and environments already existent in the attempt to improve the teaching and learning processes.

The use of 3D has become increasingly widespread recently, with attention paid to their features, like the interaction with objects, simulations, use of educational resources, among others [1]. That resulted in the development of researches involving different fields of domain inside the educational area, as it can be seen in the works of Soliman & Guel [2], Troetst, Molina & Garita [3], Silva, Morgado and Cruz [4] and Sgobbi, Tarouco and Reategui [5].

Such environments have the objective to provide 3D spaces where the student can walk and live experiences in a highly interactive environment [6] [7]. This type of approach has many characteristics and advantages to be explored, some of them are listed by Kotsilieris and Dimopoulou [8]: synchronous operation in real time; representation of a real world; persistence of data; network of people and support to communication through chat channels; use of avatars to represent individuals; immersion sensation; interactivity with the use of objects that have scripts; and, support to the use of a varied range of multimedia features.

As recognized by researchers previously mentioned, virtual worlds can be seen as a stimulating pedagogical alternative to be used in an integrated mode to teach in classrooms or distance activities. Despite the highlighted potential advantage in the educational context, Gregory et al. [9] believes that there is some common sense that virtual worlds are in a construction process, and there is a lot yet to be done before teachers, students and managers fully adopt virtual worlds as a learning space. Is important to observe that exists some problems in this type of approach, since this type of environment has not been created to this kind of use (education) and a training is

necessary for the users, besides the requests that are imposed to computer resources: dynamic modeling of 3D CAD objects may be rather complex and demanding [10]. Despite some difficulties, Chang e Law [11] highlight that the creation of virtual laboratories and use of simulations with virtual worlds in the field of sciences, chemistry, and physics have special characteristics to be explored, such as visualization of microscopic phenomena with interactive simulations. Pellas [12] highlights that the interactive simulations supply a plausible illusion and allow that the users have an experience that reflects realistic situations using this type of environment.

Christensen, Maraunchak & Stefanelli [13] reinforce that in parallel to the use of computational resources available in this type of environment, the didactic planning of the activities to be defined by the teacher is also characterized as essential and must be carefully established and organized. The interaction in virtual worlds provides a motivation for students and generally attracts the interest and enthusiasm; however, it is necessary to notice that these environments cannot effectively substitute all the other existing approaches of learning [14].

Virtual worlds have been used in various paradigms as they provide fertile ground for the implementation of different learning styles, e.g. problem-based learning, exploratory learning and distance learning [15]. The didactic planning made by the teacher in a discipline, having as base a well-defined educational approach, can guide the objectives of the activities and assist the students to perform their tasks in a more adequate and consistent way in this type of environment.

Upon the huge research field to be explored with the use of educational theories and approaches, some initiatives have been applied in the scope of Virtual Worlds. Works as Devlin, Lally, Canavan & Magill [16] and Sajjanhar and Faulkner [17] correlate the concepts of the Experimental Learning of Kolb [18], aiming to show the four steps of the proposed cycle in the didactic activities realized in the Virtual World. In the work of Gamage, Tretiakov & Crump [19], concepts based in the Constructivism of Vygotsky [20] were related to the experiment carried out, while the research of Nunes, Herpich, Amaral, Voss, Zunguze, Medina, and Tarouco [21] correlated the theory of Meaningful Learning with the learning of algorithms. In the research of Sgobbi, Tarouco and Reategui [5] presented a proposal of use of intelligent agents in the Virtual Worlds to act as virtual tutors during the realization of educational activities, correlating the denominated study by 2 Sigma Problem of Bloom [22], where the individuals that have a support of a tutor in an individual way, obtained an improvement in the evaluation of two sigma's in relation to the control group.

In order to narrow the interconnection of Virtual Worlds with the application of educational approaches to conduct didactic activities, for the scope of this research, the educational theory Mastery Learning (ML) was selected. This educational theory is an idea intended to plan instruction sequences with the objective that all students can reach a level of reasonable performance in a determined content [23]. Students that show more difficulties to reach the percentage of necessary success to advance the units can receive reinforcement activities through tutorials, discussions and complementary materials. This way, the theory of Mastery Learning can be resumed as a learning model that puts emphasis in the characteristics of the students, tolerating the individual differences and having as a requirement that the students complete one unit before passing to the next unit [24].

Brito, Silva, Barbosa, Vasconcelos, Figueiredo, Soares, and Gaspar [25] explain that Mastery Learning becomes more accessible to implement through the use of Information and Communication Technologies (ICT), where, in a learning environment, students individualize this process and progress at their own pace. This makes possible the development of activities, the elaboration of tasks, with the permanent control of the teacher and self-regulation of the student.

The possibility of insertion of different types of learning materials (videos, slides and animations) and the formulation of evaluations during a course, makes the learning environments become exemplary tools, in what concerns the aggregation of Mastery Learning with the use of ICT. In this context, it is possible to adopt Virtual Worlds, by virtue of allowing the insertion of multimedia resources and the accomplishment of tasks in the distance format, according to the preference and availability of the student.

In this sense, the main purposes of this study were: (1) present a new methodological proposal that integrates the educational and technological bias and presents itself with originality in the academic environment, whose innovation is centered on the proposition of a teaching method that assists in the teaching of Sciences in elementary school with the use of Virtual Worlds as complementary activities and having all of their educational planning based on the educational theory of Mastery Learning, and, (2) identify the potential benefits and the difficulties in this approach in the performance of the associated students in the subject of Sciences.

The use of this theory in the research arises as an exciting challenge to be explored, because it is necessary to integrate its application to the didactic planning of a discipline, and, concurrently, to adopt the Virtual Worlds as a complementary environment during this process. Other aspects that motivated the development of this project is related to the diversity of resources and

beneficial potentials that the Virtual Worlds can proportionate to the users in the educational context. Characteristics as the facility of use, collaborative character and the attractive present in the 3D resources, that provide a sensation of immersion to the user, are responsible for the transformation of these environments in an interesting alternative in different areas [26].

The authors of this paper chose the field of sciences because it comprises a large number of contents that offers the opportunity of developing simulations to be presented to students. Chiu [27] explains that physical laboratory experiments in Science enable students to interact with observable scientific phenomena, but students often fail to make connections with underlying molecular-level behaviors. Virtual laboratory experiments and computer-based visualizations enable students to interact with unobservable scientific concepts [28].

The possibility of building laboratories in Virtual Worlds was configured as an alternative to be explored in the tests carried out, which reinforced the choice for the subject of Sciences. As previously emphasized, the conduction of the activities in the course and at the Virtual World created was guided by the precepts of Mastery Learning. Marteleira [23] points out that the use of environments of this type has, in terms of the operationalization of Mastery Learning, a great potential for the elaboration of interactive activities of remediation and enrichment, thus facilitating teachers to develop learning units following the principles of this theory.

II. VIRTUAL WORLDS IN EDUCATION

A Virtual Worlds can be defined as persistent online environments generated by a computer where people can interact, whether for work or leisure, in a comparative way to the real world [29]. Xenos et al. [30] consider Virtual Worlds as immersive three-dimensional interactive and graphical environments, which may be a replica of an existing physical place or an imaginary place, or even places that are impossible to visit in real life due to constraints such as high cost and/or security issues.

As an example of Virtual Worlds that have been used by different researches, are Active Worlds, Open Simulator, Second Life and Open Wonderland. Usually, users can navigate the entire environment scene, interact with objects (touch, save, push items, etc.), or talk to other Virtual World users [31].

The creation of Virtual Worlds aimed to education requires that many factors are considered, for example, pedagogical objectives and well-defined teaching strategies based in learning theories, friendly design and objects capable to encourage the interaction and collaboration between the users [21]. Such points must be analyzed in a detailed way, with the objective to

beneficially explore the existent potential in this kind of environment in the educational context.

It is important to highlight that genuinely this kind of environment was not developed for educational use, differently from other types of software as Moodle that is a learning virtual environment. However, the characteristics present in this environment, like immersion, collaboration, communication, and interaction can create possibilities so that the students in the moment of the realization of educational activities are more active and explore new opportunities of learning in the virtual world. Such conclusions are confirmed by Fernández-Gallego, Lama, Vidal & Mucientes [32], that understand that the students overpass an observation state and receipt of information to be more important in the learning process, in a more autonomous and active way.

A wide variety of teaching areas have been approached for the construction of didactic activities in Virtual Worlds, such as:

Algorithms and Programming Logics: in the analyzed works, the main focus is in the use of programming resources provided by the Virtual World with the use of scripts to teach students the basic concepts of logic and algorithms. The software Scratch and Scratch4OS are used as support tools since the students can construct codes using visual blocks and insert these in the 3D objects of the environment [12]. Educational theories, as the Significant Learning [33] and Mastery Learning [34], are used to substantiate the researches realized. The results were considered positive since the students have a vision in a real time of the function performed by the code in the object.

Mathematics: the studies presented in this scope approaches the Virtual Worlds in a different way, the objects referred in the environment are subject to the X, Y and Z positions. Such factor stimulates the exploration of research in the Geometry topics [35] and Calculation [36], due to the possibility to teach concepts referring to the tridimensional localization of objects, distance calculations and resolution of challenges involving these topics.

Health: the Virtual Worlds allow different types of movement to the users, like flying, running, walking, in addition to resources for communication (textual or through voice). Such resources can be explored in the context of health, mainly in topics as obesity of patients, whether infantile [37], as in the part of psychological treatments [38]. The use of videos and virtual agents to demonstrate practical exercises and instigate the participants to realize in the real world, as the communication between groups for the therapy of patients inside the Virtual World, were some of the used solutions in the highlighted researches, highlighting the results of

good performance of the participants and the positive feedback supplied to them.

Aviation: the training with Virtual Worlds are being explored in the academic area, mainly in the scope of aviation. Works as Pinheiro, Fernandes & Maia [39] that involve the construction of a virtual platform for the training of maintenance of hunts, and Lee, Park, Park, Kim & Oh [40], that approaches a more centralized scope in the mechanical part and of ammunition equipment, can be seen as pioneers in the use of Virtual Worlds with this purpose.

Foreign Language: can be considered a common practice in environments that provide the use of chats, the sharing of experiences and the practice of new foreign languages. With this in mind, the Virtual World has been explored as a complementary alternative for the teaching of this topic. Researches that involve the practice of the vocabulary [41], anxiety assistance by means of conversation in the environment [42] and practices involving the thematic of games to auxiliary in the language learning [43], are some of the explored alternatives in the academic area. The results are positive, where the practice with people from other places in the environment, it is an important experience and assists to aggregate new knowledge about the studied language.

In the scope of this article, the sciences area presents an instigator character to be explored by virtue of the types of contents present, for example, water cycle, atoms, physical and chemical phenomena, where many practical activities can be developed in a virtual way in this type of environment. The virtual worlds also open the possibility of multimedia resources insertion like texts, videos, slides, links, sounds, and quizzes to complement the educational activities that can be articulated [1]. Such resources can instigate the users to engage in a higher degree of interaction in the environment [44] and [1]. By providing learners with the freedom to choose the type of learning materials to explore, it makes learners create and design in the learning process, thus develop ownership on the process and environment of learning [45].

In addition to the multimedia resources, the Virtual Worlds allow, by means of 3D modeling of objects and programming resources, to create simulations of physical and chemical phenomena of a determined research area. These types of simulations do not consume natural and human resources to support experiences and, finally yet importantly, reduce risks of human or environmental accidents from eventual problems during experiences.

Despite these advantages discussed, it is important to highlight that the creation of a new Virtual World composed of multimedia and simulation resources needs a learning curve by the development team responsible. The Virtual World may need updating and therefore can be unreliable or in need of significant amounts of

maintenance, besides others reasons suggested for the disinterest as the lack of support to educators in terms of technical and pedagogical support or provision of additional time to develop virtual world lessons [46]. Insufficient bandwidth, data traffic, download and streaming during the user's interaction can be problematic, especially if several computers are sharing a network [46], [47], [48]. It is important to consider these problems when this kind of environment is adopted. The lack of support for access using mobile devices can also be considered as one of the main problems currently faced in the research developed with Virtual Worlds, as can be seen in the research of Herpich et. al [21]. Such support can already be considered as one of the main requirements to be explored in the future, in which only a more robust solution, known as Lumiya, is currently available to access a Virtual World.

Despite these disadvantages discussed, the benefits provided by Virtual Worlds have been shown as stimulating to continue the development of scenarios and simulations with educational character. Science, technology, engineering, and mathematics (STEM) classrooms are often environments where new technologies are implemented due to the nature of the content addressed [29]. In science classrooms specifically, the implementation of computer-based science teaching methods has been regarded as an important strategy because "it adapts to today's students who grew up in an increasingly digital world and are more accustomed to visual learning" [49]. In other words, an appropriated technological infrastructure with a well-structured instructional design method combined with learning theories or models can assist instructors to clarify the appropriate conditions on how students can learn in this type of environment.

III. MASTERY LEARNING AND THEIR INTEGRATION WITH VIRTUAL WORLDS

In 1968, Bloom proposed a model in his article "Learning for Mastery", where he believed that if the students received the opportunity to learn a proportional quality of instruction to the personal need, more than 90% of them could reach the aimed competence level [50]. Bloom defends the belief that all students at one class can reach an elevated level of performance in the academic activities and minimize the differences of learning among them.

There are alternatives that can be embraced to narrow these differences among the students that reach high and low percentages and assist the individuals that obtained an inferior performance of what is desired, through reinforcement activities that take in consideration the individual characteristics of each one [51] and [52]. John and Barchok [53] and Ozdemir and Erdemci [54]

understand that the motivational level of the student about the course is important in his / her learning, therefore, it becomes crucial that the topics addressed are clarified and assimilated by the students.

The schematic of the operation of the Mastery Learning can be seen in Figure 1 [55], where the contents are divided into small units ordered by a logic sequence with specific predetermined objectives, that are followed until being reached. Based on the illustration, it becomes possible to identify the basic principles that guide Mastery Learning [56]:

- Clearly define the objectives that represent the purposes of the course;
- Divide the curriculum into relatively small learning units, each with its own objectives and assessments;
- Identify learning materials and strategies: teaching, modeling, training, assessment, tutoring, and reinforcement should be included;
- Each unit is preceded by brief diagnostic tests (pre-test) or formative assessments;
- The results of the formative tests should be used to provide supplemental instruction or corrective activities to help the student overcome the problems.

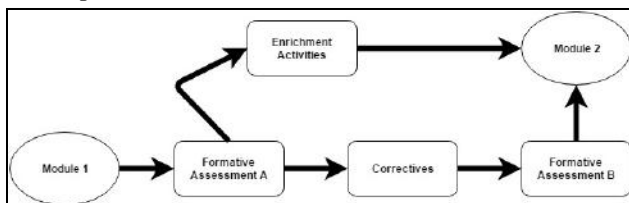


Fig.1: The process of Mastery Learning

Source: Zimmerman & Dibeneditto [55]

Tests in small questionnaires, written works, oral presentations, demonstrations of abilities and performances can be applied [57]. The objective of these evaluations is to measure if the student has the necessary knowledge so that he/she can advance to the next module or reinforcement activities that must be applied. Also, for Guskey [58], the use of these procedures (brief questionnaires, oral presentations, written papers, for example) allows for the systematic monitoring of students' progress and leads to feedback, as it assesses the extent to which the most important objectives of the unit are being achieved by students and clarifies what they need to improve.

The students that do not reach the domain level stipulated by the teacher must receive an immediate feedback with the application of reinforcement activities (complimentary classes or group works) and do a new evaluation to measure the level of evolution, while the others that already have a knowledge over the required can be fitted in enrichment activities [50]. If reinforcement is

successful in helping students remediating their learning difficulties, then almost all the students will demonstrate readiness to take the remedial examination [59].

The learning materials used in the classes can be presented in different formats, whether by readings, demonstrations/simulations, discussions, videos or any approach that the teacher understands to be the most appropriated [60]. This diversity of material types to be used by the teacher can be integrated to the present approach in the Virtual Worlds, where the use of videos, slides, texts, and simulations can be explored in the didactic activities performed by the students in the environment for the learning of sciences. From the point of view defended by Purbohadi, Nugroho, Santosa & Kumara [61], this theory can be easily introduced both in the present format and in the distance format, if the technological support is appropriated.

Mastery learning is relevant to competency-based education, given the shared emphasis on defined objectives rather than defined learning time or number of procedures [62]. It is in this context that the research developed in this article is fitted, where the possibility to make an integration of the realized activities is opened in the classroom, with the use of a 3D virtual environment to make the reinforcement works or specialization in the distance modality, as the diversification of multimedia resources proportionate in the Virtual Worlds. Although this proposal has potential to be explored, it is important to highlight some problems acknowledged in the academic area towards the use of the educational theory of the Mastery Learning.

Some main criticized points are the high level of performance for the approval (90%) originally stipulated by the theory and the cost of time that this approach involves to be applied, where Arlin and Webster [63] explain that many critics treat as inconvenient the additional time that needs to be supplied to the students that have the most difficulties to learn, due to the schedule grid and formulation of additional activities and materials. Bloom [50] defend these critics clarifying that the necessary additional time for the students with bigger difficulties is not permanent, seen that this learning will be better concretized in this initial step and in the posterior contents, their difficulties will be naturally minimized.

According to Šimić, Gasevic, and Devedzic [64], Virtual Learning Environments play an important role in the development of distance activities, which can be used to manage and monitor learning activities outside the classroom, as well as to record students' learning activities and progressions. This finding is fundamental for the application of a course, which is based on the precepts established by Mastery Learning. Nowadays,

Mastery Learning is used on large scale in dynamic, adaptive educational systems [65] [66].

In the scope of this article, where the integration among realized activities in the classroom with complementary reinforcements realized in the virtual world follow the precepts of the Mastery Learning, some adaptations had to be made to avoid the problems previously mentioned. The adaptations realized and the conduction form embraced by this project are presented in section 2.

IV. RELATED STUDIES

The analysis of the literature made for the development of this section aimed to evidence some important points related to the use of Virtual Worlds in areas of general sciences, as physics, chemistry, and biology. In compliance with this analysis, some main educational approaches and analysis involving motivational and usability aspects that were executed in some of the works found in the literature were also highlighted.

One of the main identified points is related to the intense use of 3D simulations in virtual worlds, which objective is to show phenomena of the real life in an accurate and detailed way. Due to the fact that the scope of this article is centralized in the area of sciences, some comparisons with other related areas, as physics and chemistry, are possible to be done, where both also have a great number of possible phenomena to be referenced in a virtual way in this kind of environment. Topics related to acceleration, free fall, capacitors, polarity, and electromagnetism, which representation and visualization by means of simulations become one of the main stimulations for the students in the Virtual World, were approached in the work done by Peachey, Withnail & Braithwaite [67]. The results of these works are instigative, seen that the topics are mainly visual and interactive, in which the Virtual World is a positive alternative to complement the processes of teaching and learning.

In the scope of these works, the realization of the executed didactic activities involving the physical area was rooted in different theories and educational practices, with the theory of cognitive load and constructivism concepts. The visualization and interaction with the simulations in the Virtual World can have a great number of visual elements to be processed by the students, what, according to Sweller [68] can produce a abnormal cognitive load if the instruction material is presented in a complex way, inconsistent or with a big quantity of visual grouped elements.

Chemistry is also related to the scope of this article, where was identified in this area a tendency to the use of simulations and multimedia resources as slides, texts and videos [69], as well as the use of Gamification techniques in the learning of these topics is represented in the work

of Shudayfat, Moldoveanu, Moldoveanu, Gradinaru and Dascalu [70]. Aspects related to the motivation of the students in using the Virtual World to teach chemistry, the usability of the environment and its potential for the learning process are the main approached points in the analyzed works. As it was verified in Physics, by being of a more interactive and visual area, where phenomena in micro and macro scales can be represented, this type of approach is being effective in the learning process of the students.

With the areas mentioned before, it is essential to highlight the relevant works in the study area realized in this research. The research did by Kennedy-Clark [71] presents a perspective on the usage of Virtual Worlds by teachers in training in the Sciences area. 28 participants were selected for the research, a questionnaire is answered at the end of the experiment about the interaction in the Virtual World that was aimed to teach Sciences. The results showed that the teachers were able to see the benefits related to the visualization form and interaction with the 3D objectives, as the motivational aspect in using the environment, being aware of the difficulties existent in implementing an environment of this size.

In the work developed by Rutten et al. [72] has as main focus the investigation of the impact of the use of simulations in teaching Sciences, a systematic review being realized in the literature of this scope of research. 51 publications were selected, where the results of the analysis showed the viability of the use of simulations in Sciences to complement the learning method considered traditional, emphasizing that this type of resource supports the improvement of a comprehension of the experiment seen in the real laboratories.

Jacobson, Taylor, and Richards [73] present a research that approaches the use of Virtual Worlds aimed to teach Sciences, having as a characteristic the realization of works with a more playful character. Two groups of the eighth grade, in one period of two weeks, used the proposed environment. As results, it was possible to see significant gains in the evaluations made and positive progress in the learning of the students is considered an environment apt for the use in this teaching area.

In relation to Mastery Learning, hundreds of works that use this theory in the last 60 years can be found. Leonard, Hollot, and Gerace [74] identified at least five large-scale surveys that were conducted by different researchers in this period, and four of them concluded that most of the studies analyzed had positive effects in schools, while the fifth presented positive and negative views on the use of this approach.

The area of physics is also used with Mastery Learning, in which the studies analyzed involved the use of Virtual Learning Environments, both in the distance modality,

addressed in the work of Gladding, Gutmann, Schroeder, and Stelzer [75], and in face-to-face, seen in the works of Wongwatkit and Hwang [76] and Wongwatkit, Panjaburee and Srisawasdi [77]. The focus was on monitoring students' progress and performance in a more active way, seeking to understand the conceptual problems of learning, their preferences for learning styles and to propose teaching and reinforcement activities that could aid in the learning process. The experimental results showed that the students had evidence of improvement in their attitude of learning, better understanding and greater perception in the resolution of the activities proposed for the area of Physics.

As for the area of this research, there are several works to be explored. Özden [78] highlights the possibility of using technology to assist in the teaching of science in the fundamental series. In addition, the integration of Mastery Learning to this type of approach is also emphasized, and the proposal of the article is centered on explaining this integration, its benefits, and disadvantages. Thus, the author highlights the need for the teacher to be aware of the way of applying this theory using a Virtual Learning Environment focused on teaching science, how the processes should be carefully conducted, providing the appropriate didactic materials, individualized instruction or in groups, besides the application of formative evaluations.

Agboghorom's research [79] sought to investigate the effects of the application of Mastery Learning in Science teaching, establishing an experiment of the Near-Experimental type, with pre-test and post-test. A control and experimental group were defined, totaling 120 elementary students in a science course, whose topic was Metabolism of the human body. The experiment group received instructions and activities based on Mastery Learning, while the control group continued to learn based on the traditional method of teaching. The experiment demonstrated that the use of Mastery Learning helped students to improve their evaluation performance, and it is recommended to use this approach to teaching science.

The assertions discussed in the detailed works, reinforce the importance of the multimedia and technological resources exploration that allow the representation of contents and simulations in the Sciences area, inside the Virtual Worlds. Allied to this, is the use of educational approaches and theories to articulate activities in the environment, in which this analysis consisted in an important know-how for the development of this work.

Based on what was mentioned before, it is possible to see that the proposal of using Virtual Worlds, more specifically OpenSim, has the potential to remit an aperture of the application possibilities in the Sciences area. The identification of the use of Virtual Worlds with

an educational base guiding the activities carried out helped to reinforce the need for this type of planning for the use of environments of this size, which was considered as an extra motivation for the adoption of Mastery Learning as a strategy to be followed during this work. The main difference identified in this work is centered on the proposition of an approach based on the educational theory Mastery Learning, which consists of an approach widely diffused in the academic environment and with a character of interdisciplinary application. Attached to this proposal, is the insertion of technological resources, which can be considered as an emerging practice, which has been revalorizing the Mastery Learning in the midst of academic research.

In this context, the technological resource adopted was the Virtual Worlds, which consist of a solution widely diffused in the academic environment and of an interdisciplinary nature. It is important to emphasize that, for the most part, the papers analyzed do not aim to propose a clear and definite method but to carry out researches using Virtual Worlds based on some educational theory, in order to ascertain their impact on learning, however, without defining a new approach.

Therefore, it was possible to plan the development of a virtual laboratory composed by multimedia and simulation resources that present many contents of sciences in the Virtual World, which identified works were in a differentiated scope of this project. The use of the Mastery Learning theory to organize the didactic activities with the students in the virtual world can be seen as an important differential in this research in relation to the other analyzed works, highlighting the conduction form of the activities, articulated as a permanent reinforcement during the subject.

V. METHODS

The research question of this study was the following: Does the introduction of an approach to assist in Science teaching with the application of activities in Virtual Worlds and the planning of activities guided by the precepts of Mastery Learning can improve student's learning? In order to answer this research question, several tests were carried out with participants in the subject of Science with the use of a developed Virtual World and activities with Mastery Learning theory. This research and the results obtained are described in the following sections.

The planning used for the development of this project was based in the case study, that had the objective to implement an approach with the use of the virtual worlds and the articulation of the didactic activities based in the Mastery Learning theory, changing the traditional method that was being applied with the participants of this project. The case study investigated contemporaneous

phenomena inside the context of real life, in situations where the frontiers among the phenomenon and context are not clearly established, where many sources of evidence are used [80]. Added to this, an analysis was realized about the quantitative type, based in the measure (generally numerical) of few objective variables, in the emphasis of comparison of the results and in the intensive use of technical statistics [81]. The results obtained are coming from the evaluations did by the participants during the experiment periods, where the analyzes of the performance of the students required the application of statistical techniques that can prove the significance of the results.

The theoretic research and the analysis of the related works provide the creation of a base of initial knowledge for the construction of this research. The necessary technological infrastructure to implement the virtual world was selected based on the experiments realized by the authors of the work. The platform selected to develop and implement the 3D virtual world was OpenSim. The virtual world was hosted on the WAMP web server. The viewer used to visualize the virtual world by the students was Singularity. Established the necessary technological infrastructure, the experiment was delineated following the molds of the educational theory of the integrated Mastery Learning, some necessary adaptations being made to adequate the context where the tests were made. The research described in this article covers 2 periods of testing with different groups of users in each of these periods. The procedures of the study were strictly the same for the 2 periods, followed by a protocol of execution of activities exactly the same for the two stages of testing, only changing the groups of participants in each. In this way, the study procedures described in this section occurred in exactly the same way for both test periods. The first phase of the experiment occurred in 2016 during all the trimester that had a total duration of 4 months, while the second phase of the experiment occurred in 2017 also during all the trimester with a total duration of 4 months. The procedures described below are exactly the same for the two test periods that were performed.

Firstly, the objectives of the subject were previously clarified to the students so that they could know the contents that were about to be taught. The content of the subject was divided into 3 units, following the established precepts of the Mastery Learning:

1. Constitution of the subject - atoms and molecules
2. Physical and chemical phenomena and Energy sources;
3. Ground and health: Pollution and diseases;

The theory of Mastery Learning defends that the initial and intermediary evaluations for each subject are made for each unit of the subject, as complementary activities

are made to reinforce the students that had a performance over the required or to improve the knowledge of the students that obtained the required grade, a new step being made of evaluations to analyze the performance of the students.

As mentioned before in section 1.2, this procedure requires an elevated workload for the teacher in the creation of materials and activities, in addition, to expend a significant quantity of time so that all process is executed, as it was originally defined by theory. Based on this problem the adaptations were made in the application form of this approach with the objective to make it less instructional.

This way, the students had a weekly class with the duration of 40 minutes in the morning period, where the content was exposed in the oral form by the teacher, using the blackboard to present slides. The complementary activities were stipulated in the distance modality during all the semester and not only after the realization of the tests, being that the students should realize the virtual world and the Moodle to perform the activities required by the teacher to complement the knowledge acquired in the classroom. This adaptation had the objective to realize the attempt to diminish the elevated time load originally required by the original process of the application of the theory Mastery Learning, in addition to supplying constant reinforcement activities and not only after the realization of the tests.

The virtual world used by the students was composed by a virtual laboratory divided in five different types of rooms: videos, texts, slides, questions, and simulations. The room of texts and slides had theoretical contents related to the units of the subject.

The questions room allowed the students to answer questions of multiple choices in a panel that was shown on the screen, where the feedback was immediately given. About the video room, they were directly taken from YouTube and had explanations about the contents.

The simulation room had many 3D animated representations and experiments related to the contents approached in the subject, being 34 simulations constructed in the Virtual World for the students to interact. Figure 2 presents the representation of molecules and atoms in the environment, while Figure 3 shows some cases of energy and pollution sources.

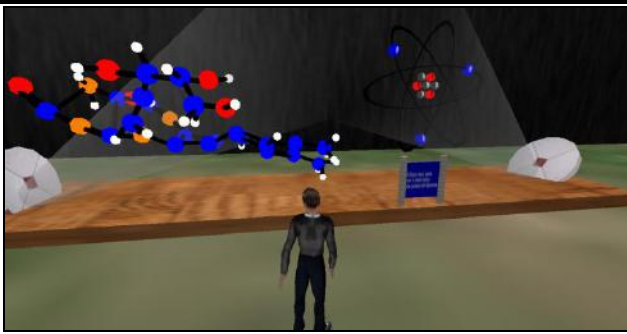


Fig.2: Simulations of atoms and molecules



Fig.3: Simulations on Energy Sources and Pollution

The place where the experiment occurred did not have an informatics laboratory, because of this, the complementary activities had to be carried out by the students distance-based, with the support of their families. It is important to highlight that for the students that used the Virtual World, an exposing class happened at the beginning of the experiment in each phase, where the basic commands of the movement were presented and the process necessary to install and the configuration of the viewer were also explained. Furthermore, tutorials in the format of texts and videos were released to the students to facilitate the access to the Virtual World in their homes. As explained in the previous section, the tests were performed in two different periods with different groups of users, but following exactly the same procedures. The description was made in the way as the experiment was conducted, as the laboratory created in the Virtual World, the next section presents details referring to the participants of this research.

a. FIRST PERIOD OF TESTS

Details about the first period of tests involving the participants, data collection instruments and the procedure adopted for the analysis of the results are described below.

Participants

3 classes of the sixth grade of the elementary school enrolled in a subject of Sciences were selected to participate in the experiment. Each class had 25 students, total of 75 students.

Among the 75 students of this sample, 38 (50.66%) were girls and 37 (49.34%) were boys, which age range was

between 15 and 11 years. The students were divided into 3 different groups, including the three classes. The groups were arranged as follows:

- Group 1: 13 students chose to only participate in face-to-face classes, they didn't access Moodle or the Virtual World;
- Group 2: 49 students chose to participate in face-to-face classes and to carry out complementary activities in distance way using the Moodle environment;
- Group 3: 13 students chose to participate in face-to-face classes and carry out complementary activities in distance way using the Virtual World;

It is important to highlight that no student of group 3 had previously interacted with a platform of Virtual Worlds. However, in relation to the Moodle environment, all had used it in the previous year on other subjects. Because the school does not have an informatics laboratory and the access to the Virtual World was done distance based by the students, the number of participant in this group considerably decreased in relation to the size of the available sample. The positive point to be highlighted is that the 13 students of this group used the virtual world during all the semester and interacted with all resources and simulations available in the environment.

Instrument of research

Students of the first period of testing did 5 types of evaluations, applied in printed format in the classroom by the teacher of the subject. The first evaluation was a pre-test applied on the first day of class of each period, about all the contents of the 3 units defined in the subject, having 8 questions of multiple choice. It is important to clarify that all students had not had previous classes about the contents of this experiment.

The content of the subject was divided into 3 units, where at the end of each one was applied an intermediate test composed of questions of multiple choice about the contents of that specific unit. In the end, a post-test including all content of the subject was applied having 21 mixed questions among multiple and written choices, being different from the pre-test applied at the beginning of the trimester of each period. Interviews were conducted with participants to evaluate the approach implemented and identify the strengths, weakness, and modifications needed.

Data Analyzis

The tabulation of the results obtained with the five evaluations applied in the three groups needed a statistical analyzis, which objective was to compare the groups and to analyze the existence of significant results referring to the application of this proposal. For this, it was necessary to formulate the hypothesis, which in the scope of this

article, the non-parametric approach was selected with the test of Kruskal-Wallis, being possible to compare three population.

Furthermore, the test Kruskal-Wallis was used to test the null hypothesis that all populations have equal functions of distribution against the alternative hypothesis that at least two of the populations have different distribution functions. For that, two hypotheses were created:

- H0: the groups have the same distribution of values in the grades.
- H1: The groups do not have the same distribution of values in the grades.

In this way, the final goal was to compare the hypotheses to verify whether there were significant differences in the averages of the 3 groups belonging to this experiment, noting that the group that used the Virtual World got a performance which was significant in relation to the others. To complement the statistical analysis performed and provide a clearer view of the opinion of the students, interviews were conducted with participants to evaluate the approach implemented.

b. SECOND PERIOD OF TESTS

Details about the second period of tests involving the participants, data collection instruments and the procedure adopted for the analysis of the results are described below.

Participants

Although the implementation protocol was the same as in the first period, the participants were different, being 3 new classes of the sixth year in the same subject, a total of 74 students, divided into 2 different groups:

- Group 2: 46 students who chose to attend the classes and carry out complementary activities distance based, using the Moodle environment;
- Group 3: 28 students who chose to attend the classes and carry out complementary activities distance based, using the Virtual World;

The names of the groups were kept equal to the previous phase to avoid distortion in the reading of the analyzes. In this phase of experimentation, no student chose not to use any of the available environments, in this way, a third group did not need to be created. The 28 students who were using the Virtual World in this phase had an introductory class to the environment, for familiarization with the way of interaction and how to perform the necessary procedures so that they could access the environment distance based. It is important to highlight that the participants also used the environment freely and on their own will and motivation, using it constantly and carrying out the proposed activities.

Instrument of research

Students of the second period of testing also did 5 types of evaluations, applied in printed format in the classroom by the teacher of the subject. The tests were exactly the

same as those applied in the first test period, without any changes. Interviews were conducted with participants aimed to present pertinent information about the resources that were used in the environment if the proposal was approved by the students and other relevant factors, as possible difficulties and benefits identified by the participants.

Data Analyzis

The procedures adopted for this second test period are exactly the same as those described and applied in the first phase of experimentation, except for the type of applied statistical technique. Thus, the non-parametric hypothesis test selected for this phase was the Wilcoxon-Mann-Whitney test, being used in this case because there were two samples (Group 2 and Group 3). This test verifies whether the two groups come from the same population, that is, test whether the two independent groups are homogeneous and have the same distribution [82]. Also, two hypotheses were created as in the first test period. In order to complement the statistical analysis carried out and provide a clearer view of the opinion of the students, interviews were conducted with participants.

VI. RESULTS

For the analysis of the results in each period, statistical non-parametric methods were used, considering that the data are not continuous, non-normal and small sample size. The non-parametric Kruskal-Wallis test was selected in the first period to compare more than two samples (K samples), while Wilcoxon-Mann-Whitney test was used in the second period to compare two samples, considering that the data generated during the research were ordinals. A critical level of significance of 5% was considered ($\alpha = 0.05$) for both period of tests, whenever the p-value is less than 0.05 ($p < 0.05$), the result is considered statistically significant. Results of each test period are presented in the following subsections.

Results of the First Period

The first test was carried out in order to identify if the three classes had homogeneous performances in the assessments performed, ascertaining whether it was necessary to perform separate analyzes for classes. 5 evaluations were realized in total, and they were the pre-test, an assessment for each of the three modules and the post-test. Table 1 presents the results obtained with the analysis of Kruskal-Wallis.

As it can be seen in Table 1, all p-values are above 0.05, this way we can assume that all classes were homogeneous in terms of their performances in assessments. This allows the analysis to be performed jointly with the students of the three classes, separating only participants in the three groups previously described. From this observation, a comparison of the medians of the evaluations of the students was made in relation to the

three groups created to check if there was a statistically significant difference between the groups if the p-value has a value less than Alpha. Table 2 presents the results of analyzes performed with the Kruskal-Wallis test.

Table.1: Comparison of the results of the three classes

Class	Pre-test	Eval 1	Eval 2	Eval 3	Post-test
601	36.64	34.84	36.38	31.00	36.68
602	37.78	37.52	38.54	39.84	38.36
603	39.58	41.64	39.08	43.16	38.96
p-value	0.8881	0.5350	0.89631	0.11996	0.92856
	63	1	6	4	5

Table.2: Comparison of the medians in the three groups

Platform	Pre-test	Eval 1	Eval 2	Eval 3	Post-test
1	29.42	27.88	25.81	33.00	26.08
2	38.04	38.50	39.71	39.15	38.46
3	46.42	46.23	43.73	38.65	48.19
p-value	0.132	0.093	0.068	0.654	0.033

As seen in Table 2, the pre-test and the three intermediary assessments conducted showed no significant differences, which can be regarded as an expected result, since the pre-test students had not yet studied the content covered in the evidence and intermediary tests, the contents were smaller and more specific, which ultimately resulted in this balance of grades. It is important to see that this type of monitoring of the group of students can be considered positive; in virtue of the Mastery Learning theory adopts the application of initial and intermediary evaluations for each module.

It was evidenced by the statistical analysis that at least two groups differed from the medians of the scores in the post-test evaluation since the p-value (0.033) was less than 0.05. In the other ratings, there was a statistical significance, which means that there is no difference in the population or if there is, was not possible to see it, due to sample size. Figure 4 represents the Pairwise Comparisons of the groups.

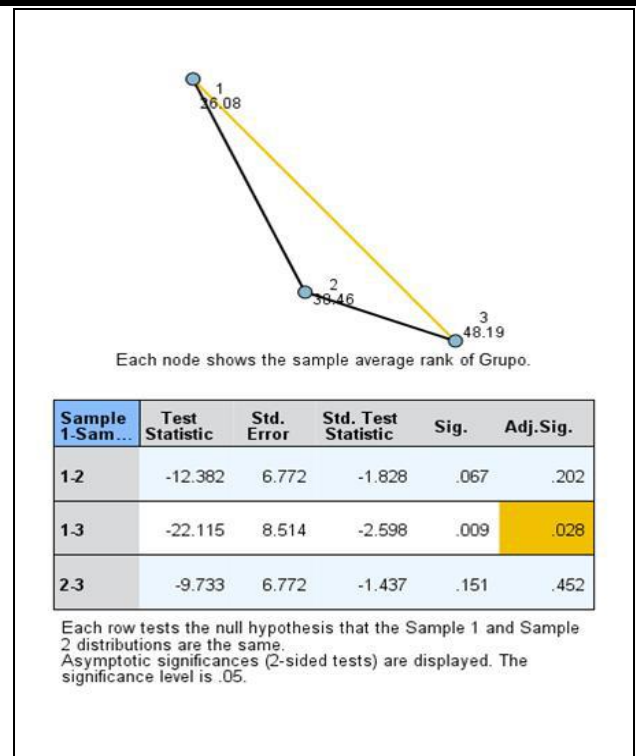


Fig.4: Pairwise Comparisons of Groups

To compare the medians of the groups regarding the assessment of the post-test, there was a difference only between groups 1 and 3. In this way, the statistical analysis found that the participants who used the virtual world (Group 3) were significantly better than the participants who did not use any type of environment (Group 1). In the comparison made between group 1 and group 2 (participants who have used Moodle) the statistically significant difference was not observed. The use of Moodle environment for supplementary studies was an approach already adopted previously by the teacher of the subject, and this factor can be one of the reasons for not having a significant difference between the group using Moodle and the students who have chosen to only study during the period in person in the classroom and at home with their grades. The observation of a significant difference in the post-test between Group 1 and Group 3 can be considered positive, being justified by the use of the virtual world as a complementary activity, with characteristics such as interactivity and visualization of 3D animated objects can be considered as final in the learning process of these students. For a better visualization and comparison of the scores obtained with the post-test, Figure 5 represents the results of the analysis performed by means of Box Plots.

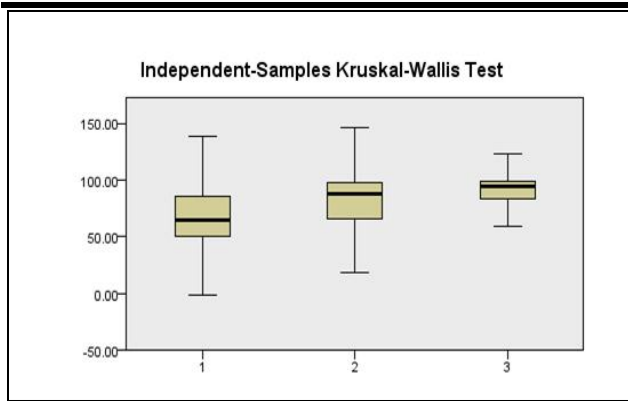


Fig.5: Box Plots of the Kruskal-Wallis Test

Regarding the comparison of Group 2 and Group 3, the analysis showed that it was possible to observe a significant difference between the grades of the post-test, as one of the plausible causes from a statistical point of view is due to the low number of participants who used the virtual world, a factor that makes it difficult to understand with greater accuracy, the significant changes in the analysis. Although this result was found, in the analysis of medians it was possible to see that although not significant, the grades obtained by Group 3 were equivalent to the grades of Group 2 at the post-test. This allows us to infer, based on the medians of groups and statistical analysis performed, that despite the non-significant evidence of improvement in results, the Group 3 that used the virtual world can be considered equivalent to Group 2 who used the Moodle.

Results of the Second Period

As in the first test period, it was necessary to check if these three new classes had homogeneous performances in the evaluations carried out, checking if it was necessary to perform analyzes separated by classes. Table 3 presents the results obtained in the analysis, in which we have the three classes that participated in the experiment and the five evaluations carried out.

Table.3: Comparison of the results of the three classes

Class	Pre-test	Eval 1	Eval 2	Eval 3	Post-test
601	60.00	84.00	90.00	100.00	83.00
602	50.00	88.00	87.50	87.50	83.00
603	60.00	92.00	90.00	85.00	83.00
P-value	0.085	0.658	0.55	0.108	0.745

The p-value obtained for each of the evaluations performed by the classes is above the established level of significance of 0.05, in this way, it is possible to assume that all the classes were homogeneous regarding their performance in the evaluations. This allows the analysis to be done jointly with the students of the three groups,

separating only the participants in the two groups previously described.

A comparison of the medians of the student's evaluations regarding the two groups was carried out to verify if there was a statistically significant difference between the groups if the p-value presented a value lower than 0.05. Table 4 presents the results of the analysis carried out, in which Group 2 concentrates the students who used Moodle and Group 3 has the students who used the Virtual World. The pre-test performed did not show significant differences, so the null hypothesis for this case was maintained. In this evaluation, the median of Group 3 (60.00) had a higher value in relation to Group 2 (50.00).

Table.5: Comparison of the medians in the two groups

Platform	Pre-test	Eval 1	Eval 2	Eval 3	Post-test
2	50.00	84.00	85.00	90.00	83.00
3	60.00	94.00	90.00	90.00	84.50
p-value	0.265	0.044	0.297	0.347	0.309

In the first intermediate test, it was possible to verify significant differences in the observed medians, thus rejecting the null hypothesis in this case. The median of Group 3 (94.00) was higher than the Group 2 median (84.00). In addition to this observation, the concentration of the scores in Group 3 is better distributed, as well as a smaller amplitude, which reinforces the lower variability of the data, to the point of becoming significant when compared with the results of Group 2.

Regarding the second intermediate test, the median value of Group 3 was 90.00, which was higher than the median of Group 2 (85.00), but no significant difference was found. Despite this, the distribution of the grades is similarly concentrated in both groups, as well as their amplitude, which indicates that both had similar variations. Therefore, the advantage in Group 3 is not significant, being centered on the superiority of the median value, which slightly leads to a better performance of the participants in this group.

Box Plot of the third intermediate evaluation showed the equality of the medians of the two groups (90.00), with no significant difference. However, the differential is centered on the distribution more concentrated in Group 3, as well as in the lower amplitude, which results in a lower variability and shows that the scores were more constant in this median range.

Finally, the post-test performed in this third phase presented a slightly higher median of Group 3 (84.50), compared to Group 2 (83), as seen in Figure 8. As well, the distribution of the data is better concentrated in the group that used the Virtual World, presenting smaller amplitude and consequently a smaller variance of the grades, in relation to the group that used the Moodle

environment. This implies in observing a performance improvement of Group 3 in relation to Group 2, noting that this observation did not present significant differences in the post-test.

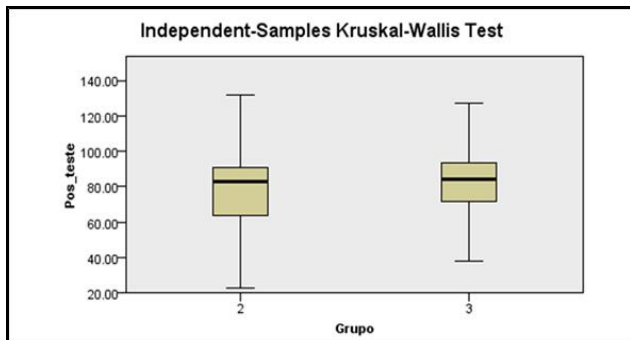


Fig.6: Box Plots of the Kruskal-Wallis Post-Test

In this way, analysis of this second period of tests reinforced the previously presented scenario, in which it was possible to infer an equal or better performance of the group that used the Virtual World in relation to the group that used Moodle, although not in a significant way. In this phase, the performance in the intermediate tests was superior for the participants who were interacting with the Virtual World, being in the first evaluation verified a superiority in a significant way, just as the post-test presented signs of equality or superiority for this group. Distributions of the grades were shown to be better concentrated in the Virtual World group, as well as smaller amplitudes and less variability in the intermediate and post-test evaluations. In this way, it was again possible to verify results of the application of the method that could be considered positive and satisfactory, highlighting the potential to be explored as a complementary alternative in the teaching and learning process.

Interconnection of the Results

The analysis of the results in the two periods of the experimentation process was completed, and the statistical analyzes performed were described. It is important to see that the groups in the two periods were formed naturally, based on the personal choices of each student in relation to the type of environment that would use or none of them. The grades had high and low variations in all groups in both phases, and varied performances were verified, which can be considered positive since there was no predominance of a group with students with better grades or who only had students with greater difficulties of learning. Therefore, in order to finalize the process of analysis of the results from this study, it was necessary to make a comparative evaluation from the evaluation point of view, between the results obtained in the two test periods.

The non-parametric Kruskal-Wallis test was applied in order to determine if the comparison of the performance

of the groups presented significant differences in the medians analyzed in each of the five evaluations. Group 1 was formed only by participants in the first test period who did not use any environment. Group 2 was formed by participants who used Moodle in both periods, as well as Group 3 that was formed by participants who used the Virtual World in both phases. The objective was to ascertain the overall performance of the groups and provide an overview of the evaluation of the approach performed, considering participants from different years, but who were being tested under the same conditions, with the exception of Group 1 that was only in 2016.

Table 5 presents the results of the analysis performed, in which the medians of groups 2 and 3 cover the values of the two test periods, while the median of Group 1 only addresses the first period. As observed in previous analyzes, Group 3 that used the Virtual World obtained higher scores in the medians in this analysis.

Table.5: Comparison of the medians in the groups

Platform	Pre-test	Eval 1	Eval 2	Eval 3	Post-test
1	40.00	64.00	70.00	75.00	65.00
2	50.00	84.00	85.00	85.00	83.00
3	60.00	92.00	90.00	90.00	88.00
p-value	0.041	0.007	0.027	0.101	0.059

In this case, there was a significant difference in performance between Group 3 and Group 1, which did not use any platform. Participants in Group 1 were not willing to interact with any environment and obtained inferior performances from the pre-test to the post-test, which could indicate even a lack of commitment of these in the contents covered in the discipline, besides the lack of support provided by the resources present in both environments at the time of the study.

In the case of the first intermediate evaluation, in both periods of tests, the medians of Group 3 were superior to the other groups, being significant the difference in the second period. In this analysis, it becomes possible to identify that there was a significant difference (p-value of 0.041 less than 0.05), which refers to rejection of the null hypothesis and presents a superior performance of Group 3 in relation to Group 1. In the comparison between the groups by the Box Plot, it is possible to visualize that Group 3 presents a more concentrated distribution of the grades with smaller amplitude and higher median, which leads to a lower variability. This allows inferring that the performance of Group 3 showed signs of superiority in all analyzes when compared to Group 1 and was equally or better in this evaluation when compared to Group 2.

In the second evaluation, the medians of Group 3 were superior to the other groups in the two periods analyzed previously, but there was no significant difference. In this

analysis, it was possible to identify that there was a significant difference (p-value of 0.007 less than 0.05), which refers to the rejection of the null hypothesis and presents a superior performance of Group 3 in relation to Group 1. In the comparison between the groups by the Box Plot, as previously occurred in these two phases, again it was possible to identify that Group 3 presents a more concentrated distribution of the grades, with smaller amplitude and higher median, which leads to a lower variability. As in the first evaluation, this analysis allows to infer that the performance of Group 3 showed signs of superiority in all analyzes when compared to Group 1, and was equally well or better in this evaluation when compared to Group 2.

In the third evaluation, the medians of Group 3 were equal to the medians of Group 2 in both periods, while the medians in Group 3 were higher in the first period when compared to the medians in Group 1. In this analysis, the lack of significant difference was identified, which maintain the null hypothesis, but the median of Group 3 was superior to the others. In the comparison between the groups by Box Plot, it was possible to observe that Group 3 when compared to Group 1, presents a more concentrated distribution of the grades with a smaller amplitude, which leads to a lower variability. In the comparison between groups 2 and 3, it was possible to observe a similarity in the distribution of grades and amplitude, in spite of the fact that the median was higher in Group 3 in this analysis, it shows the performance equalization of these two groups in this evaluation in both periods of tests.

Finally, the analysis of the post-test in the first period returned to a superiority of the Group 3 median in relation to the others, being significant the difference when compared to Group 1. In the case of the second test period, there was no significant difference, but Group 3 had a median higher than Group 2. In this analysis performed between the two phases, as seen in Figure 9, it is possible to verify in the Box Plot that the Group 3 median was higher than the other medians, with p-value 0.059, close to 0.05, which would result in a significant difference in relation to Group 1.

It was also possible to verify that the concentration of the grades is better distributed in Group 3, with a smaller amplitude, which results in a lower variability of the grades. This refers to a superior performance of Group 3 when compared to Group 1, as well as results in an equal or superior performance of this group in relation to Group 2, in the two phases.

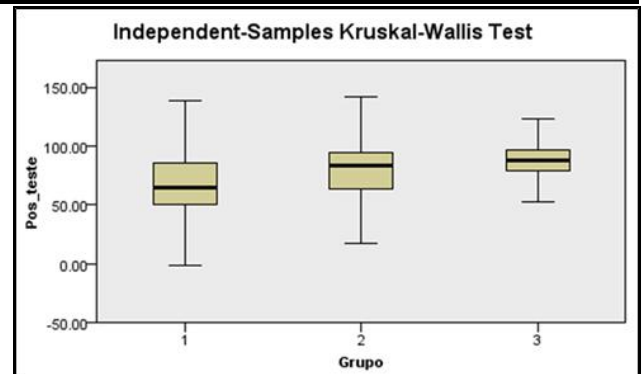


Fig.7: Box Plot of the comparison between groups in the third intermediate evaluation

This analysis reinforced the tendency observed in the interpretation of the results, in which it was verified that the performance of the group that used the Virtual World, in relation to the group that did not use any environment, was always superior, being of significant form or not. The medians, the way of distribution of the grades, amplitude and variability in the evaluations were better in Group 3 than in Group 1, which clearly demonstrates the superior performance of the participants who had the activities of reinforcement in the Virtual World in their process of learning, when compared with those who only studied with their notes.

In the comparison between the group that used the Virtual World and the group that used the Moodle environment, the analyzes did not show significant differences in the statistical verification performed, except for the first intermediate evaluation in the second period, in which Group 3 was better than Group 2. In spite of this only significant difference in performance, in all evaluations the performance of the group that used the Virtual World was equal to or greater than the performance of the group that used Moodle, in the questions of values of the medians, of the form of distribution data, scale and variability of data, with more cases of Group 3 superiority being identified than of equality in the evaluation analyzes.

VII DISCUSSION

The findings of the analyzes carried out on the research related to the scope of this research demonstrated the lack of research involving both areas in an integrated way, which was motivating for the development of this work. In order to explore the potentialities of each of these areas and to solve their limitations, this integrated approach was proposed with a focus on the teaching of Sciences for elementary school, with two periods of tests being carried out.

The results of the first experiment period could be considered positive, in which the group of students who used the Virtual World performed better than the group

that chose not to use any environment. Regarding the group that used Moodle, the results were also positive in relation to the group that chose not to test any of the environments but did not have significant differences.

In the comparison between the Virtual World and Moodle groups, it was not possible to identify significant differences, however, the medians were larger for the participants who used the Virtual World, as well as, there was a better distribution of the grades in the evaluations and their amplitudes were smaller, causing less variability.

In the second period of the tests, only two groups were established, being formed by students who used the Virtual World and Moodle. The groups had similar performances regarding their medians in the evaluations, however, the distribution of grades was better concentrated in the Virtual World group, resulting in a smaller amplitude and variability. These results showed that this group was similar or even better than the participants who used Moodle, again being a positive result to be considered, and essential for the consolidation of the proposed approach.

By comparing the three groups, without dividing periods, it was possible to observe significant differences in three of the five evaluations performed, as well as in the others, the medians were superior. This resulted in significant differences in the performance of the Virtual World group compared to the group that did not use any approach. In comparison to the Moodle environment, Virtual World users had higher medians, with better distribution of grades, lower amplitude, and variation, but without significance.

In relation to the interviews carried out with the students, in which different students of the two test periods were selected, the pattern of the responses was positive, which indicates that the students unanimously approved the adoption of this type of proposal and they indicated that they would like to continue to perform complementary activities in the Virtual World in the coming semesters and the adoption of Mastery Learning approach.

Experimentation with these spaces and tools for simulation could facilitate the students' acquisition of competences and construction of knowledge [83]. The use of Virtual World with a focus on science education can be regarded as a valid alternative and beneficial when compared with most traditional teaching method, in that the teacher ministers the class in person and only with the blackboard and slide presentations. It was emphasized the use of simulations and questionnaires as something positive at the time of the study for evaluations, as well as they described to have liked to use this type of environment and expressed the desire to continue to use it in the coming semesters. The problems mentioned above

were also highlighted by them, such as the slowness and the requirement of a good internet connection and improvements planned for future steps.

The analysis carried out in this article with the description of the theoretical reference highlighted the way of conducting the educational theory of Mastery Learning, its advantages and disadvantages, as well as related works built in different areas of teaching. The exposition of the way of applying this theory, through its integration with Information and Communication Technologies, from which new research possibilities emerged, have also become important points for the academic environment. Mastery learning brings about behavioral advantages that include positive change in attitude, nature of approach to a problem, spirit to achieve one's best and beyond, and sense of rising to the challenge [84].

In terms of pedagogical resources, ICTs have been identified as innovative solutions that allow the elaboration of educational proposals that are more dynamic, interactive and integrated to the current conjuncture [85]. The study carried out in this research allowed the integration of Mastery Learning with a learning environment created in Virtual World, which is outside the context that had been applied in previous research, that approached the use of Moodle. Tüzün and Özdiñç [86] explain that Virtual Worlds have the potential to provide individuals with more meaningful and long-term data compared to traditional or interactive multimedia environments. Using simulations in technological environments allows students to access data and information from remote sites, to relate visible and invisible data, to manipulate environments and variables, to influence changes or processes and to practice skills that would be difficult to develop in real life [83]. This factor has led to new exploration fronts, culminating in the creation and validation of the approach described in this article for science education.

Limitations

The process of implementation (development and deployment) of the Virtual World may be one of the most complicated issues of the solution proposed here for a school environment [85]. This finding was based on the essential work carried out by the teacher of the discipline, who together with the authors of this research, sought to articulate the complementary activities to be proposed with Mastery Learning, to assist in the creation of simulations in the Virtual World and to review the process. These activities have become valuable for the correct and proper functioning of the proposed method.

The process of developing the Virtual World requires more advanced technological knowledge in information technology and education, which in most cases is not

possible to be carried out by teachers who do not have knowledge of these areas. This reinforces the fact that an interdisciplinary team is essential for the development of this proposal and adds quality to the work developed.

Regarding the resources of the school environment that adopts the proposed Virtual World solution, the main problems identified were centered on the limitations involving infrastructures such as Internet connection speed and hardware resources. Because it is a three-dimensional environment, which consumes hardware and Internet connection resources, due to the data rendering and storage process, this type of problem ends up being a limitation, considering that it somehow escapes from the control of the teacher, being considered as an external factor that may occur and jeopardize the interaction of the students with the teaching materials available.

The installation and configuration of the viewer were also considered a challenge, since the students were children, with the help of their parents, who were supposed to carry out this process in their homes. In this context, there is the fact that Virtual World does not provide adequate support for use on mobile devices or on a page in a browser (like Moodle), requiring the installation of software on the user's computer, which causes difficulties to users as described above.

This point should be taken into account, identifying its target audience when applying this type of approach, as well as ways to facilitate this process. It is important to emphasize that despite the limitations identified, the process was able to be conducted properly and validation of the approach occurred correctly.

VIII. CONCLUSIONS

In this study, the virtual worlds were presented as an environment that allows the creation of 3D static and interactive objects, containing resources for communication between individuals, as well as to establish a high degree of interactivity and sense of immersion to the participants. The educational focus that was developed in the Virtual World to assist the teaching of science aimed to cover the elements mentioned above. The experiment adopted enabled the demonstration that this type of approach can be created with a focus on science teaching, in which the multimedia resources such as slides, texts, questions, and videos could be inserted into the environment, beyond the creation of interactive 3D simulations through the use of script programming. The evaluation of the participants made it clear that the resources used were considered important in the learning process and helped in the study period for the evaluations, noting that problems involving the internet connection speed and the ability of the computer hardware were identified as the main obstacles during the experiment.

The adoption of precepts of Mastery Learning as the basis for the formulation of activities and assessments encompassed the groups established during the experiment, in which both the students and the teacher who gave the activities considered positive this type of approach. The application of initial evaluations, at the end of each module and at the end of the semester allows the teacher to have a clearer vision and detailed status of each student, allowing the adoption of corrective measures during the semester, if he considers it necessary. It is important to emphasize that with the use of virtual worlds and Moodle as complementary activities, students had a satisfactory performance in all evaluations, which did not require that the teacher had to perform the recovery measures of activities during the experiment.

This factor can be considered as a positive outcome of the adopted approach, in which the group of students who did not use any of the environments got enough grades for approval, but at no time the group was with the median of grades above other groups. This demonstrates that the use of Mastery Learning for the planning of teaching activities during the semester, adopting Moodle and Virtual Worlds as places where students could perform reinforcement activities can be considered positive and beneficial.

The study made it possible to identify limitations highlighted by different researchers, who criticized the time required to conduct the activities and the excessive workload of teachers, as originally proposed by the Mastery Learning theory. However, this study allowed us to envisage new possibilities of adapting the adopted procedures, seeking to make the temporal issue more flexible and concomitantly reducing the workload of the teacher, whose main support was centralized in the use of technological resources, more specifically with the application of Virtual Worlds integrated to this theory. It was precisely at this point, taking into account its limitations and advantages, together with the exploration of computational resources in this environment, that the initiatives for the construction of this research emerged. The modification of the original method proposed, altering its way of conducting and proposing its integration to an environment of learning outside the context that had been applied in previous researches, that approached the use of Moodle, sent new exploration fronts, that culminated in the creation and validation of this approach.

This way of planning and adoption is not exclusively linked to the area of sciences but can serve as an approach to be adopted by teachers in different areas, this being one of the main contributions of this study. As subsequent stages of this project, new experiments are already being applied in the field of Geography and Algorithms,

showing that this approach is already being replicated to other areas of teaching.

One of the main aspects to be explored is related to the use of the mobile devices to have access to the Virtual World. This access, although it can be realized through an Internet browser, can also be through a specific program that personalizes and facilitates to explore all the didactic resources of the Virtual World. This problematic includes an instigating field of research to be explored in the future, from which important solutions can emerge for the academic and professional environment, which have helped in a significant way the diffusion of Virtual Worlds. The integration of this type of environment with Moodle can also be considered an interesting research area, for example, the Sloodle tool already does the mentioned integration. Although this type of initiative has lost momentum over the last few years, since there has been considerable time involved in creating and maintaining a resource in a Virtual World, as in "real worlds" where it is necessary periodic maintenance [86]. The creation of didactic content authoring tools that facilitate the availability of Virtual Worlds is a promising future work. It is now considered a complex process by [87]. Therefore, this is characterized as a still active need, which would significantly facilitate the difficulty of development for teachers in non-technological areas, allowing the inclusion of didactic materials such as videos, slides, and questions.

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Correlation between pyocyanin production and hydrocarbonoclastic activity in nine strains of *Pseudomonas aeruginosa*

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Abstract— *The more pyocyanin produced by the hydrocarbon degrading Pseudomonas aeruginosa strains, the more hydrocarbons would be assimilated and transformed. To evaluate this assumption, we assessed the potential use of nine wild types of pyocyanin-producing P. aeruginosa in bioremediation. They exhibit concentrations of pyocyanin ranging from 0.08 to 28.68 µg/mL. Hydrocarbonoclastic activity in the presence of pyocyanin was determined by two protocols. First, a high correlation was found between the synthesis of pyocyanin and the emulsification index of lubricating oil. Second, two strains were tested for their ability to degrade anthracene and pyrene in soil by the concentration of pigment produced. Microcosms were filled with 250g of sterile sandy soil, supplemented with glycerin and then contaminated with a 20 mg/kg of mixture of the two compounds. The volume of the inoculum suspension ($\approx 10^8$ CFU/mL) was equivalent to 5% of the soil mass contained in the microcosms. Static incubation lasted 60 days at 25°C. A roughly 60-fold difference between the pigment concentrations produced by the two strains resulted in an increase of 65 and 45% in the pyrene and anthracene biodegradation, also indicating that the molecule served as a co-substrate of pyrene degradation.*

Keywords— **Bioremediation; Biodegradation; Petroleum hydrocarbons; Pyocyanin; Pyrene.**

I. INTRODUCTION

Pseudomonas aeruginosa is a ubiquitous aerobic Gram-negative rod, measuring 0.5 µm in width by 1.5 µm in length and endowed with a single polar flagellum, whose preferential habitat is the soil (Abdul-Hussein and Atia 2016). The bacterium exhibits remarkable metabolic versatility, ensuring its persistence in environments with different physicochemical conditions, which may exert different degrees of selective pressures (Maia et al. 2009; Pirnay et al. 2005). In addition, *P. aeruginosa* can utilize more than 90 molecules as a source of carbon and energy (Scott-Thomas et al. 2010), among which are paraffinic (Karamalidis et al. 2010), naphthenic (Shekhar, Godheja, and Modi 2015), aromatic (Zhang et al. 2005) and polycyclic aromatic hydrocarbons (Filinov et al. 2010). This characteristic makes the bacterium an excellent choice as an agent of removal of these compounds in the environment (Salam 2016; Atzél et al. 2008).

P. aeruginosa synthesizes at least six different pigments: fluorescein (Allydice-Francis et al. 2012), pyoverdine (Yin et al. 2017), pyorubin A and B (Abu et al. 2013), pyomyelin (Ferguson, Cahilli, and Quilty 2007) and pyocyanin (Viana et al. 2017). The latter, a fluorescent phenazine compound of exuberant blue-greenish coloration is synthesized exclusively by 90-95% of the strains (Mavrodi et al. 2001) and its main function is to

participate in reactions involving the production of reactive oxygen species (Muller and Merret 2014) and in the reduction of the Fe^{3+} ion, an important growth factor for bacteria (Jayaseelan, Ramaswany, and Dharmaraj 2009).

Most of the studies involving pyocyanin have focused on clinical issues, generally related to antibiotic multi-resistance (Kerr and Snelling 2009), antimicrobial activity (Martins et al. 2014) and immunological changes or responses caused by opportunistic infections (Sales-Neto et al. 2016). However, the synthesis of pyocyanin is associated to a response mechanism to environments with high selective pressures as hydrocarbon-contaminated soils (Bahari et al. 2017), allowing *P. aeruginosa* to persist as well as to use hydrocarbons as the sole source of carbon. This could be applied to the bioremediation processes.

Interest in the role of pyocyanin in the degradation of hydrocarbons is very recent and the topic is still little explored (Mangwani, Kumari, and Das 2015; Wu et al. 2014). The correlation with pyocyanin and biosurfactant synthesis was first reported in this decade (Das and Ma 2013). The production of 10.89 $\mu\text{g/mL}$ of the pigment reflected emulsification indices (E_n) of three fuels between 60 and 75%, while another strain, whose production of pyocyanin was significantly lower, 4.81 $\mu\text{g/mL}$, the E_{24} obtained were between 25 and 40%, reflected in a biosurfactant synthesis that was ten-fold less.

In order to verify the importance of the pigment in the hydrocarbonoclastic activity of *P. aeruginosa* strains and to assume that the more pyocyanin produced, the more hydrocarbons would be assimilated and transformed, we chose as the main objective of this study to evaluate the biodegradation of pyrene and anthracene in soil by wild type strains of *P. aeruginosa* and to correlate this with the concentration of pyocyanin.

II. MATERIAL AND METHODS

Pseudomonas aeruginosa

Nine wild type strains were tested. They were taken from the collection of the Laboratory of Environmental Microbiology of the Federal University of Paraíba, the samples having been collected by our research group from highly selective pressure environments, such as gas stations, activated sludge and wastewater, all in the city of João Pessoa-PB, Brazil (Cavalcanti et al. 2017). Some characteristics of these isolates are summarized in Tab. 1.

Production of fluorescent pigments and determination of the concentration of pyocyanin

The production of pyocyanin and fluorescein was stimulated using traditional media (King, Ward, and Raney 1954). The inoculum was prepared with 0.85%

NaCl solution, standardized with tube No. 1 of the MacFarland scale, from fresh culture of each strain of *P. aeruginosa* on nutrient agar (APHA, AWWA, and WEF 2012). For the synthesis of pyocyanin, 1 mL of the suspension was transferred to conical flasks containing 200 mL of King A broth. Incubation occurred under 150 rpm shaking at $29\pm 1^\circ\text{C}$ for 72h (El-Fouly et al., 2015). To detect fluorescein, King B agar was used. Static incubation was conducted under the same temperature and time conditions as described above.

Pyocyanin extraction was conducted by combining the two methodologies (Nowroozi, Sepahi, and Rashmonejad 2012; Hassani et al. 2011). A 10 mL volume of the King A broth containing the cells and the pigment dissolved after 72h was transferred to test tubes and then 3 mL of chloroform was added. After vigorous vortexing, the tubes were allowed to stand for 2 hours and the pyocyanin in the protonated form was retained in the chloroform phase, which turned blue. Then, 1.5mL of the blue phase was transferred to another tube and 1 mL of a 0.2 mol/L HCl solution was added. After vigorous stirring, pyocyanin was obtained in its red acidic form. The tubes were also allowed to stand for 2 hours. The concentration of pyocyanin ($\mu\text{g/mL}$) was estimated by measuring the optical density of the acidified supernatant at $\lambda=520\text{nm}$. The measured value was multiplied by the molar extinction coefficient 17.072 (Das and Ma 2013) and subsequently corrected for the ratio between the spent volume of chloroform in the extraction and the rate for acidification. The assay was performed in duplicate.

Index of emulsification of hydrocarbons (E_n)

Each strain was inoculated as previously described in nutrient broth. After incubation under agitation of 150 rpm for 24 h at $29\pm 1^\circ\text{C}$, a volume of 2 mL was transferred to tubes, to which same volume of gasoline, kerosene and lubricating oil was added. The control of the test was performed with 1% SDS solution. The mixture of the aqueous and oily phases was accomplished by vigorous vortexing for 2 minutes and then allowed to stand. E_{24} - E_{72} were calculated from the height measurement of the emulsion layer, divided by the height of the total volume in the tube, multiplied by 100 (Naem et al. 2017). The test was performed in duplicate.

Biodegradation tests for polycyclic aromatic hydrocarbons (PAH)

The tests were conducted in sealed microcosms of polyethylene, filled with 250g of sterile soil contaminated with 10 mg/kg of both PAH anthracene and pyrene (Merk, Darmstadt, Germany), to which had been added 0.25 mL/kg glycerol (Vasconcelos, Oliveira, and de França 2013). The function of glycerin was to serve as an

alternative source of carbon for the production of biomass as well as co-substrate of the PAH removal process, representing 0.32 mg/kg of carbon. The PAHs dissolved in acetone were sprayed on the soil (Eom et al. 2007), which was then stirred and allowed to stand for 30 minutes in a sterile environment until solvent volatilization. The soil characterization is summarized in Tab. 2.

Two strains were tested: TGC07 (PYO+) and TGC06 (PYO-). The pre-inoculum was prepared from the cultures of the King A broth, incubated under agitation at 150 rpm for 72 h at $29 \pm 1^\circ\text{C}$. Then, a volume of the bacterial suspension containing approximately 10^8 CFU/mL was added to the microcosms, equivalent to 5% of the soil mass contained in the microcosms (Palittapongpim et al. 1998) and obtaining moisture content of about 20%. Incubation occurred for 60 days at 25°C . The abiotic losses were estimated in the microcosms containing the contaminated sterilized soil, added with 10% (w/v) silver nitrate solution (Vasconcelos, de Frisanga, and Oliveira 2011). The test was conducted in duplicate. The levels of anthracene and pyrene were detected by GC-MS (Method 8270C) (USEPA 1996). The extracts were obtained by soxhlet extraction using dichloromethane (Method 3540C) (USEPA 1996) and the preconcentration of the samples was conducted under N_2 atmosphere.

Complementary tests

The biomass value was determined by the dry weight technique (Olsson and Nielsen 1997). The *P. aeruginosa* strains were incubated with 150 rpm shaking in 200 mL of King A broth for 72h. After, a 10 mL volume was centrifuged at 10,000 rpm for 15 minutes. The cells were rinsed three times with a 0.85% NaCl solution and at the end, 10 ml were resuspended and incubated at 80°C for 24h. The biomass, in dry weight (mg/L), was calculated from the difference between the masses before and after the incubation. The test was performed in duplicate.

The estimate of the mineralized CO_2 in the microcosms was performed as described by Severino et al. (2004) each tendays during the biodegradation tests. A vessel containing 25 mL of the 0.5 mol/L NaOH solution was left inside the microcosms. NaOH was titrated with 0.5 mol/L HCl solution in the presence of phenol red. The amount of CO_2 (mg/kg of soil) produced by the strains was estimated by the difference between the spent volume of acid to neutralize the base in the control and in the treatment, using equation Eq. (1):

$$\text{CO}_2 = [(V_1 - V_0) \times 44] \div 0.25 \quad (1)$$

Where V_1 - volume (mL) of HCl required to neutralize NaOH in the treatment; V_0 - volume (mL) of HCl required to neutralize the base in the microcosm control; 44 - the molecular weight of CO_2 ; and 0.25 - mass (kg) of the soil in the microcosm. The focus of the

following methodology was to estimate gas emission in order to discount the estimated values between only two conditions: in the first condition, we aimed to detect microbiological stimulation due to the addition of glycerol rather than to verify from which specific carbon source the CO_2 had been produced. In the second condition, we wanted to find out the amount of CO_2 produced by abiotic reactions in order to avoid overestimating gas emission. Biotic activities in uncontaminated soil were not considered in this case because only microbiota were used in the microcosm tests.

Statistical treatment

The Pearson correlation between the concentration of pyocyanin and biomass produced with E_{72} was verified, compared to low-pyocyanin-producing strains. We used the IBM® SPSS® Statistics version 21 program, considering significant if $p < 0.05$.

III. RESULTS

Production of pyocyanin and correlation with emulsification index

The concentration of pyocyanin produced ranged from 0.08 to 28.68 $\mu\text{g/mL}$ on average. Alteration of the medium staining occurred in the 48-72h-incubation interval. The strains that produced less than $0.80\mu\text{g/mL}$ were coded as PYO- and the others as PYO+. This value represents 10 times more than the lowest concentration detected. Regardless of the higher or lower concentration of the pigment, the determined biomass values were similar, ranging from 8 to 10 mg/L, as presented in Tab.3.

Throughout the emulsification test, when the indices were registered, they increased, reaching the maximum in $t=72\text{h}$. These values are presented in Table 4. The strains were better able to emulsify the kerosene and especially the lubricating oil, to the detriment of the gasoline.

In descending order, the percentages of strains that emulsified the fuels were: 100% (lubricating oil), 89% (kerosene) and 22% (gasoline). The E_{72} in the control was higher than the maximum obtained by the *P. aeruginosa* strains with the gasoline, but lower than that verified in the lubricating oil, except for the PYO- strains. In relation to kerosene, the results were quite different: E_{72} was the same as that determined by five strains, inferior to three (TGC01, TGC03 and TGC09) and superior to one (TGC06).

Among the PYO+ strains, a 96.7% correlation was found between the synthesis of pyocyanin and E_{72} of the lubricating oil ($p = 0.07$). A high correlation (92.6%) was also obtained between E_{72} of the lubricating oil and kerosene ($p = 0.023$). Although statistically non-significant ($p = 0.18$), there was a 70.7% correlation between biomass production and pyocyanin synthesis. The same pattern,

however was observed among PYO⁻ (72.2%, $p = 0.28$). No other comparisons were statistically significant.

Biodegradation of anthracene and pyrene

The percentages of removal of the two PAH by TGC07 (PYO⁺) and TGC06 (PYO⁻) were different, in terms of the pyocyanin concentration. TGC07 produced approximately 60 times more pyocyanin than TGC06 and archived higher biodegradation rates of the anthracene and pyrene. After 60 days of processing, the performance of TGC07 in both compounds degradation was about 45 and 65% higher than TGC06. There was a preferential degradation of the anthracene to the detriment of pyrene in both strains, and TGC07 produced 25% more CO₂, compared to TGC06. The results obtained are presented in Tab. 5.

IV. DISCUSSION

Production of pyocyanin

The particular nutritional and metabolic versatility presented by *P. aeruginosa* makes the bacteria common to different environments (Bellin et al. 2014). In some of these environments, the nutritional shortage especially related to PO₄⁻³ and Ca⁺² ions, forces the pyocyanin-producing strains to exhibit the pigment (Whooley and McLoughlin 1982). The synthesis of pyocyanin can be a sign of a resistance factor to certain compounds present in the environment, which may be toxic to other microorganisms, such as heavy metals (Muller and Merrett 2004), detergents (Lefebvre et al. 2017), dyes (Sarioglu et al. 2017) and petroleum hydrocarbons (Mittal and Singh 2009).

Although organic matter is widely available in these environments, the selective pressure exerted on the microbiota forces *P. aeruginosa* to combine mechanisms to persist (Deng 2012), thus enabling the ability to triumph over competing organisms (Özcan and Kahraman 2015). On the other hand, factors other than pyocyanin, such as alginate production, rhamnolipids and adhesins, among others (Winstanley, O'Brien, and Brockhundst 2016; Das et al. 2014), favor the resilience of *P. aeruginosa* since the pigment is not synthesized by 5 to 10% of the strains (Finlayson et al. 2011).

In aqueous media, concentrations of pyocyanin may range from 0.31 to 80 µg/mL (Hassani et al. 2011; El-Shouny, Al-Bidani, and Hamza 2011). *In vitro* production display of the pigment occurs within 48 hours if specific conditions of temperature and agitation are offered, i.e., 30°C and 150rpm (Agrawal and Chauhan 2016). With the King A medium, the pyocyanin is synthesized during the final part of the log phase and at the beginning of the stationary phase (Cabeen 2014). This time is dependent on the generation time of the strains. Under these cultivation

conditions, *P. aeruginosa* tends to have a generation time ranging from 3 to 6 h (Vasconcelos, Lima, and Calazans 2010; Tamagnini and Gonzales 1997), which justifies the appearance of the blue-greenish coloration of the strains of the present study, between 48 and 72 hours after the beginning of the incubation. However, the culture medium also influences this result. In mineral broth and GSNB, for example, pyocyanin was detected diffused in the medium, after 96h of incubation at 37°C (El-Fouly et al. 2015).

Three strains exhibited concentrations higher than 20 µg/mL of pyocyanin after 72h of incubation and the maximum value obtained was TGC02 (28.68±0.05 µg/mL). This concentration was similar to that obtained in a recent study, using the same incubation conditions, 26.12 µg/mL, and when the main source of nitrogen was 13 g/L peptone (Agrawal and Chauhan 2016). On the other hand, studies that used some modifications of the traditional methodology obtained amounts of the pigment between 9.3 and 42.0 µg/mL (Barakat et al. 2015; El-Fouly et al. 2011). Thus, for optimization in the process, aiming towards the use of PYO⁺ in the bioremediation of hydrocarbons, higher concentrations of pyocyanin might be obtained in these strains, suggesting future research on the subject.

Correlation of E_n and biomass production with the synthesis of pyocyanin

In the environment, one of the main roles played by *P. aeruginosa* includes the mineralization of several natural or synthetic compounds (Frimmersdorf et al. 2010). Due to the ability to transform organic matter into biomass and energy, the bacterium represents a potential bioremediation agent for soils contaminated by hydrocarbons (Das and Chandran 2007; Zhang et al. 2005). Ecologically, pigment synthesis guarantees many advantages to *P. aeruginosa*, even though antimicrobial activity against bacteria (Jayaseelan, Ramaswamy, and Dharmaraj 2014) and fungi (Sudhakar and Karpagam 2011) is still the most investigated property of pyocyanin.

In recent years, there has been a growing interest in the role of pigment in the biodegradation of hydrocarbons (Das and Das 2015; Das et al. 2013). Although very recent, the question is important for the petroleum industry, as it provides a better understanding of the participation of the pyocyanin in the processes of oil removal, given the potential of the application of *P. aeruginosa* in the interventions for the removal of oil at certain sites.

Previous studies have shown that the production of higher concentration of pyocyanin in PPGAS medium was proportional to the increase of E₂₄ in gasoline, diesel oil and hexadecane. The pyocyanin was shown to assist in the process of synthesis of tensioactive molecules,

indispensable for assimilation of these hydrocarbons by the bacterium. The highest index obtained was 50%, coinciding with the higher concentration of biosurfactant synthesized in PPGAS medium. It is important to note that pyocyanin has no emulsifying properties but may serve as a cellular signal for the synthesis of surfactant compounds (Das and Das 2015; Das et al. 2013).

In the present study, there was a high correlation between lubrication oil and kerosene E_{72} . The most statistically significant correlation, however, occurred with the E_{72} of the lubricating oil and pyocyanin synthesis. This indicated that the type of fuel had the highest influence as well as suggested that pyocyanin might be a species-specific factor involved in the degradation of the oil by *P. aeruginosa*.

The low E_{72} of gasoline and diesel possibly can be explained by the toxicity of these fuels. Both are very volatile, a characteristic that makes them more harmful to the cells, when compared to the hydrocarbons endowed with longer carbon chains, as in the case of kerosene (C11-C14) and lubricating oil (C20-C40) (Adam and Duncan 2002).

There were no significant differences in the determined values of biomass produced. It is known that one of the functions of pyocyanin is to participate in the process of assimilation of growth factors in environments with nutrient scarcity (Tredget et al. 2004). The production of pyocyanin in traditional media used in the routine of a Microbiology laboratory is based on the energy state of *P. aeruginosa*, which is reduced under conditions of low nutrient concentration, resulting in a decrease in the growth rate and an increase in the concentration of pigment. On the other hand, under favorable nutritional conditions, the energy generation capacity increases, reflecting in the growth rate, with repression of the synthesis of pyocyanin (Whooley and McLoughlin 1982).

This fact could not be observed in the present study. In theory, the biomass values of the five PYO+ strains should have been lower than the other four PYO- strains. However, the medium used in the test had peptone and glycerol in its composition, factors that stimulate pigment synthesis, as well as being responsible for the development of biomass (Norman et al. 2004). This association of nutrients justifies the high percentage of correlation between these variables.

To reinforce this observation, a recent study on the production of biosurfactants by *P. aeruginosa* strains showed a significant increase in microbial biomass when the peptone content was increased 3.5-fold and the glycerol concentration reduced to half of the content of the LB broth composition. Under these conditions, pyocyanin was also synthesized, because the oligopeptides present in

peptone serve as essential nutrients for the synthesis of fluorescent pigments (Das et al. 2015).

This opens new horizons to try to identify whether the E_n of certain hydrocarbons correlates better with the biomass or the concentration of pyocyanin or both. The findings of this work suggest higher correlations with the production of pyocyanin and, thus, indicate *P. aeruginosa* as one of the species with potential for applications in bioremediation.

Effect of the concentration of pyocyanin on the biodegradation of PAH

PAHs are compounds with high mutagenic and carcinogenic potential, formed in incomplete combustion processes and released into the environment, the vast majority as a result of human activity (Romero et al. 2010). The physicochemical properties of PAH give these compounds a recalcitrant nature when present in soil (Van Herwijnen et al. 2003). When they have 2 and 3 rings, such as anthracene, they are referred to as low molecular weight PAH. Those containing 4 rings, such as pyrene, or above, are classified as PAH of high molecular weight (Daugulis and McCracken 2003). The assimilation and mineralization of PAH in soils is only possible for certain organisms that exhibit hydrocarboclastic activity, as in the case of *P. aeruginosa* (Bello-Akinoso et al. 2016).

Preferred degradation of a certain microbe by a class of PAH or to a specific PAH can be verified from the determination of the ratio of the initial and final concentrations of the high and low molecular weight of the PAHs. The negative value indicated that the preferential consumption of *P. aeruginosa* strains was by anthracene (Tolun et al. 2006). In a previous study, anthracene was also the most consumed PAH when mixed with pyrene (Dean-Ross, Moody, and Cerniglia 2002). However, in the literature the preferential consumption by high molecular weight PAH has been well documented (Cavalcanti et al. 2017; Vasconcelos, Oliveira, and de França 2013; Vasconcelos, de França, and Oliveira 2011; Bengtsson and Zerhouni 2003). The greater consumption of anthracene by TGC06 and TGC07 strains may be justified by some characteristics of the molecule: solubility in water (0.7 mg/L) and vapor pressure (2.55×10^{-5} mmHg), higher than pyrene, which presents 0.145 mg/L and 4.25×10^{-6} mmHg, respectively (Bojes and Pope 2007; Mroziak, Piotrowska-Seget, and Łabużek 2003).

The degradation of the anthracene by *P. aeruginosa* begins with the oxidation at the 1,2-position of the molecule and in the sequence fission of the ring occurs, producing salicylate and catechol, which undergoes ortho- or meta-cleavage form intermediates of the tricarboxylic acid cycle (Yong and Zhong 2013). From these intermediates, the energy required for the anthracene to be

used as the co-substrate in the removal of the pyrene is provided. It is possible that with the depletion of glycerol, the anthracene assumed the co-substrate function, justifying its greater reduction by the two tested strains.

Cometabolism is one of the microbial strategies for the removal of recalcitrant compounds in soil. Cavalcanti et al. (2017) described the event by investigating the role of cakes from the processing of oleaginous plants as co-substrates during the removal of phenanthrene and pyrene, employing consortia composed of different pseudomonad strains. After 60 days, there was a preference for pyrene and part of this removal, about 80%, was aided by the consumption of phenanthrene, since there was no supplementation of the soil with another carbon source.

The co-substrates are also important for the maintenance of the biomass throughout the hydrocarbon removal bioprocess. In addition, an inoculum with high cell concentration ensures that the expected adaptation events, subsequent to the introduction of the strains in the soil, are not significantly affected and therefore do not reflect a reduction of the biodegradation rate in the first days (Baggi 2000).

Although the nutritional versatility of *P. aeruginosa* may simplify the reason for the removal of approximately 30% of the two PAH by TGC06, the literature proposes that the mechanism that can maintain the hydrocarbonoclastic activity in PYO- strains is based on the hypothesis that *P. aeruginosa* synthesizes other bioactive phenazines, including the final intermediate of pyocyanin biosynthesis, MPCAB (5-methylphenazine-1-carboxylic acid betaine), even if PYO- strains do not encode the conversion-related genes in pyocyanin (Chieda et al. 2008). In addition, most of phenazinic intermediates may act as auto-inducers for the synthesis of tensoactive compounds by *P. aeruginosa* (Bahari et al. 2017; Mangwani, Kumari, and Das 2015).

The concentration of glycerol employed may also have governed cell growth after the addition of the inoculum to the soil. A previous study evaluated different compounds as additional sources of carbon for the production of biomass in soils and glycerol exerted this function from the concentration of 0.07%. After 24h, more than 80% of the compound had diffused into the soil, particularly stimulating the cells near the diffusion regions (Duquenne et al. 1999).

The concentration of glycerol employed in the experiments resulted in a mass ratio of 100:3 between each PAH, individually, with glycerol. The literature reports that in a mass ratio of 100:8, there was preferential consumption of glycerol by a consortium made up of bacteria and fungi (Vasconcelos, Oliveira, and de França 2013). This interfered negatively in the removal

percentage of 16 priority PAHs in 60 days. When the mass ratio was reduced to 100:3, glycerol could be used as a co-substrate during the bioremediation process, resulting in a removal of about 70% of the same 16 priority PAHs after 60 days. It should be noted that the concentrations of anthracene and pyrene were ten and one hundred times lower than those used in the present study, but the percentages of removal of the two PAHs were about 40 and 71%, which reinforces the function of glycerol as an adjuvant and not the preferential source of carbon in both that and in our study.

The moisture content in the microcosms was appropriate for the biodegradation process of PAH. In addition to being essential for metabolic reactions to occur, the water extends the solid/liquid interface, increasing oxygen diffusion, as well as mass transfer ratio. In addition, water competes for the same PAH adsorption site in the soil, allowing an increase in the degree of removal of these compounds (Bengtsson and Zerhouni 2003; Ettema and Wardle 2002).

The estimation of CO₂ produced is a simple alternative monitoring tool and can be applied without the obligation of quantification of the cultivable biota (Amadori, Fumagalli, and Mello 2009). Under the conditions offered in the experiments, the emitted concentrations of CO₂ were compatible to those determined in a natural soil, of semi-arid region, with moisture content similar to the one used in this work (Zhang et al. 2003). This indicates that there was a growth stimulation in TGC7 and TGC06 by the addition of glycerol. Other supplements available in the literature produced distinct responses. While the addition of 40 mg/kg of peanut and sesame cakes contributed to the generation of about 500 mg/kg of CO₂ in 60 days (Cavalcanti et al. 2017), much lower values (between 2.4 and 35 mg/kg) were obtained by using 10% (w/w) of sugarcane bagasse, manure and castor cake (Severino et al. 2004).

The diffusion constant of pyocyanin in the soil is $0.5 \times 10^{-9} \text{ m}^2/\text{s}$, which in solid media represents a diffusion time of 3 minutes between two points measuring 1 μm , distant from each other, 1 mm (Bellin et al. 2014). It is important to emphasize that pyocyanin, as a bioactive compound, the *in situ* application of pyocyanin-producing strains, may lead to disturbances of the microbiota present in the area to be treated. The same can be intuited when *P. aeruginosa* is investigated on a laboratory scale. A study on the subject was conducted and verified that some members of the microbial community were inhibited in the presence of 9.5M of pyocyanin, and even then, after 50 days of the process, there was specific removal of dibenzothiophenes, naphthalene, and C29-C30 Hopanes (Norman et al. 2004). It was concluded that the

use of pyocyanin-producing strains is possible, since the excreted pyocyanin may affect other microorganisms, even though this inhibition will be limited to the space surrounding the *P. aeruginosa* colony in the soil (Ajello and Hoadley 1976).

Because pyocyanin assumes the role of auto-inducer in cell signaling processes that result in the synthesis of surfactant compounds, the molecule emerges as an interesting research target, among the possible metabolic strategies employed by *P. aeruginosa* in hydrocarbon mineralization (Vinckx et al. 2010). Biosurfactants secreted in the soil favor the displacement of the bacterium towards PAH and consequently its assimilation (Kaskatepe and Yildiz 2016; Alsohim et al. 2014). In addition, pyocyanin when involved in the *P. aeruginosa* density sensing mechanism may also participate in the expression of genes involved in the development of biofilms and favor the degradation of some PAHs, including pyrene (Mangwani, Kumari, and Das 2015). If we consider that similar results by PYO- in the anthracene and pyrene degradation, it is possible that other phenazines rather than pyocyanin may have been involved in the metabolism of hydrocarbons by *P. aeruginosa*. A deepening of these new fronts of research that have emerged from this work guides and encourages future studies that will try to better understand the mechanisms of this process.

V. CONCLUSION

Under the conditions established by the present study, pyocyanin was involved in the emulsification of lubricating oil and biodegradation of two PAH by *P. aeruginosa*. However, the strains continued to exert hydrocarbonoclastic activity even when pyocyanin was synthesized in low concentrations. The preliminary results suggest that the phenotypic criterion of pigment production may be relevant in the choice of *P. aeruginosa* aiming complex hydrocarbons biodegradation propouses.

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TABLES

Table.1: Phenotypic characteristics and origin of *Pseudomonas aeruginosa* strains

Strain	Isolation site	Pyo	Flu	Growth at 42°C	Act	Cet
TGC01	Soil (gas station)	+	-	+	+	+
TGC02	Soil (gas station)	+	+	+	+	+
TGC03	Soil (gas station)	+	+	+	+	+
TGC04	Soil (gas station)	+	+	+	+	+
TGC05	Soil (gas station)	+	+	+	+	+
TGC06	Soil (gas station)	+	-	+	+	+
TGC07	Soil (gas station)	+	+	+	+	-
TGC08	Activated sludge	+	-	+	+	+
TGC09	Wastewater (pigsty)	+	-	+	+	+

Ace – acetamide utilization test; Cet – resistance to cetrinide; Pyo – pyocyanin; Flu – fluorescein.

Table.2: Physical and chemical characterization of soil

Parameter	Result	Reference
pH	7.7±0.2	(EMBRAPA 1979)
Holding water capacity (%)	30.1±0.7	(Watwood, White, and Dahn 1991)
Humidity (%)	0.31±0.01	(EMBRAPA 1979)
Grain size distribution (%)		(ABNT 1984)
Clay (< 0.02 mm)	0.99	
Silt (0.002-0.02 mm)	1.29	
Fine sand (0.02-0.2 mm)	21.42	
Medium sand (0.2-0.5 mm)	41.51	
Coarse sand (0.5-1.0 mm)	32.93	
Gravel (> 1.0 mm)	1.86	
Total organic carbon (mg/Kg)	7.4	(USEPA 1996)
Total N (mg/Kg)	31.8	(USEPA 1993)
Total P (mg/Kg)	3.4	(USEPA 1978)

Table.3: Pyocyanin concentration and culture biomass (72h)

Strains	Pyocyanin($\mu\text{g/mL}$)	X (mg/L)
TGC01	8.02 \pm 0.01	8.0 \pm 0.1
TGC02	28.68 \pm 0.05	10.0 \pm 1,4
TGC03	8.99 \pm 0.38	8.0 \pm 0,2
TGC04	20.33 \pm 1.98	8.0 \pm 0.1
TGC05	0.13 \pm 0.01	8.0 \pm 0.1
TGC06	0.36 \pm 0.02	9.0 \pm 0,2
TGC07	21.54 \pm 0.33	8.0 \pm 0,1
TGC08	0.08 \pm 0.04	8.5 \pm 0.7
TGC09	0.10 \pm 0.01	8.5 \pm 0.1

Table.4: E_{72} (%) for fuels from *Pseudomonas aeruginosa* strains

Strains	Fossil fuels		
	Gasoline	Kerosene	Lubricating oil
TGC01 (PYO+)	–	5.0 \pm 0.0	50.0 \pm 0.2
TGC02 (PYO+)	–	10.0 \pm 0.0	100.0 \pm 0.0
TGC03 (PYO+)	–	7.5 \pm 0.1	55.0 \pm 0.5
TGC04 (PYO+)	–	10.0 \pm 0.0	87.5 \pm 0.3
TGC07 (PYO+)	7.5 \pm 0.1	10.0 \pm 0.1	97.5 \pm 0.1
TGC05 (PYO–)	–	10.0 \pm 0.1	10.0 \pm 0.2
TGC06 (PYO–)	–	22.5 \pm 0.1	25.0 \pm 0.1
TGC08 (PYO–)	2.5 \pm 0.2	10.0 \pm 0.0	5.0 \pm 0.1
TGC09 (PYO–)	–	–	10.0 \pm 0.5

Control (1% SDS) – gasoline (37.5 \pm 0.2), kerosene (10.0 \pm 0.0) and lubricating oil (47.5 \pm 0.2).

Table.5: Removal of anthracene and pyrene after 60 days of bioprocess*

Strains	Pyocyanin ($\mu\text{g/mL}$)	Biodegradation (%)		Δ	CO ₂ emission (mg/Kg)
		Anthracene	Pyrene		
TGC07	21.55 \pm 0.92	62.0 \pm 0.1	49.2 \pm 0.1	- 0.25	422.4 \pm 0.5
TGC06	0.36 \pm 0.08	34.1 \pm 0.6	29.8 \pm 2.3	- 0.06	316.8 \pm 0.8

* Results were calculated with abiotic loss of 15.1 \pm 0,1%

Δ – ratio of initial and final concentration between anthracene and pyrene

The Management of Knowledge in the School Context and the continued Training of Teachers in Service

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Abstract—The present work analyses the administration within a school organization from a pedagogical perspective, understanding that pedagogical coordination acts with the management, being responsible for coordinating the progress of the work in the organization, ensuring the articulation of interpersonal relations, the conditions for the personal and professional development of the people of the school. The research was carried out in one school maintained by Brazil's federal government, located in the city of Rio de Janeiro that is attended exclusively by students in the initial years of fundamental education. As instruments of data collection, a structured interview and a semi-open questionnaire were used. The obtained data were worked quantitatively, using percentage frequency, and qualitatively, using content analysis. It was concluded that, using knowledge management strategies, several opportunities for continuing teacher training in service take place in the planning meetings of the school's teaching team and considering that, the pedagogical actions are also planned in these meetings.

Keywords — *management of knowledge, pedagogical actions, fundamental education, structured interview, questionnaire.*

I. INTRODUCTION

In this era of globalization, competition at all levels is a reality. In this context, an organization needs to look for ways to gain advantage over the others to establish itself and be recognized as offering a good product to the society.

In Brazil, the basic education in the public schools is free of charge to the population and is of the responsibility of cities. However, in addition to the private initiatives, there are some schools maintained by the state and federal governments that offer elementary education on a smaller scale.

The fundamental school chosen for this study is maintained by the federal government and has about 250 students, most in early childhood education.

Analyzing the training background of the teaching staff, it is found that the work force that works on the campus is well prepared academically — many teachers have postgraduate degrees, some having masters' and/or doctorates—but there are also many with little or no experience in the classroom, and most are without the knowledge of how the work is developed at school. This is because most of these teachers have been working for less than five years in the institution, as shown in figure 1.

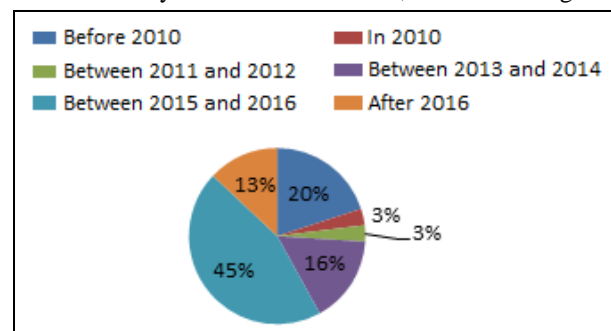


Fig. 1: Percentage of permanent teachers joining the faculty, per year. Source: Elaborated by the author

The absence of more in-depth knowledge on the part of the teachers about the pedagogical planning carried out in the institution that are applied with the students in the fundamental school itself, contributes to the need for continued training in service of all those involved.

The present article, using knowledge management tools, aims to evaluate the pedagogical management of this fundamental school in Rio de Janeiro, Brazil, aiming to reach levels of excellence in the educational area.

II. CONTEXTUALIZATION

2.1-Knowledge management

According to Davenport and Prusak [1], knowledge management is the collection of processes that govern the creation, dissemination and utilization of knowledge to fully achieve the objectives of an organization.

Nonaka and Takeuchi [2] define knowledge management as a characterization of the process of continuous creation

of new knowledge, disseminating it through the organization and rapidly incorporating it into new products or services, developing new technologies and systems that perpetuate change within the company. In their view, organizational knowledge grows when it is fully shared.

According to Nonaka and Takeuchi [2] and Angeloni [3], in order for knowledge to be generated, the organization must provide training conditions so that the individual can create organizational knowledge. Important factors to take into account include:

- Organizational Intention – Related to the aspiration of an organization, its goals and objectives. In general, efforts to achieve intent are framed within the organization's strategy.
- Autonomy of the members of the organization – Enables the self-motivation of the individuals to create knowledge, because the team will be able to meet the unexpected opportunities.
- Fluctuation and creative chaos – Situations are purposely inserted by top management in the sector/organization with the aim of stimulating creativity: through dialogue, through social interaction, seeking alternatives for solving the simulated crisis situation.
- Superfluity or Redundancy – Information that transcends the immediate operational requirements of organization members is intentionally overlapped, triggering an increase in the volume of information to be processed.
- Organizational Infrastructure – Promotes the creation and dissemination of knowledge when its members can change their context.
- Great number of requirements – Makes easy the confrontation on different situations by part of the members of the organization, when they can count on several requirements from a combination of information quickly and flexibly.
- Information Technology (IT) – The third dimension, which plays a fundamental role in the process of capturing, storing and sharing information and knowledge. However, it does not eliminate the importance of conversation, of dialogue between team members. Therefore, it is no use for the organization to exceed its span of human attention for the implementation of modern information technologies, believing that it is investing in knowledge management [6].

2.2-Training continued in service

The information society has brought many changes in its structure. These deeply affect the school and require a reassessment of its role in the world today. As Fávero

and Tornieto [4] state, the school has been challenged to rediscover its place in the information society. However, Libâneo [5] points out that although the school is affected in its functions, organizational structure, content and methods, it remains a solid and necessary institution for the democratization of society. It can be said that there is no pedagogical reform without teachers, because it is these professionals who are active and involved in the dissemination of knowledge.

In order to carry out the educational functions, the teacher needs to have had an initial training, which refers to the teaching of theoretical and practical knowledge for professional training, complemented by internships. But in order to keep up with the changes in the information society, in which knowledge and action are constantly changing, it is urgent that the teachers be able to find a continuous means for their education, a natural and legitimate context for the development of their practice, an action that happens with the collective and in the collective of the pairs, together with the pedagogical coordinator [7].

In his research, Christov [8] points out that the collective pedagogical work hours in the workplace itself are among the actions that make up a continuing education program in service. Its viability is, on the part of the educational institution, the organization of the school's work with a privileged time for collective and individual studies by the teachers. In these spaces there is the reflection on the practice of the educators involved, in view of the desired transformations for the classroom and for the construction of the participants' intellectual autonomy.

2.3-The role of the pedagogical coordinator in the school

In this perspective, it is essential to analyze the role of the coordinator and the pedagogical supervisors, such as the exchange of experiences between them and the teachers who work in classrooms, as this dynamic can enrich the on-going training of all involved in this educational journey.

Christov [8] explains that the essential attribute of the pedagogical coordinator is associated with the in-service teacher training process. The researcher points out that it is necessary to build new bases on which to think and to intervene in schools. And in this construction, the coordinating teacher serves as a fundamental agent to ensure that the moments of encounter between teachers and coordinators in the school are productive.

According to Geglio [7], the pedagogical coordinator's condition of being a continuing education agent is conferred on him by the position he occupies. Fusari [9] also emphasizes the importance of the school as a nucleus of continuing education and the pedagogical coordinator

as one of the professionals responsible for articulating this process.

Vasconcellos [10] notes that the coordinator must be questioning, unbalanced and provocative in order to value the collective effort and the cooperation among the teachers who work in the classrooms, encouraging them and providing them with elements that contribute to the growth of the team. Therefore, he understands that the coordinator plays an important role in the training of educators.

2.4-Structure of pedagogical management and planning meetings in the school

In the initial years of elementary education in this school, there is the figure of the pedagogical coordinators, teachers who work directly with a group of teachers who teach classes in certain years of elementary school, aiming at a better monitoring of the pedagogical plan.

They participate in the planning meetings of the teachers working in the classrooms of the common core, namely: Portuguese, mathematics, social studies and the sciences.

There are also teachers in the school who teach classes from other disciplines to the students of the initial years of elementary school, namely visual arts, physical education, music education, educational informatics and literature.

On a weekly basis, the teachers belonging to the school have, during their hours in the institution, a time for meetings with their peers, with pedagogical coordination and/or orientation. The aim of these weekly meetings is to build a quality of work to be developed with students, leading them to think and build their knowledge, always seeking partnership with families. In addition, questions are still raised and discussed that are observed regarding the development of students.

III. THE RESEARCH METHODOLOGY

For this study, a bibliographical search was carried out, through a series of materials published in several sources, used to construct the theoretical-methodological foundation of the research, on the following subjects: knowledge management, on-going teacher training and the pedagogical coordinator's work.

Descriptive research was also carried out, analyzing the perceptions of the group of teachers who work in the initial years of elementary education of the school regarding the opportunities for continuing education in service that emerged in the weekly meetings of planning.

A case study was elaborated, accomplished by interviews and use of a questionnaire with the faculty that works in that school.

The approach chosen to conduct this research was a mixed (qualitative-quantitative) method, considering that

there were both non-measurable data and data that could be analyzed by the use of statistical instruments.

A questionnaire was sent to all 48 persons who worked in the school observed in the 2017 academic year as either pedagogical staff (that are teachers, but don't work in the classroom) or classroom teachers. However, not everyone was able to participate as respondents. The sample thus corresponds to the 33 questionnaires returned. In addition, 16 individuals were interviewed, including permanent and temporary teachers of the campus, encompassing teachers from the different disciplines that are offered to students as well as classroom teachers and those who work in the pedagogical coordination and orientation.

Content analysis was chosen to apply to the qualitative data obtained. According to Gray [11], this is one of the most common approaches when there are qualitative data. It consists of making inferences about the data by systematically and objectively identifying special characteristics (classes or categories) between them.

IV. SEARCH RESULTS

The teachers in the group were asked about the use of some procedures for knowledge management, as highlighted by Paiva [12].

The following procedures were presented to the respondents:

- formation of practice communities or study groups;
- preparation of catalog of suggestions;
- mapping of best practices;
- formation of interest groups; and
- formation of virtual groups, so that those involved can resolve their doubts/present suggestions in social networks or through applications.

The results of this query are shown in Figure 2.

In 97% of the questionnaires returned, the elaboration of a catalog of suggestions was identified as one of the procedures of knowledge management used in the school. This cataloguing is done by filing a copy of each activity performed in the classes in a folder. In addition, each pedagogical coordinator maintains a digital file related to the activities carried out in each year of schooling.

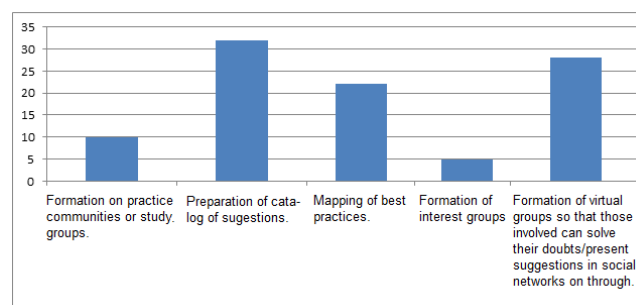


Fig.2: Procedures used in school for knowledge management, in the view of respondents. Source: Data obtained in the questionnaires.

As many as 84.8% of the respondents pointed out the formation of virtual groups so that those involved can resolve their doubts, present their suggestions and discuss the elaboration of activities outside the planning meetings in social networks or through applications as a knowledge management procedure used. The creation of groups of e-mails with WhatsApp and on Facebook is the most used. Among the respondents, 66.7% indicated that the mapping of best practices began to become a routine. The written and photographic records of the activities carried out are material for exhibition at the meetings of responsible persons, in the workshops held in the school auditorium and in congresses and symposiums in which the teachers participate. They serve as a source of inquiry so that any errors detected when performing the activity are corrected and not repeated.

Of the teachers who answered the questionnaire, 30.3% perceived the formation of practice communities or study groups as a knowledge management procedure present in the school. From the planning meetings and even in the function of the work developed, some teachers pointed out that they felt the need to study, in a group, subjects directly linked to the content worked, which supported them for better performance in the classroom.

Moreover, 15.2% of the teachers pointed out the formation of interest groups as a procedure of knowledge management present in the school. In the same way as the previous procedure, in relation to the work developed, the difficulties encountered and the problems to be faced, the teachers come together in interest groups, collectively seeking solutions that can be common problems or deepening discussion about themes of interest of the group.

The teachers were also questioned about their view on the existence of conditions that favor the creation, dissemination and socialization of knowledge in an organization, according to Nonaka and Takeuchi's Theory of Knowledge Creation [2].

The conditions presented in the questionnaire to the group of respondent teachers were as follows:

- Environment conducive to sharing ideas through creative conversations.
- Good relationships that favor/enable the creation of knowledge (social interaction, dialogue).
- Organizational intent.
- Autonomy of the members of the organization.
- Fluctuation and creative chaos (situations are inserted by management aiming to stimulate creativity).
- Superfluity or Redundancy (sharing among information organization members beyond immediate operational requirements, targeting intrusion learning).
- Great number of requirements (knowledge that comes from combining information quickly and flexibly).

- Organizational infrastructure (members of the organization can change context).
- Information technology (in the service of the circulation of the flow of information and knowledge in an effective way).

The results of this questionnaire are presented in Figure 3 below.

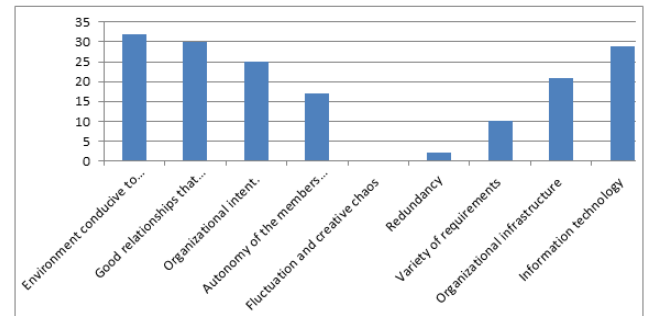


Fig. 3: Conditions that favor the creation, dissemination and socialization of knowledge in an organization present on the campus in the view of respondents. Source: Data obtained in the questionnaires

None of the respondents perceives it to be a practice of the school to carry out fluctuation and creative chaos. They do not identify it as a practice that pseudocrises, fictitious problem situations, are inserted by the administrators on the campus so as to stimulate the creativity of the servers to find solutions for them.

Only 6.1% pointed to redundancy or superfluity, the sharing among members of the organization of information beyond the immediate operational requirements, aiming at intrusion learning, as being present on campus.

Already, 97% of those who answered the questionnaires report that there is a favorable environment on the campus to share ideas through creative conversations. And the planning meetings are privileged places where this sharing occurs. It is the moment in which the pedagogical team and regent teachers (teachers who work in classrooms) present their ideas and these, collectively, are enriched by the contributions and participation of all those involved.

When questioned as to whether they perceived on the campus where they work that there are good relations that favor and/or enable the creation of knowledge, 90.9% answered yes. The social interaction and the dialogue are elements identified as present in the planning meetings, as well as in online or virtual communications, in which teachers exchange ideas for the construction of the work to be developed.

Regarding the organizational intention as one of the favorable conditions for the creation, dissemination and socialization of knowledge in an organization to be

present on the campus, 75.8% said they perceive this condition in their workplace. There are elements that prove that the *campus* has the intention to construct a collective working environment with dissemination and socialization of the knowledge that all can share. Those are:

- the existence of a common schedule between teachers of same school grade;
- the presence of a pedagogical team on campus, to make happen weekly work planning meetings and discussions about the problems experienced by teachers with their classes and students;
- in addition, the pedagogical seminars, held annually, are occasions when the campus presents the work developed for the entire community. There is also encouragement from the pedagogical team and even from the regent teachers that this work be presented in congresses and seminars in order to publicize the work done in the external community and society.

Teachers were questioned as to whether they perceived that members of the organization have autonomy for the creation, dissemination and socialization of knowledge on the campus, and 66.7% responded in the affirmative. After the presentation of the contents to be worked, of the objectives that they should achieve and from the discussions of possibilities of how the work can be developed, the teachers have the autonomy to carry out the work differently, attending to the interests and needs of their classes.

When questioned about the presence of the variety of requirements, that is, whether it is a common practice at school that solutions to the problems detected are solved by applying knowledge from the combination of information quickly and flexibly and by accessing information at all the levels of the organization, only 30.3% responded that they perceive this to occur in the school.

Teachers were also asked about their perception of whether the organizational infrastructure facilitates the creation, dissemination and socialization of knowledge, to which 63.6% gave the favorable answer. The institution conducts consultations among peers every three years for the renewal (or not) of the school's pedagogical team, and thus the members of the organization can change their roles, sometimes holding positions on the team of coordinating pedagogy for the school, sometimes being part of the team of regent teachers.

With respect to information technology, when asked if this effectively serves the circulation and flow of information and knowledge on campus, 87.9% of the teachers said yes. Teachers from different years of schooling and from different disciplines who work with the initial years of elementary education pointed out that

social networks and applications are great helpers that favor the circulation of information on campus and that it proves to be a facilitating tool for materials built collectively as well as ideas that are improved and shared among group members.

When questioned about whether, in their view, the planning meetings that the teachers participate in provide continuous in-service training for all teachers involved, 91% of the respondents said yes, 6% said that it was not, and 3% did not know how to respond.

The teacher-respondents cited actions developed in the meetings that provide continued training in service for all involved:

- In the planning meetings, the coordinators and the regent teachers present different work proposals. These proposals are collectively analyzed, discussed, expanded and then implemented. Subsequently, an evaluation is made of the work developed for new planning.
- In the planning meetings with the area coordinators and with the pedagogical guides, there is a discussion of the practices (the 'how to' in the classroom). Thus, with the participation and contribution of all involved, the practices are more dynamic and current.
- In the planning meetings, the pedagogical coordinators present and guide the teachers on how to use materials that stimulates the students and games in the classroom. In this way, some students are more effectively helped with their difficulties with the use of materials and concrete situations in which they are used.
- In the planning meetings, there is an exchange of experiences and information between all the teachers involved. The pedagogical supervisors carry out activities with the classes; they know the students and they exchange suggestions with the regent teachers about how to work with them. In addition, as these teachers often see the development of students over the years of schooling, they know their life histories and the problems their families are going through, and they exchange this information with the teachers who work with them within a given year of schooling. The system of pedagogical coordination presents alternative practices to be implemented with the students, which were developed in other years with other classes, but which proved to be successful experiences in that context.
- The campus pedagogic team encourages that teachers to document their work with the students and to present it at meetings, seminars, and conferences.
- At the planning meetings, there is a reflection on the part of the teachers, both the pedagogical team and the teachers in charge, as well as the exercise of their practices, in relation to the everyday experiences inside

and outside the classroom of all those involved at the meeting.

- The planning meetings provide for the sharing of ideas, knowledge, pedagogical practices and actions between the pedagogical team and the regent teachers.
- In the planning meetings, the pedagogical problems of the classes and the difficulties of the students are presented. After discussion, there is a collective survey of various teaching strategies, often innovative, respecting the diverse characteristics of the students and taking into account the difficulties encountered in each group.
- It is possible to share methodologies and activities to be developed in the moments in which the work is discussed. Often, after hearing the suggestions presented by the team, other ideas still appear in the meeting. In addition, sometimes, with the development of work, new paths are travelled.
- The pedagogical team guides the teachers in the development of the work in the planning meetings. From these guidelines, teachers are free to think about other proposals and/or extensions of those presented. In the meetings, there is the sharing of experiences with the group of teachers who work with that year of schooling.
- In the meetings, there is often the planning of activities differentiated according to the needs/difficulties of the students/classes.
- In the planning meetings, there is the exchange of materials and methodologies to be applied in classes. Members of the pedagogical team bring suggestions, and the classroom teacher presents their ideas.
- There is, on campus, the Nucleus of Attention to People with Special Needs (NAPSN). The core coordinator guides teachers on strategies for working with students with specific needs, both the regent teachers and those who interact with these students in the classroom, as well as those who perform Specialized Educational Assistance (SEA).
- The NAPSN coordinator provides teachers with information about the different syndromes or disorders that are presented by the students in the classes. It also gives guidance on how teachers can modify the work with these students in order to achieve their goals in the best possible way [13];
- The coordinator of educational informatics, the teachers of this discipline and even the teachers in other fields who are attuned to technology study and bring in new technological resources (software and hardware);
- The planning of interdisciplinary pedagogical projects, when the assembled campus thinks about the actions to be developed in order to achieve them, is a rich time for the exchange of experiences and opportunities for

continuing education for teachers. Teachers from all disciplines who work with the students and the pedagogical team present their proposals for work and, collectively, seek points where it is possible to integrate. In this way, team members think about the work as a whole, and there is an incentive to the research by the teachers for greater knowledge about the subjects to be approached.

- The dialogue that permeates the meetings allows the initial ideas presented by both the pedagogical team and the teachers to be improved and become a better quality work to be developed with the students.
- Planning always seeks to focus on the contextualization and integration of activities. The participation of all allows the development of a work in which the student has a more global vision of the world in which he/she lives. The exchanges of experience that happen favor the growth of all involved.

V. CONCLUSIONS

Based on the questionnaires and interviews, it was concluded that:

- Respondents indicate that in the school environment, they perceive the existence of several conditions that favor the creation, dissemination and socialization of knowledge and that such conditions favor the meetings for the continued in-service training of teachers.
- Respondents point to the existence of a favorable condition for the exchange of experiences in the planning meetings that result in the growth of all the participants.
- The preparation of a list of suggestions for the consultation of teachers to work, as well as the mapping of the best practices (with the record of the observations made by those who applied this work), is indicated by almost all the teachers on the campus as important so that possible flaws can be corrected.
- Organizational intent is also perceived as a present condition that makes a difference. The existence of common schedules between teachers working with the same year of schooling (in the timetable for teachers to stay in school), as well as the presence of a pedagogical team on campus, favors this social and professional interaction.
- The organizational infrastructure is noticed by most of the respondents as facilitator of the creation, dissemination and socialization of knowledge, since this is the case of a public institution that is obliged by Federal law, every three years, to make a consultation to fill the positions of pedagogical manager, coordinators and pedagogical guides.

- Most respondents feel autonomous in making some decisions about the work to be done with their classrooms, even though they understand that they do not have complete autonomy.
- Almost all of the respondents point to information technology as being a strong ally in this process of continuous training: the uses of social networks and applications facilitate the flow of information and knowledge flow effectively between groups for the development of work, serving as an extension of planning meetings.

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Performance Analysis of Anaerobic Baffled Reactor and Constructed Wetland for Community Based Wastewater in Dar Es Salam, Tanzania

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Abstract— *The treatment performance of community based (decentralized) wastewater treatment systems are not monitored by municipalities in Tanzania and therefore these systems pose pollution threat to receiving water bodies. The aim of this research is to assess and compare the treatment performance of existing community based technologies which are affordable, manageable and climate compatible in Tanzania. The selected existing decentralized technologies for this study were Anaerobic Baffled Reactor (ABR) found in Kigamboni, Dar es Salaam and Constructed Wetland (CW) found in Mbagala, Dar es Salaam. Wastewater samples in and out of these systems were collected and analyzed for physical, chemical and biological parameters. The observed average effluent concentration of BOD₅ (67.5, 90 mg/L), NH₃-N (276.6, 115.7 mg/L), PO₄-P (13.2, 17.7 mg/L) and FC (9 x10⁶, 4.2x10⁶ counts/100mL) in ABR and CW, respectively testified to an inferior standard of treatment caused by mismanaged operation and maintenance. Both ABR and CW with slight adjustment were found to be effective in removal of all physical, chemical and biological parameters.*

Keywords— *Community, wastewater, treatment, baffled reactor, Constructed wetland.*

I. INTRODUCTION

Selection of a proper wastewater technology and infrastructure is a daunting challenge and continue to be a priority issues in developing countries especially in Tanzania. The wastewater management proposed for the new city of Kigamboni is the centralized model by using Membrane BioReactor (MBR) technology for wastewater treatment (Hakiardhi, 2012; URT, 2010). The proposed technology is widely used in developed countries but not in Africa. In Africa, MBR is only available in cape Town, South Africa and in Casablanca, Morocco (Judd, 2015; Singhirunnusorn, 2009). However, research shows that, for developing countries centralized, mechanical

wastewater treatment options like MBR are not highly recommended, in some places many such plants have been neglected. As an example in Mexico more than 90% of the centralized systems were not functional (Flores *et al.*, 2009). The reasons behind neglect the treatment plants were related to failure of government to provide necessary operation and maintenance requirement. The selected technologies were not sustainable, sustainability in this context is not only that, the technology should be economical but also, should be socially acceptable, feasible in term of technology and institutions, and be environmental acceptable (Singhirunnusorn, 2009).

For the proposed eco-city of Kigamboni, there is a risk that, most operational cost, maintenance cost (material and equipment), energy cost will not be effectively expensed. Its common in developing countries that, decision makers tries to select expensive technologies, with a belief that, because technologies work better in developed countries, it will do it anywhere else. This is can be true, but most of such choices are not usually feasible in developing countries (Hophmayer-Tokich, 2006; Weichgrebe *et al.*, 2008). The impacts of selecting a non-sustainable wastewater treatment technology spreads beyond its immediate time of operations, it affects the future generation as well (Massoud *et al.*, 2009). Lack of expertise, and government support could result into ineffectiveness of the MBR technology for this new eco-city.

The aim of this research was to assess and compare the treatment performance of existing technologies which are affordable, manageable and climate compatible in Tanzania. The selected existing technologies for this study were Anaerobic Baffled Reactor (ABR) and Constructed Wetland (CW) found in Kigamboni and Mbagala, respectively. The study was conducted in years 2015-2016. These technologies are simple in design, construction, operation and maintenance, have low capital, operation and maintenance costs and they have

high efficiency in wastewater treatment (Mbvette *et al.*, 2001; Hoffmann *et al.*, 2011; UN-HABITAT, 2008; Zhang *et al.*, 2014).

II. MATERIALS AND METHODS

2.1 Site location

Wastewater sources for this study were collected from two sites. The first site is the Sludge Treatment Plant (STP) which is an anaerobic Decentralized wastewater treatment (DEWAT) plant run by UMAWA, the local community in Kigamboni area. The second site was the Constructed Wetland treatment at St. Anthony High school in Temeke district.

2.2. Experimental Methods

The Kigamboni Anaerobic Sludge Treatment Plant (STP - DEWATs system) found in Kigamboni comprise of biogas digester, Anaerobic Baffled Reactor (ABR) and it treats sewage collected from Pit Latrines and Septic Tanks (Figure 1 and Figure 2). It was designed to serves about 5500 people. Before the plant had been constructed, the sewage had to be transported to municipal waste

stabilization ponds for treatment. This plant also produces biogas energy which is used for cooking (Krzeminski *et al.*, 2012). The project was constructed by the German organization called Bremen Overseas Research and Development Association (BORDA), and commissioned the plant to UMAWA, a community-based organization from Kigamboni. The sizing of the plant is as follows, biogas digester (settling tank 50m³, Anaerobic Baffled Reactors 12 m³, Sludge drying bed 50m³, and the French drain 8m³. As detailed in table 1, the plant is designed to treat 4.8m³/day, this is the sum total the black water and grey water amounting into 1.4 and 3.4 m³/day respectively. The designed BOD, Total Nitrogen and Total Phosphorus is 97, 19 and 3 mg/L, respectively. The designed flow rate is 0.7m³/h. Wastewater from pit latrines are poured into biogas settler to settle big particles and trapping the biogas produced (BORDA, 2016). Currently the system is hydraulically overloaded and there is uncontrolled infiltration of storm water into sewer manhole that leads to under performance of the system in treatment of wastewater.

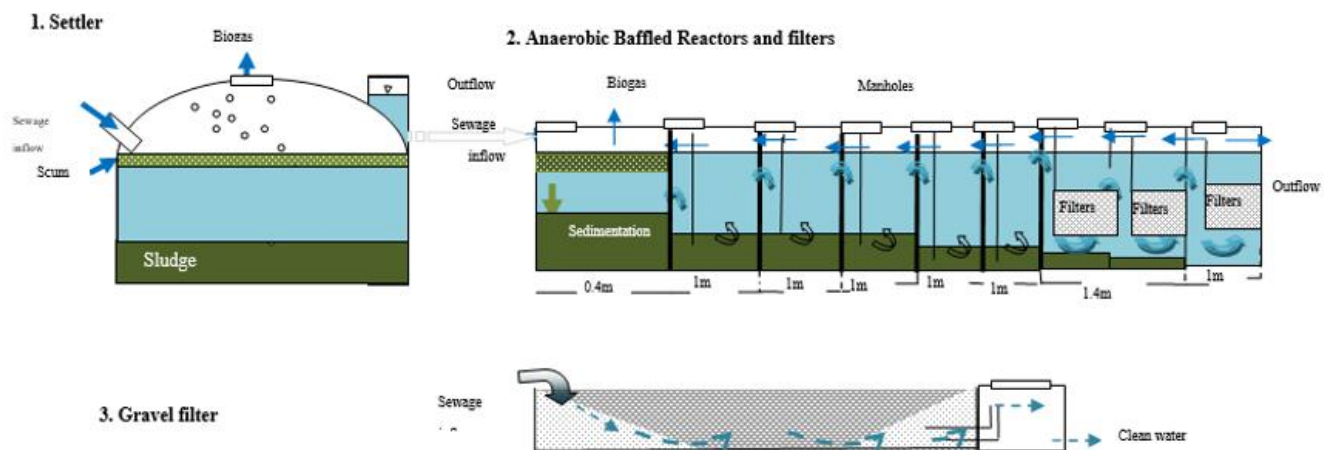


Fig.1: Schematic diagram of the sludge treatment plant operating in Kigamboni area

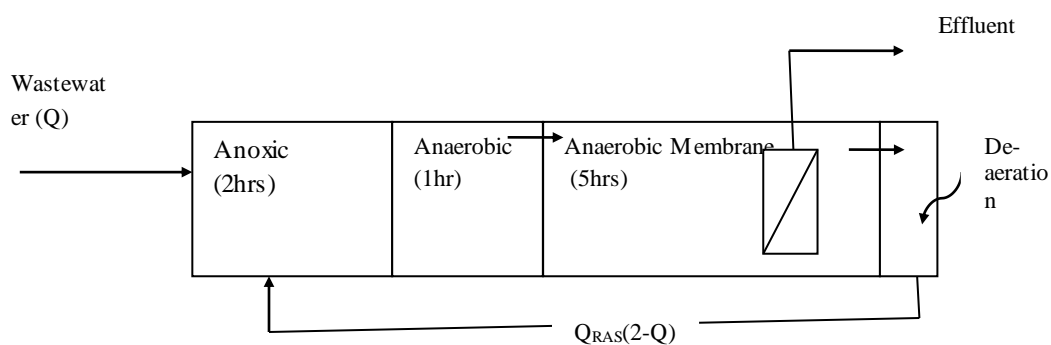


Fig.2: schematic process diagram of Hyundai Advanced Nutrient Treatment (HANT) Process according (Yoon *et al.*, 2004)

Table.1: Design parameters

Wastewater parameter	Flow (m ³ /day)	Suspended solid (TSS) (kg/day)	BOD -load (mg/L)	COD (mg/L)	Total-N (mg/L)	Total -P (mg/L)
Black water	1.4	0.2	265	559	59	3
Gray water	3.4	0.0425	25	51	3	3
Kigamboni STP inflow	4.8	0.3	97	204	19	3
Kigamboni STP effluent	4.8	0.01	40	80	16	3

Another wastewater treatment technology found in the study area is the constructed wetlands (CWs). There are four (4) CWs that are constructed in parallel at the St. Anthony High school in Mbagala (about 10 kilometres, outside of Kigamboni project area). The CWs serve about 2000 people (High school student). The dimension of each wetland cell is 15m x 5m x 0.6m. They receive wastewater from septic tank at a flow rate of 11 m³/day. The system is still new; it had an age of less than a year by November, 2015 a time of sample collection.

2.3 Sampling and Analysis of Parameters

The influent and effluent wastewater samples were collected from the anaerobic Sludge Treatment Plant (STP) located in Kigamboni area for a period of four months. Other influent and effluent wastewater samples were collected from the Subsurface Flow Constructed Wetland System (SFCWS) for the same period. Wastewater samples were collected from influent and effluent of ABR and CW for the laboratory analysis twice per month for four months from November, 2015 to February, 2016 and the average values for each month were used in data analysis.

Wastewater parameters analysed were physical (pH and temperature) Biological and Biochemical (Faecal coliforms (FC) and Biological Oxygen Demand (BOD₅)) and chemical (Nitrate Nitrogen (NO₃-N), Ammonia Nitrogen (NH₃-N), and Phosphate Phosphorus (PO₄-P)).

Table.2: Mean Effluents Performance of Different Physical, Chemical and Biological Parameters for (DEWAT)

Parameters	Mean (Avg) Influent	Mean (Avg) Effluent	Tanzania Wastewater Discharge Standards
pH	7.55	7.86	6.5-8.5
Temperature, °C	22	28	20 - 35
Phosphate (mg/L)	19.67	13.18	6
Nitrate-nitrogen (mg/L)	1.95	4.58	20
Biological Oxygen Demand(mg/L)	371	67.5	30
Total Suspended Solids(mg/L)	1784.8	1009	100
Ammonia -Nitrogen	231.8	276.6	7.5
Faecal Coliform(Count/100mL)* 10 ⁶	20.25	9	0.01

Physical parameters were analysed in situ using pH and conductivity meters. Chemical and biological parameters were analysed in Ardhi University Laboratory according to standard methods (APHA, 2012).

III. RESULTS AND DISCUSSION

3.1 Performance of Decentralized Wastewater Treatment (DEWAT), A BORDA based anaerobic baffled reactor Sludge Treatment Plant (STP) found in Kigamboni

The results of pH in the influent of this ABR plant ranged from 7.45 -7.66 with an average of 7.55 while in the effluent ranged from 7.51 - 8.18, with an average of 7.86 (Table 2). Generally the performance of this plant met the required national wastewater discharge standards which require that pH of effluent treated wastewater to be between 6.5 and 8.5 (TBS, 2005). The temperature in the influent and effluent ranged from 22 – 28 with an average of 25. The temperature and pH for the this plant is conducive for the microbial activities, they are within the accepted average of 25 °C and 6.5 to 9 for pH according to (Balthazar, 2014; Metcalf & Eddy, 2004; Elyasi, 2015; Hann, 2015)

The influent BOD concentration varied between 364 and 384mg/L with average of 374 mg/L. The average effluent BOD was 67.3mg/L which is above the designed effluent BOD for this DEWATS plant (40mg/L).

These values will affect the plant uptake. On other hand, effluent results of NO₃-N levers ranged from 1.4 to 1.95mg/L. This is a good result as it complies with the Tanzanian standards and even FAO recommend standard of a range 5-30mg/L. In theory, nitrification process is the one that, lead to higher values of NO₃-N. However, values of Ammonia-Nitrogen recoded was higher in the effluent, this could be due to anaerobic nature of ABR, does not allow oxidation of NH₄ to nitrite, and then to NO₃, this could be the reason of low NO₃ in this plant (Hann, 2015; Yoon *et al.*, 2004; Ahamed *et al.*, 2015; Krishna *et al.*, 2009; Li *et al.*, 2015; Xu-Sadri *et al.*, 2015). Values for phosphates concentration in the influent of this constructed ABR plant ranged from 17.5-21.5mg/L with an average of 19.6mg/L. Meanwhile, phosphates values in the effluent ranged from 11.3-15.5mg/L, with an average of 13.18mg/L (Table 2). This amount of the phosphate will be suitable for the users of treated wastewater, especially for the irrigation of landscape and urban farms. Values for (FC) count in the influent of this ABR 22.5 x 10⁶ -18 x 10⁶ count/100mL with an average of 22.5 x 10⁶ Count/100mL. Meanwhile, (FC) count values in the effluent ranged from 10 to 8 x 10⁶ Count/100mL, with an average of 9 x 10⁶ Count/100mL. The effluent values of FC are not in an acceptable range for the release in the environment (TBS, 2005), however if an additional chlorination is added to this water, the result will lead to the good water that could be even allowed for other domestic uses (Mwegoha *et al.*, 2013).

3.2 Performance of constructed wetland at St. Anthony High school, Tanzania

Values for pH in the influent of this constructed wetland ranged from 7.18 -7.46 with an average of 7.3 (Figure 3). While pH values in the effluent ranged from 7.15 -7.63, with an average of 7.4, these average pH results indicates that the variation in the influent and effluent is not significantly different. In terms of performance, this plant met the required national wastewater discharge standards which require that pH of treated wastewater effluent to be between 6.5 and 8.5 (TBS, 2005). The temperature in the influent and effluent ranged from 22.5 – 27.5 with an average of 25 (Figure 3). The temperature and pH for the this plant is conducive for the microbial activities, they are within the accepted range of 20-30 °C and 6.5 to 9 for pH according to (Balthazar, 2014; Metcalf & Eddy, 2004; Kihila *et al.*, 2014).

Values for BOD concentration in the influent of this constructed wetland ranged from 76-420 mg/L with an average of 156.8mg/L. Meanwhile, BOD values in the effluent ranged from 42-260mg/L, with an average of 90mg/L. The removal efficiency is 42.6%. The BOD values for effluent and influent for this wetland is shown in Figure 4. The effluent BOD is supposed to be 30mg/L

or below, to meet the allowable discharge standards (TBS, 2005). The higher BOD values in the effluents could be due to reason that the wetland is recently started to be operated and the wetland plants were still at early stage of growth during the time of the sample collection. This could mean that, there was no enough roots system for diffusing the oxygen from the plants to the wastewater (Sim, 2003). To improve the performance, close monitoring and compliance to the operation and maintenance requirement as stated in the operation manual, is required (Njau *et al.*, 2010).

The (NO₃-N) values for effluent and influent for this wetland is shown in Figure 5. Values for (NO₃-N) concentration in the influent of this constructed wetland ranged from 1.9 -25 mg/L with an average of 7.72mg/L. Meanwhile, (NO₃-N) values in the effluent ranged from 1.5 -21.5mg/L, with an average of 6.3mg/L. The removal efficiency is 18.4%. The effluent Nitrate values for this plant are lower than the required standard which is 20 mg/L (TBS, 2005). This could be due to low influent Nitrate values (Senzia, 2003; Bigambo, 2003).

The (NH₃-N) values for effluent and influent for this wetland is shown in Figure 6. Values for (NH₃-N) concentration in the influent of this constructed wetland ranged from 48 - 136.05 mg/L with an average of 123.1mg/L. Meanwhile, (NH₃-N) values in the effluent ranged from 35 - 134.2mg/L, with an average of 115.7mg/L. The removal efficiency is 6%. Effluent Ammonia-Nitrogen values for this plant are bigger than the required discharge standard which is 25 mg/L (TBS, 2005).

Values for phosphates concentration in the influent of this constructed wetland ranged from 16.4 -18.51 mg/L with an average of 17.7mg/L. Meanwhile, phosphates values in the effluent ranged from 12.34 -16.1mg/L, with an average of 14.7mg/L. The removal efficiency is 16.9%. The effluent values of phosphate are relatively high than the allowable discharge a standard which is 6mg/L (TBS, 2005).

The Fecal coliform (FC) values for effluent and influent for this wetland are shown in Figure 7. Values for (FC) count in the influent of this constructed wetland ranged from 5 x 10⁶ -18 x 10⁶ count/100mL with an average of 12.8 x 10⁶ Count/100mL. Meanwhile, (FC) count values in the effluent ranged from 3 to 6 x 10⁶ Count/100mL, with an average of 4.2 x 10⁶ Count/100mL. The effluent values of FC are not in an acceptable range for the release in the environment (TBS, 2005), however if an additional chlorination is added to this water, the result will lead to the good water that could be even allowed for other domestic uses. One of major source of the faecal contamination in the aquatic environment is the wastewater effluents, faecal contamination lot of problems in human health and environment. When

thinking about water reuses for sensitive functions it is important to consider the wastewater treatment that

efficiently remove fecal to large extent (Mwegoha *et al.*, 2013).

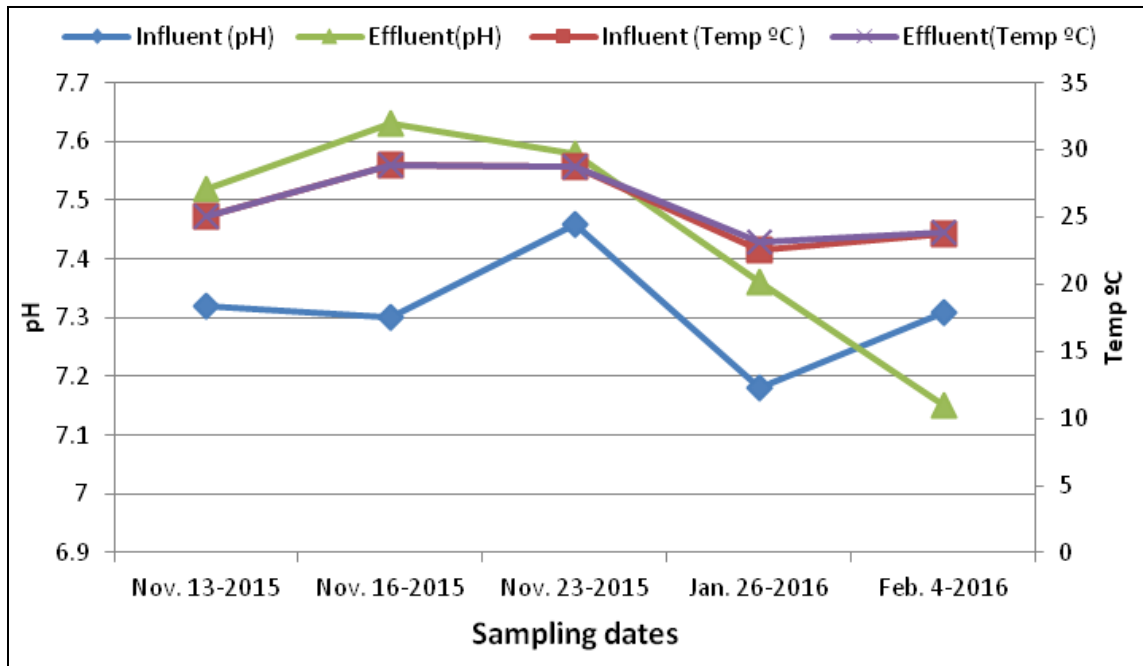


Fig.3: Variation of pH and Temperature

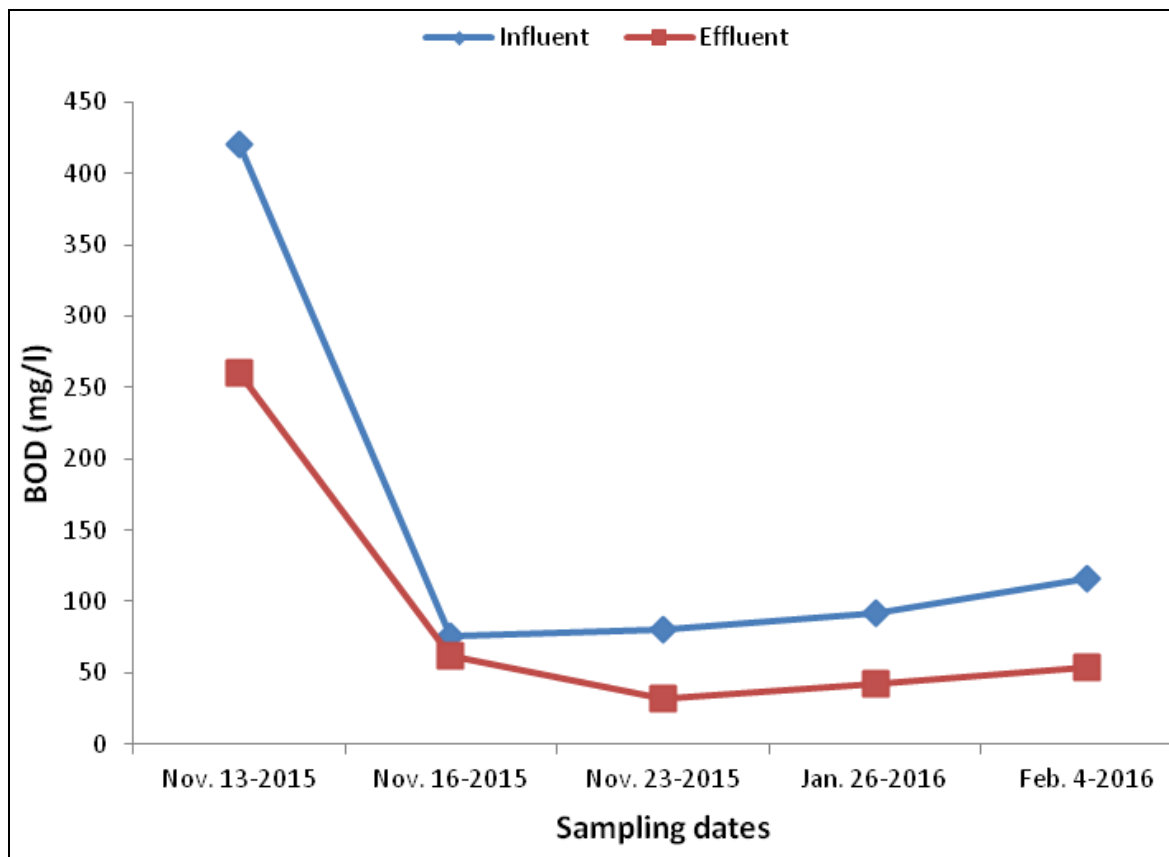


Fig.4: Variation of BOD

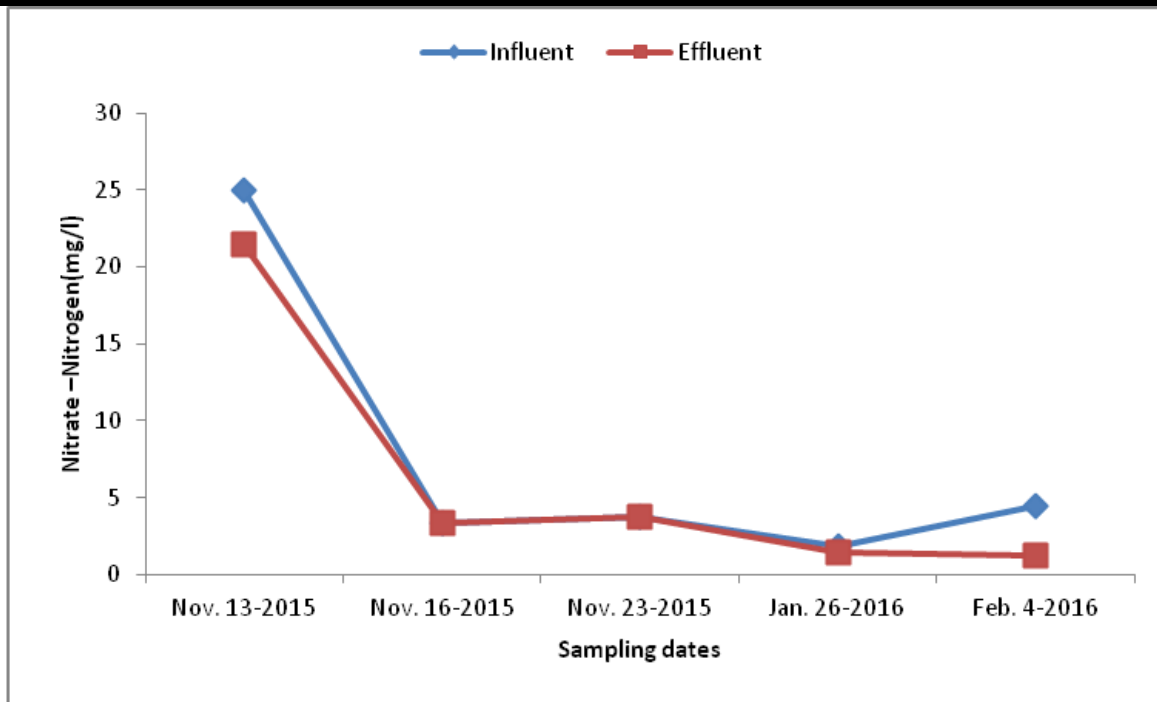


Fig.5: Variation of Nitrate Nitrogen

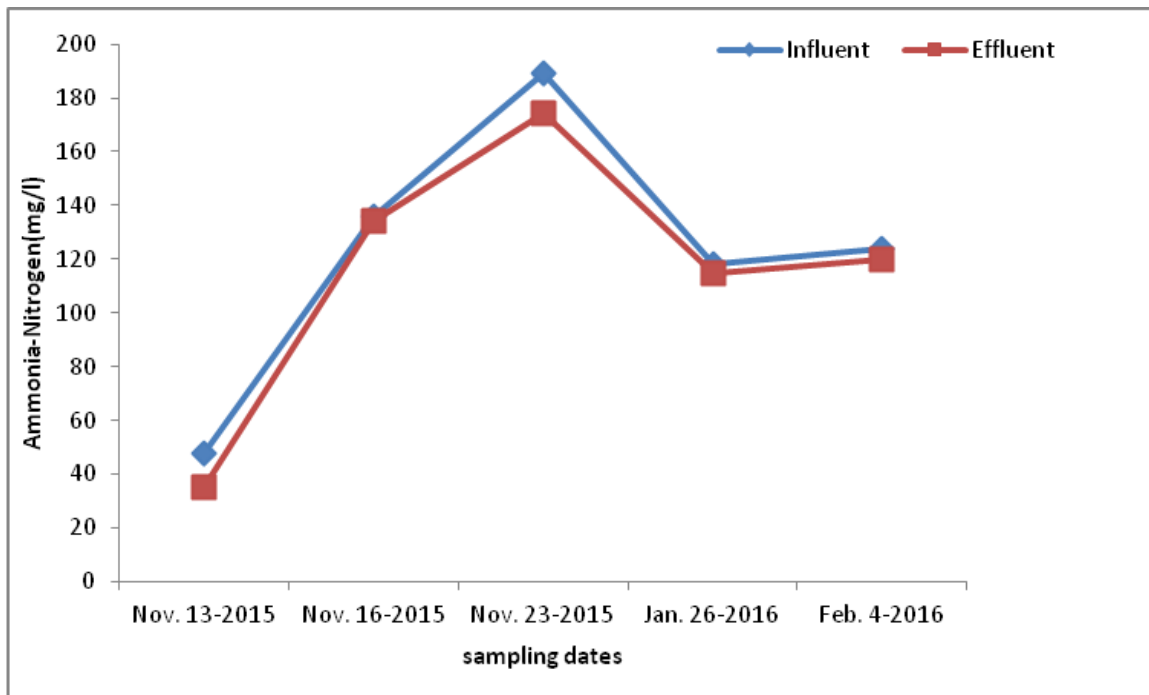


Fig.6: Variation of Ammonia Nitrogen

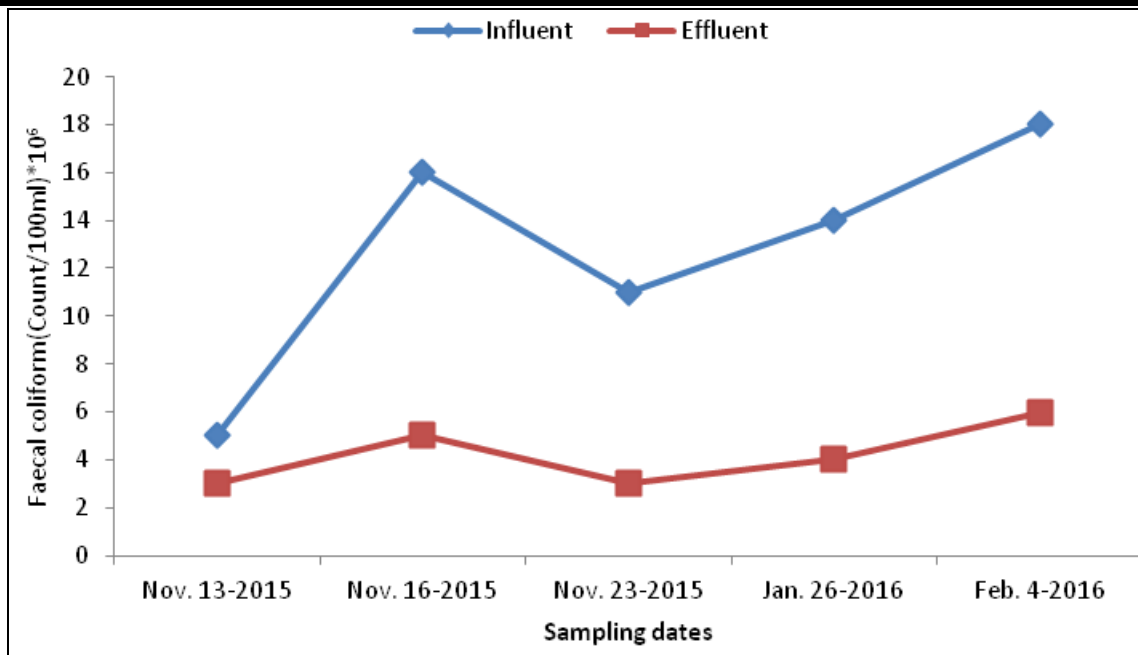


Fig.7: Variation of Faecal Coliforms

IV. CONCLUSIONS

In general, performance of this ABR plant was not producing good-quality of treated wastewater effluent. The reason for inadequate performance is that, wastewater and faecal sludge feed into the treatment plant is about 10-15 m³/day, this is up to three times higher than designed capacity, this ABR plant is designed for 4.8m³/day. The overloading is due to increase of number of household that, use this treatment plant, initially only 5500 people was using this but now up to 15000 people are use this plant, these people who mainly use pit latrines and septic tanks, prefer this ABR services instead of the municipal waste stabilization ponds for treatment, which is far and costly for them. Because of this, hydraulic overlaying resulted into poor removal performance of BOD and other parameters such as NH₃-N, PO₄-P, FC. Large amount of wastewater was not properly treated. The designed flow rate emptying or releasing wastewater the plant is 7m³/h. The operated flow rate was higher beyond its designed capacity; this is because the wastewaters are emptied at high speed from the tank to the treatment plant. Because of high speed of inflow rate at the influent chamber of the settling tank, it affects the performances of the Anaerobic Baffled Reactors (ABR), as wastewater does not settle in the active sludge and therefore not properly perform anaerobic treatment. In this plant, there are four ABR in series, so the wastewater retention time is shorter than expected. Also wastewater tends to bypass the horizontal sand filter, which is in the land chamber to polish the final effluent. To ensure discharging standards are met, this study, suggest that, wastewater and faecal sludge inputs have to be as per design. The efficiency of ABR will increase when the input of big quantities of water is loaded slowly in the

digester. It is recommended that a pipe with small diameter be used to feed the digester.

The performance for these CWs in removing pollutants is relatively low 6% - 43% and this could be due to the reasons that, the wetland cell is still new (with an operation period of less than 1 year), wetland plants are still at early stage of growth and therefore there is insufficient oxygen released to the CW that lead to limited growth of aerobic bacteria who are responsible for aerobic decomposition of organic matters. However, literature concludes that, properly designed, operated and maintained constructed wetlands have high performance in removal of pollutants from wastewater, the performance in the removal of pollutants reaches up to 99.0% (Balthazar, 2014; Kimwaga *et al.*, 2013).

Both ABR and CWS with slight adjustment were found to be effective in removal of all physical, chemical and biological parameters.

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Fuzzy Inference System for fault detection in internal combustion engines in Thermoelectric Power Generating Plants

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Abstract—In this work, an approach to implement a simplified fuzzy inference model for monitoring the conditions of workings of power generators through the pressure values of combustion temperature and engine water pressure is displayed. The model helps the supervisory system, through real-time evaluation of the operating conditions of the engine in percentage rates. The application of tools based on computational intelligence, have shown efficiency in various areas of industrial engineering.

Keywords— *Computational intelligence, Fuzzy logic, Internal combustion engine, Monitoring.*

I. INTRODUCTION

Generation of Electric Energy (EE) is increasing in developing countries due to the massive consumption of EE, although in Brazil the main source of EE be Hydraulic generation with 66% of total generation (Trindade, Sperling, & Bourbon, 2017), Still have a significant percentage coming from non-renewable energy sources accounting for 18%, in northern Brazil 18.2% of the total energy are Thermoelectric (EPE, 2017). In Brazil, it uses the thermal energy in a strategic way, as it can be produced in a constant amount throughout the year, unlike hydropower, which have the dependent production level of rivers (Lima & Souza, 2014). Power generation by motor generator (MG) is strategic but with a high cost of deployment and maintenance.

Because of this high cost, predictive maintenance based on the MGs runs parameters, is earning more and more importance in preventing failure of these engines. Because of the critical features that this equipment is for power systems, especially in developing countries. Several techniques for fault detection in MGs have been applied, such as: Martinez uses a model-based approach with a multi-variable generation of waste from the main fault situations, arranged in a matrix characteristic of fault signatures, establishing a standard reference to continuously evaluate waste in on-line operating conditions (Coronado-Martinez, Ruiz-Sanchez, & Suarez-Cerda, 2017). Fonseca performs a diagnosis of the technical conditions of the engine using a lubricating analysis, vibration analysis, and thermography (Fonseca, Bezerra, Brito, Leite, & Nascimento, 2018).

A new technique for failure prediction in a plant controlled by computerized SCADA system (Mayadevi, Vinodchandra, & Ushakumari, 2012), A method that detects combustion failures caused by a fuel deficiency in a cylinder, even in its early stages is presented by Nieto (Nieto, Blazquez, Platero, & Casado, 2017). A cylinder balancing method is disclosed which minimizes the crankshaft torsional vibrations at medium speed internal combustion engines (Ostman & Toivonen, 2008).

A systems Supervisory Control and Data Acquisition are designed to allow human operators supervise, maintain and control critical infrastructure (Samtani, Yu, Zhu, Patton, & Chen, 2016), Sanchez and Suarez for fault

detection in fossil power plants operation using recurrent neural networks (Sanchez, Suarez, & Ruz, 2004).

This paper proposes a fuzzy inference model for detection and modeling of incipient faults in combustion engine components of the power generators.

The proposed method allows detection of incipient faults in the main motor, whereas the values of the following quantities: the combustion pressure in the cylinder, and cooling water temperature and pressure.

The proposed failure patterns are based on values set in the characteristic structure of the machine so that they can be reproduced in a wide range of sets of motorcycle generators. The advantages of the proposed system are its low intrusiveness, simplified deployment and cost efficiency.

II. LITERATURE REVIEW: FUZZY INFERENCE SYSTEMS

Fuzzy logic was initially defined by Zadeh (Zadeh, 1965) and presented in scientific circles through his article "Fuzzy Sets" published in the journal Information and Control (Chenci, Rignel, & Lucas, 2011). Zadeh introduced the concept of fuzzy sets defining them in terms of mapping a set in the unit interval on the real line (Brown, 1971).

The problem of making decisions to classify the objects of the universe into two or more classes was considered

appropriate in the context of the theory of fuzzy sets (Capocelli & De Luca, 1973). Fuzzy logic is a logic based on the theory of fuzzy sets (Gonçalves, Junior, Leite, da Costa Junior, & de Lima Tostes, 2013).

It differs from traditional logic systems in their characteristics and their details. In this logic, the exact reasoning corresponds to a limit case of approximate reasoning, being interpreted as a writing process of fuzzy relations (Gomide & Gudwin, 1994).

The fuzzy logic is the point of an input spatial map to an output space, and the main mechanism to define this space is a list of if-then rules called instructions. Unlike conventional logic, Fuzzy logic uses the idea that all things admit membership degrees (Marro, Souza, Cavalcante, Bezerra, & Nunes, 2010) (Pereira, Bighi, Gabriel, & Gabriel, 2008).

The fuzzy inference model adopted for the failure prediction system of the engine is based on computer simulations of the combustion pressure in the cylinder values and cooling water temperature and pressure, selected as relevant variables for analysis.

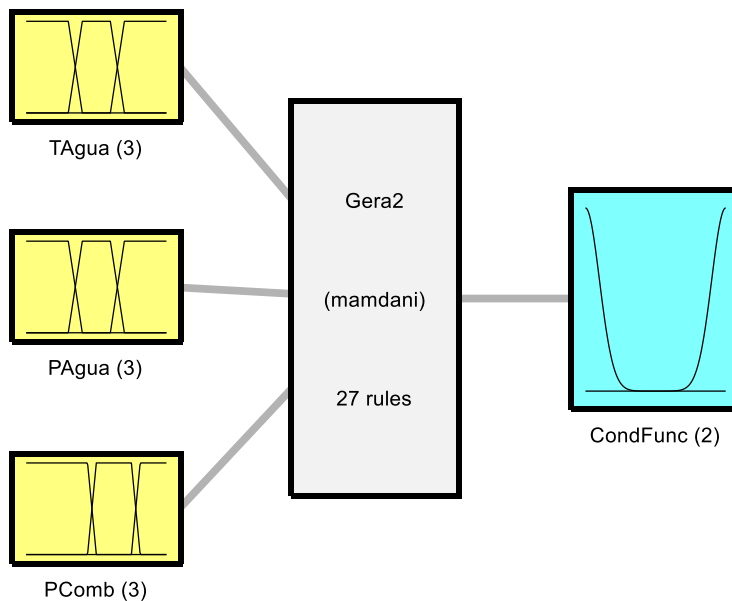
So it can be built the system that interprets the rules, you must first define all terms adjectives that describe them.

As an example, the description of the membership functions with numeric range and the linguistic value of each selected variable, are presented in Table 1:

Table.1: System Suitability functions.

Type	Linguistic variables	set Cloudy	Numeric range	description
Input	Water temperature (TAGUA)	Low	[0 - 100]	The expected value for the water temperature is between 40 and 80 degrees Celsius.
		Normal		
		High		
	Water Pressure (Pagua)	Low	[0 - 6]	The expected value of the water pressure is between 2 and 5 bar.
		Normal		
		High		
combustion pressure (PComb)	Low	[0 - 220] to	The expected value for the combustion pressure is between 40 and 180 bar.	
	Normal			
	High			
Output	CondFunc	Normal	[0 - 100]	The expected value for stability is up to 50 points.
		Not normal		

In Fig. 1, is shown implementing the inference model proposed for failure prediction in the GUI area of the user.



System Gera2: 3 inputs, 1 outputs, 27 rules

Fig.1: Input variables and system output.
 Source: Author (2018)

Once selected the number and shape of the membership functions, it must be determined for each of the membership functions, the values associated with the high and the low relevance, and the amounts of the maximum of 1 (one) and the values associated the minimum membership is equal to 0 (zero)(Medeiros, de Mello, & Campos Filho, 2007). This procedure is different for the different shapes of the membership functions available on MFLT. The most commonly used formats for membership functions are triangular (trimf), trapezoidal (trapmf) and Gaussian (gaussmf).

Regarding the description of the variables they represent the knowledge of the expert in the fuzzy inference being termed as input variables and system output, matched linguistically representing inaccuracy mode (Nogueira & Nascimento, 2017)(Poletti & Meyer, 2009). Thus, the variables of the proposed system are:

Tagua- The limits for the variable values of water temperature are set between 40 and 80 degrees Celsius. The fuzzification of this variable is trapezoidal, seen in Fig. 2.

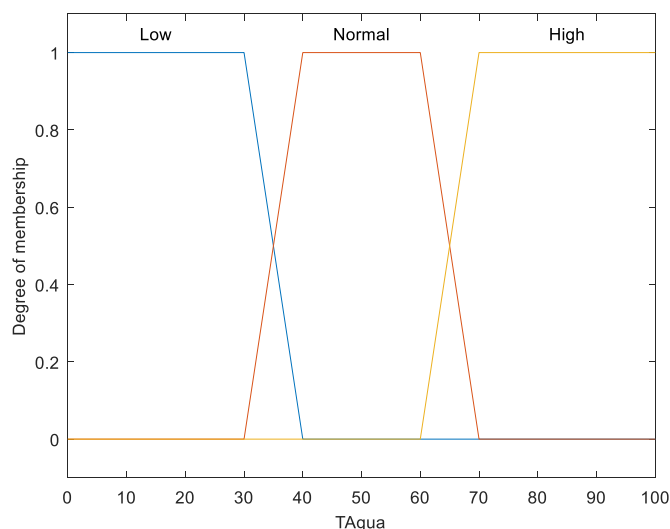


Fig.2: Tagua input variable.

Pagua- The limit values for the water pressure are set variable between 3 and 5 bar. The fuzzification of this variable is trapezoidal, as shown in Fig. 3.

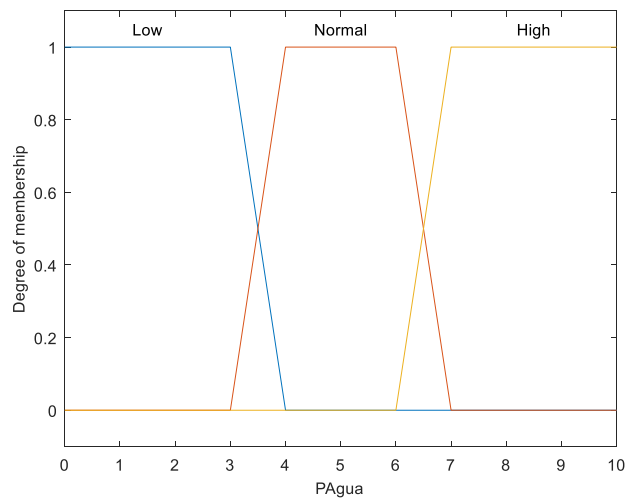


Fig 3: Pagua input variable.

pComb- The limit values for the combustion pressure variable are set between 80 and 120 bar. The fuzzification of this variable is trapezoidal, as shown in Fig. 4.

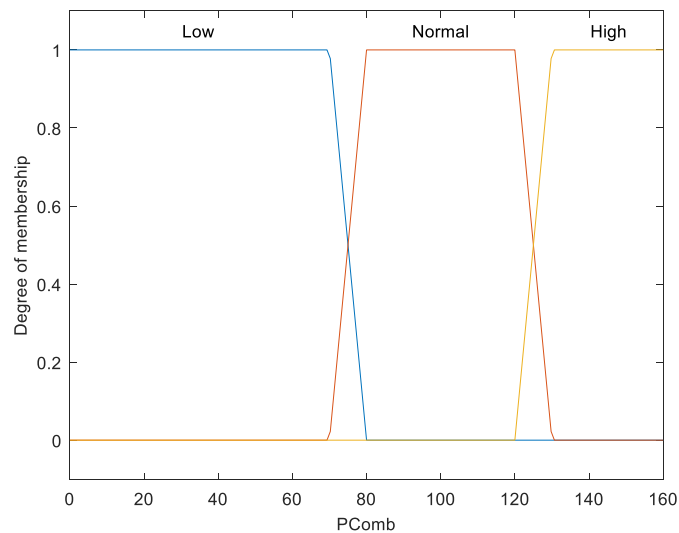


Fig.4: Pagua input variable.

CondFunc - associations of input variables are related to the output variable operating conditions, which has a fuzzification shown in Fig. 5.

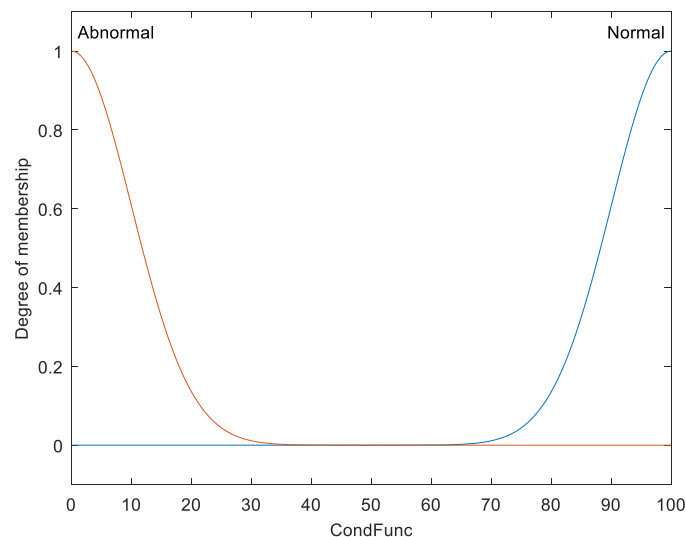


Fig.5: Output variable CondFunc

The demonstration of the basic inference rules of the language variables of the proposed system, resulted in 27 combinations applied in this fuzzy solution, which part can be seen in Fig. 6.

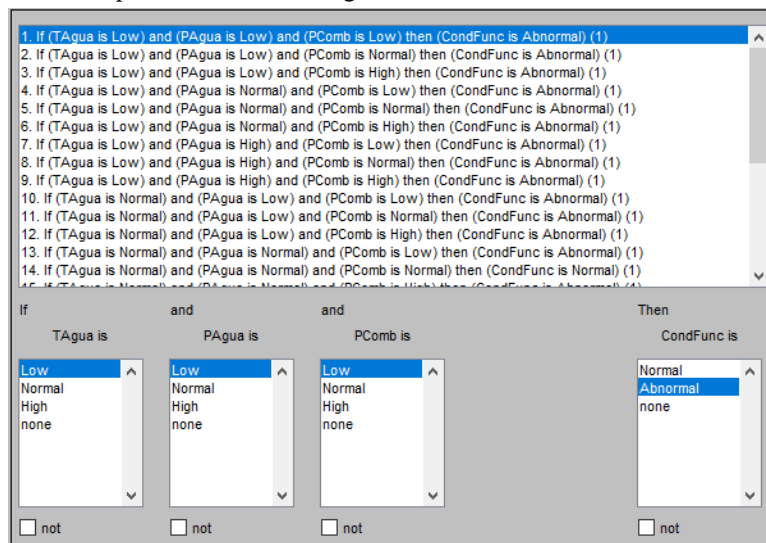


Fig.6: Combination of Inference Rules

III. ANALYSIS OF THE APPLICATION OF THE PROPOSED SYSTEM

In the viewer rules, the data is arranged in a graphical interface that facilitate the simulation and interpretation of various scenarios by combining values for the variables of the system inferences, showing the functions that reflect the overall result of the system. Adopting hypothetical input values, considering them wherein for the water temperature input variables is 50 Celsius, the water

pressure of 5 bar and combustion pressure of 100 bar, resulting is an operating condition 99.5 %, i.e. a favorable environment for the operation of the motor generator. By varying the input values, it is possible to evaluate the outputs of the proposed system, obtaining a value that allows a correct analysis of the efficiency of the method adopted for fault detection in motor operation, seen in Fig. 7.

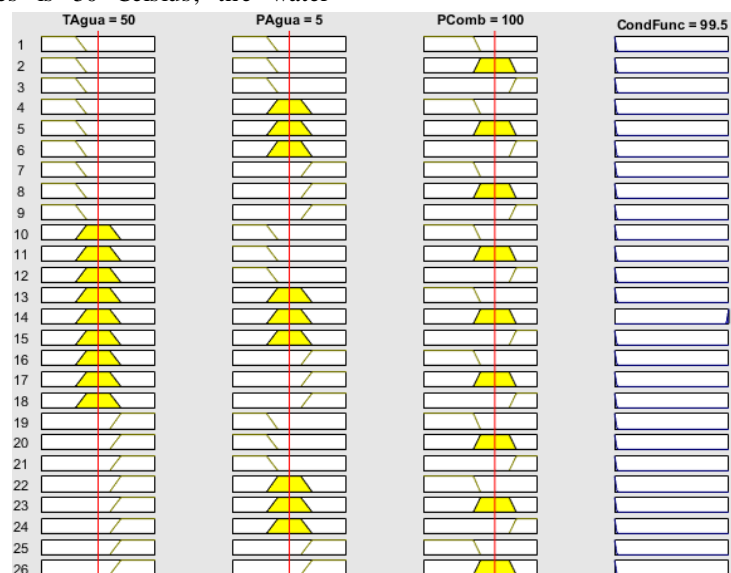


Fig.7: Viewer of Inference Rules

In Fig.7, it can be seen that for values within defined limits established for each input variable, the machining condition is present in 99.5%, a reliable value for the continued operation.

In any other operating condition exceeds the upper or lower limits of normal for the variables defined, has a worst case scenario for operation of the motor generator, is indicated shutdown for maintenance of the same, observable in FIG. 8.

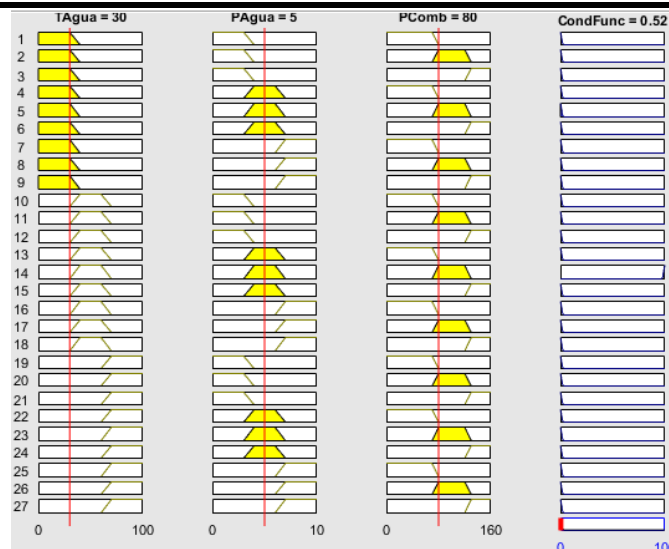


Fig.8: Viewer of Inference Rules

Fig. 8 shows the machine operating conditions (0.52%) unacceptable for continuity of operation due to the fact that the temperature of the water (30) is outside the predefined limits.

Fig. 9 shows the resultant surface plot of the proposed system.

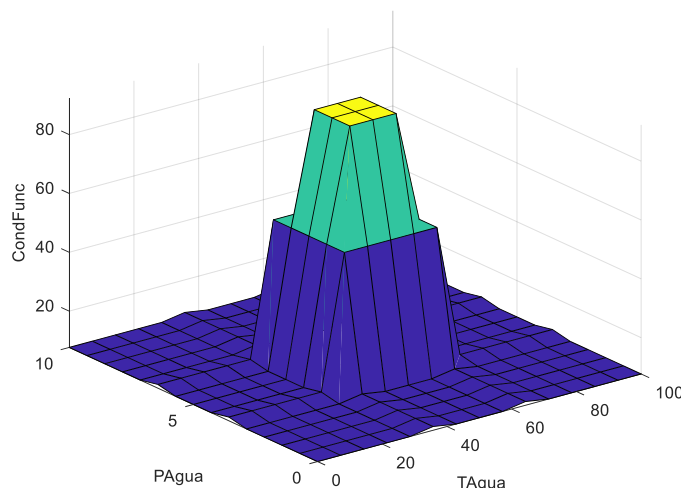


Fig.9: Surface Chart

IV. CONCLUSION

The approach proposed by the model of Fuzzy Inference proved to be streamlined and efficient for monitoring and fault detection in the operating conditions of the engine generator, enabling greater reliability and security for the protection systems. The monitoring of the variables pressure and the combustion temperature and the engine water pressure with the application of fuzzy logic proved adequate to support decision making regarding the operating conditions of the power plant generators.

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Computer Simulation and Fire Drill in an Educational Building

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Abstract — *Despite the evolution of computational models for evacuation simulations, there's still some doubt if they can generate accurate results. The objective is to analyze and compare the evacuation times of a fire drill and a computer simulation in an educational building. The method consisted of a fire drill with prior notice of a 4-floor building with classrooms in a public university. A computational model was developed for the same building and population using the evacuation simulation software Pathfinder. The results were that the evacuation times observed in the computer simulation were slightly lower than the times of the fire drill because people covered smaller distances due to the random distribution performed by the Pathfinder software and because in the drill some time was spent for the start of the movement toward the exit, which was estimated at around 30 seconds, while the software was configured for a pre-movement time equal to zero. The use of the computer simulation, therefore, proved to be an effective solution to replace the fire drill, since it allows for the identification of design failures and for the simulation of different scenarios in less time and without the need to mobilize people.*

Keywords— *Computer Simulation, Evacuation Time, Fire Drill, Fire Prevention, Human Behavior, Means of Egress.*

I. INTRODUCTION

In Brazil, the emergency exit system and other fire protection systems follow the prescriptive methods defined by federal and state standards. With regard to the design of the emergency exits in buildings, NBR 9077 [1] considers the capacity method, which specifies the minimum dimensions for the accesses, corridors and doors in relation to the floor with the largest population.

These prescriptive systems have limitations as they don't consider such variables as those related to human behavior during a fire, which is also subject to the heat, smoke and toxic gases arising from the fire. Codes based on performance usually take these conditions into account [2].

The variables used to design emergency exits are directly related to the evacuation time of the building, because the dimensions of the exits must allow for a certain population to leave a site before environmental conditions reach a critical point. The option of designing exits using computational evacuation simulation models enables designers to design buildings based on the performance of exits. With the computational models, it is possible to model the building and the population, enabling the estimation of the time required for the occupants to safely evacuate a building still in the design phase.

However, there's still some doubt if a computational evacuation simulation model can produce accurate results, bearing in mind that the assumptions may lead time to overly optimistic or conservative estimates. In addition, studies carried out in educational buildings are scarcer than studies in residential buildings.

As such, the objective of this article is to analyze and compare the evacuation times of a simulated evacuation drill and a computer simulation in an educational building.

II. EVACUATION OF BUILDINGS IN EMERGENCY SITUATIONS

2.1 Human behavior in emergency situations

In order to develop a fire safety design, the designer must not only study passive and active fire protection systems, but also human behavior in an evacuation situation.

According to Kuligowski [3], human behavior in fire situations is the study of human response, including the attitudes, decisions, behaviors and strategies used by people exposed to fire and in other similar emergencies. The main focus of the research in this field is to minimize the risk to people during an emergency situation.

According to Gwynne [4], the studies focusing on human performance in fire situations considering psychological and sociological factors are overshadowed by the emphasis given to research focusing on physical fire safety sciences. This fact is due to the lack of and difficulty in obtaining data related to human performance in fire situations.

For Kuligowski [5], the currently used assumptions in the calculation techniques regarding human behavior in an emergency situation can produce inaccurate results. In cases in which the assumptions lead to overly optimistic or conservative evacuation times, buildings and safety procedures may be designed too leniently on the one hand, or too burdensome and costly on the other.

For Kuligowski [6], the integration of the different fields of social sciences, such as sociology and psychology, would allow the expansion of knowledge in the field of human behavior in fire situations. As a consequence, buildings would become safer, benefiting the practice of engineering and preserving the lives of the people affected by the fire.

2.2 Evacuation time

The time taken for the complete evacuation of a building depends on several factors. According to Purser and Bensilum [7], the evacuation time depends on the time required for the detection of the emergency, the alarm system, the response to the alarms (pre-movement time), the profile of the occupants (such as age, physical and mental ability, asleep or awake, population density), the pre-egress behavior (such as looking for information, gathering belongings, the choice of exit and other activities), the egress (including guidance, movement toward an exit, the flow of the crowd and other factors), the design of escape routes, the number and width of exits, and the psychological and physiological influence on the flight behavior of the exposure to heat and smoke.

For the BSI (British Standards Institution) [8], the time required for safe evacuation (RSET - Required Safe Escape Time) must be less than the time available for safe evacuation (ASET - Available Safe Escape Time), i.e., the time required to evacuate a building must be less than the amount of time in which environmental conditions become unsustainable.

One of the first definitions of the times that take a fire into account includes the following definitions, according to the BSI (British Standards Institution) [8]:

- Detection time of the fire: the elapsed time since the ignition until the detection of the fire by an automatic system or by the first person to notice the fire. It depends on the type of fire detection system installed. An automatic detection system is the most recommended;

- Alert time: time between detection and the general alarm. This time can vary from 0 seconds (when the detection system is automatic) to several minutes (when the alarm system works in stages or is manually activated).

- Recognition time: the time interval between the time the fire alarm is sounded and the first person to respond to the stimulus;

- Response time: the time interval between the time when the first person notices the alarm and the moment when the first movement toward an exit is carried out. At this stage, people perform such tasks as investigating the situation, alerting others. The sum of the recognition and response times is called the pre-movement time;

- Travel time: The time starting with first movement and ending when the person reaches a safe place. Several factors influence this time, such as the physical and mental characteristics of the occupants.

2.3 Real Evacuation Simulations

The legislation dealing with the emergency plan, whether it is the national standard ABNT NBR 15.219/2005 [9], or state standards as the IT 016/2011/CBMSP [10] and the IN 031/2014 DAT/CBMSC [11], includes recommendations on fire drills in buildings, which should be performed periodically and recorded in documents including an assessment of the drill and the respective correction of the occurred failures.

In the particular case of higher-education buildings, the frequency of the fire drills is essential due to the entry of new students. Preferably, fire drills should be scheduled at the beginning of each semester to familiarize new students with the emergency procedures.

Peacock et al [12] reported that real emergencies provide realistic information about human behavior in fire, but also that data on such emergencies are harder to obtain than the data of fire drills. The data obtained through fire drills provide approximate results of human behavior in an emergency situation, making it possible to verify the efficiency of the exit systems in a building.

According to Gwynne et al. [13], the evacuation of a building on the real scale involves a drill that is representative of the evacuation of a target population, an approach that brings financial, ethical and practical problems regarding its viability. The ethical problems are related to the behavior of the persons involved and the lack of realism of the simulation, since people will not be subject to the heat, smoke and gases generated by a real fire. The practical problems are related to the fact that the

implementation of only one fire drill will not provide satisfactory answers to draw conclusions. The financial problem is related to the high cost to perform several fire drills, since one single simulation won't provide sufficient information. It is also clear that the fire drills are conducted after the construction of the building and if modifications to the building prove necessary, these can be expensive.

Kuligowski et al. [14] used fire drills to observe the speeds of people with reduced mobility on stairs. According to the authors, this data will assist in the development of computational models that engineering professionals can use to determine the time required for a safe evacuation in performance-based designs. Sano et al. [15] performed fire drill in a 25-floor building and obtained various information related to human behavior in an evacuation situation, more specifically on stairs, such as the walking speed, density and flow rate of people.

Although they don't present enough data for the design of emergency exits, fire drills are very important for the population of the building, the fire brigade and fire fighters. The people who participate in a fire drill put the emergency plan of a building into practice in order to verify whether the plan is working satisfactorily, and they provide relevant information for professionals who develop fire prevention designs [16].

2.4 Computational Models for Evacuation Simulations

Computational models for evacuation simulations are computer programs that assist fire engineering professionals in the design of emergency exits through mathematical models. Figure 1 shows the classification of evacuation models proposed by Kuligowski [17].

According to Kuligowski [18], in the behavioral models the occupants perform actions during the evacuation, in addition to moving to a safe location. These models can assign decision power to the occupants regarding the performance of actions as a result of the conditions existing in each design.

The movement models are those in which the occupant moves in the direction of the exit or to a safe location. This model is important to check areas of congestion and bottlenecks in the simulated building. The partial behavior evacuation models begin to simulate the behavior of the occupants. It is possible to represent pre-evacuation times, insert occupant characteristics, smoke effects.

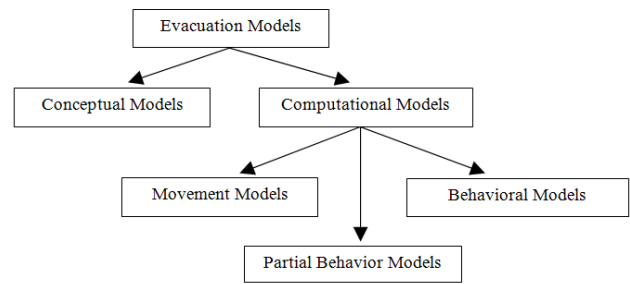


Fig. 1: Organization of Evacuation Models

In order to guide users in selecting the best computational model for the evacuation simulation, Kuligowski et al. [18] analyzed 26 currently used computational models. In this study, the models were separated into categories, such as availability of use, modeling method, display type and compatibility with CAD (computer-aided design). The categorization of the models makes the user's decision regarding the model more appropriate for the design in question.

III. METHODS AND PROCEDURES

The object of study of this research is a 4-floor classroom building, called Bloco A, of a public university located in the Southern region of Brazil. Bloco A has a total area of 5,344 m². Table 1 presents the characteristics of the building Bloco A (Figure 2 and 3) and Table 2 show the number and the dimensions of the existing emergency exits.

Table 1: Characteristics of Bloco A

Total Constructed Area	5,344 m ²
Ground Floor Area	1,945 m ²
First, Second, Third Floor Area (each)	1,133 m ²
Classrooms	27
Administrative Rooms	8
Number of Elevators	3
Height between the exit floor and the last floor	11.20 m

Table 2: Emergency exits in Bloco A

Emergency Exit	Quant. (un)	Dimension (m)
Corridors	2	2.50
Protected Stairs	2	2.20
Stair doors	2	1.40
Auditorium doors	2	2.00
Exit floor doors	2	2.00
		1.65



Fig. 2: Picture of the classrooms of Bloco A

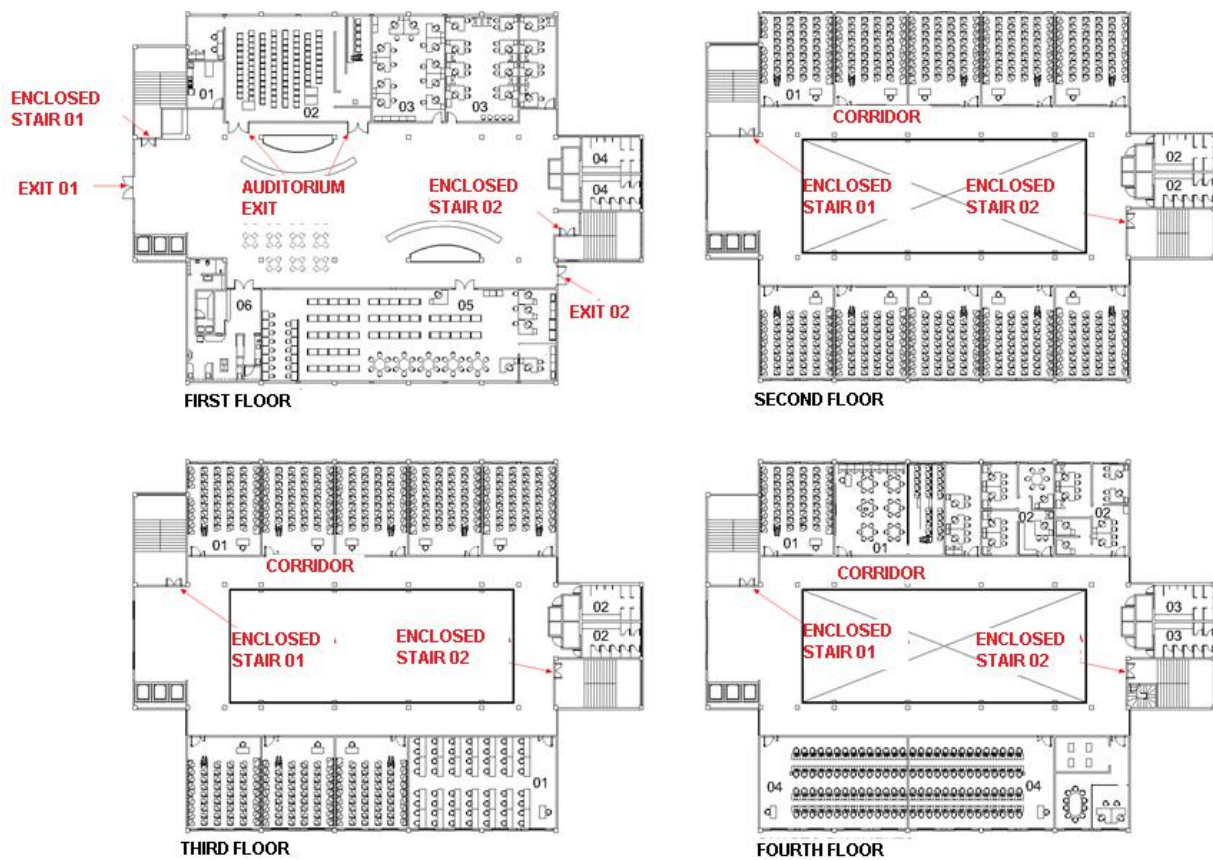


Fig. 3: Floors, Bloco A

3.1 The Simulated Building Evacuation Drill

The simulation drill was held in the context of a university that has an active emergency plan for all buildings on the campus. In case of an emergency, the users of the buildings should follow the emergency procedures as defined in the plan. To assist and signal the escape routes and installed fire protection systems, the buildings have emergency layouts displayed in all the rooms. Next to the two emergency exits on the ground floor, the emergency layouts of the building are displayed signaling the meeting points in case of an emergency.

A simulated drill was performed to observe the performance of the emergency exits of Bloco A, in addition to the behavior of people during the evacuation of the building. The drill was coordinated by the fire brigade and trainees from the university and it counted with the participation of the local Fire Department. The coordination team consisted of 12 people with the following functions during the drill: five people pointing out the exits on the floor and checking for the presence of people inside the rooms; two people pointing out the exits on the ground floor; two people pointing out the meeting

points outside the building; three people filming the building's evacuation, two of which focusing on the ground floor doors and one inside of the protected staircase 1. Three firefighters of the Fire Department also observed the drill.

The drill was performed with notice, i.e., all students, teachers, technicians and contractors were warned about its occurrence. The notices were sent via email and also announced twice in the classroom: a week before and on the day of the drill. In the classroom, the fire brigade not only informed the day and time that the exercise would be carried out, but also gave a brief training on the evacuation procedures of the building. The drill began at 9h25min with the activation of the fire alarm system consisting of a visual and audible warning. The drill counted with the participation of 329 people.

3.2 Computer Simulation

A computational model was developed for the same building and population of the simulated drill using the evacuation simulation software Pathfinder 2017, revision 2017.1.0116 [19], developed by Thunderhead Engineering Consultants, Inc., based in Manhattan, Kansas, USA.

The movement environment in Pathfinder is a triangular 3D grid that can be entered manually or automatically based on the imported data. Individuals are represented by a vertical cylinder on the movement grid. The movements of each individual are calculated independently, using an agent-based technique called inverse steering. Each person in the model operates with his own profile (size, speed) and own behavior (leave, wait). Based on his characteristics, each person uses his location to take decisions on the exit paths.

The Bloco A scenario was modeled with the emergency exit dimensions existing on the site. The population of 329 people used in this model was the same that participated in the drill.

Since the fire drill was performed with notice, the population of the building began the evacuation immediately after the alarm was triggered. For this reason, the pre-evacuation times, such as the fire detection an alarm times, were disregarded in the computational simulation. A pre-evacuation time equal to zero was considered.

The profile of the people used in the computer simulation included only persons without disabilities in accordance with the real-life simulation, with dimensions equivalent to a circle of 45.58 cm in diameter and 182.88 cm in height. These values refer to the standard profile used by the software. The walking speed varied between 0.95 and 1.55 m/s. This speed range is proposed by Korhonen [20] and is valid for adults of both sexes.

As for the behavior, the profile of the people without disabilities had independent behavior, moving directly to the nearest exit.

The simulations performed in this study used the "Randomize" option of the Pathfinder software. This option is used before running a new simulation, and it distributes the population with its different profiles and behaviors in a random manner in the scenario to be simulated. Using this option, each simulation of a given scenario provides a different result. The goal was therefore to run multiple simulations for the scenario to check the variation of the results. Based on the 15 first simulations, it was observed that the result of the simulations didn't alter the mean by more than 2%. The result of the software generates a data output summary indicating the maximum, minimum and mean times for the exits through the doors and from the rooms, the mean flow at the doors and also the individual times for each occupant.

IV. RESULTS

4.1 The Simulated Building Evacuation Drill

The simulated drill had a total duration of 173 seconds. The time count began with the triggering of the fire alarm and ended with the exit of the last occupant from the building through emergency exit 1.

With the aid of the film footage, it was possible to determine the number of participants, the distances travelled and the evacuation time. Table 3 shows the number of participants per floor in the drill.

Table.3: Number of participants in the simulated evacuation drill

Floor	Number of people
Ground floor	78
2nd floor	151
3rd floor	87
4th floor	13
TOTAL	329

The second floor had the greatest number of people since it has the classrooms with the highest concentration of students. The 4th floor had the lowest number of people with two administrative buildings occupied. The computer laboratories on this floor were not being used.



Fig. 4: Inside of the protected staircase 1

Table 4 shows the number of people who used each emergency exit in the building. The vast majority of the population used exit 1 (Figure 4).

This is explained by the higher concentration of people in the west side of the building, who should use exit 1 in case of an emergency according to the emergency plan. Another fact that may have interfered to increase the use of exit 1 is the familiarity of the population with this exit path, since it is the main entrance, which the occupants use every day to enter and exit the building.

Table 4: Use of emergency exits

Emergency Exit	Number of people	Percentage
Exit 1	257	78.1%
Exit 2	72	21.9%
Total	329	100.0%

Table 5 shows the time spent to leave the building, both through exit 1 and exit 2.

Table 5: Time to evacuate the building

Description	Time spent (s)
The first to leave through exit 1	19
The first to leave through exit 2	33
The last to leave through exit 1	173
The last to leave through exit 2	127
Total evacuation time	173

As for the distances traveled to the exit of the building, the shortest distance (11.50 m) was covered by a person who was sitting in the courtyard of the ground floor. The person who traveled the greatest distance (46.95 m), on the other hand, was working on the fourth floor. He only had to go 23.60 meters to reach a safe place, however, which in this case was the protected staircase 1, which is fire resistant for 2 hours.

The second floor of the building is attended by a student using a wheelchair to move around. This person routinely

uses the elevator to move vertically. On the day of the simulation this student was not present, but he was previously instructed to stay in a reserved space within any one of the two existing protected staircases in the building until the firefighting volunteers could carry him down the stairs. In addition to the wheelchair user, all other occupants of the building were given instructions to not use the elevator in emergency situations.

Figure 5 shows that the occupants went down through the central region of the stairs without using the handrails to guide them, and that they occupied the entire staircase, in 3 rows of people, enabling a good flow of people. This situation was identified in the fire brigade report, which suggested that the population should use the external side of the staircase, leaving the inner side for the rescue teams.



Fig. 5: Inside of the protected staircase 1 - Second floor level

Figure 6 was taken outside the building, showing the displacement of occupants until the meeting point.



Fig. 6: Population moving to the meeting point

4.2 Computer Simulation

Table 6 shows the distances traveled and the evacuation times for the simulation of scenario. The maximum total evacuation time of the building was 146.2 seconds.

Table 6: Distances traveled and total evacuation times

Profile	Distance traveled		Journey time	
	Minimum (m)	Maximum (m)	Minimum (s)	Maximum (s)
People without disabilities	0.3	80.6	0.8	146.2

Table 7 shows the results of the simulation of scenario, per floor. A significant difference in the values of the mean flow can be observed in the second floor, where the door to stairs 1 had a mean flow of 82.80 persons/min and

the door to stairs 2 had a mean flow of 49.80 persons/min. This difference occurred because the door to stairs 1 was congested at 39.7 s and some of the occupants who were near these stairs went to stairs 2, which had no agglomeration of people, generating a larger interval of time for the last occupants who used stairs 2. Consequently, the mean flow at the door for stairs 2 was lower than at the door for stairs 2.

Table.7: Results of the simulation of scenario, per floor.

Floor	Exit		Number of people who used the exit	Time (s)		Mean flow (people/min)	Specific flow (people/min.m)
	Description	Effective width (m)		First to pass through the exit	Last to pass through the exit		
Exit floor	Exit 1	2.00	197	1.90	146.20	82.20	41.10
	Exit 2	1.65	132	0.80	94.70	84.60	51.27
Second Floor	Door stairs 1	1.40	99	5.10	77.00	82.80	59.14
	Door stairs 2	1.40	52	11.40	74.30	49.80	35.57
Third Floor	Door stairs 1	1.40	60	6.80	47.40	88.80	63.43
	Door stairs 2	1.40	27	9.60	35.30	63.00	45.00
Fourth Floor	Door stairs 1	1.40	9	8.90	25.20	33.00	23.57
	Door stairs 2	1.40	4	9.20	16.40	33.00	23.57

Pathfinder provides a 3D view of the results (Figure 7). With this option you can follow the movement of the occupants, rewind or fast forward the progress of the simulation, zoom the view of the occupants in and out.

Table 8: Comparison of the use of the exits between the simulated drill and the computer simulation



Fig. 7: 3D visualization showing the congestion of people near the stairs of building

Emergency Exit	Simulated Drill		Computer Simulation	
	Number of people	Percentage	Number of people	Percentage
Exit 1	257	78.1%	197	59.9%
Exit 2	72	21.9%	132	40.1%
Total	329	100.0%	329	100.0%

4.3 Discussion of the Results

Table 8 shows a comparison of the number of people who used each one the two exits in the simulated drill and computer simulation.

The computer simulation had a different distribution of the use of each exit, 59.9% of the population used exit 1, while in the simulated drill 78.1% of the population used this exit 1. This increased concentration in exit 1 during the fire drill can be explained by the familiarity that the occupants have with this path because it is the main entrance of the building. Although some of the occupants of the upper floors were closer to exit 2, they went for exit 1 because they were familiar with it.

Table 9 compares the distances traveled until the exit in the fire drill and the computational simulation. Both the shortest and longest distance traveled in the computer simulation can be explained by the selection of the randomize option in the software, which distributes the

occupants at random in the movement grid. Another factor is that some of the occupants of the third floor decided to walk to the protected staircase 2, which was free, after waiting to get on the protected staircase 1, which was congested. This displacement resulted in this longer path.

Table.9: Comparison of the distances traveled in the simulated drill and the computer simulation

Description	Distance (m)	
	Simulated Drill	Computer Simulation
Shortest distance traveled until the exit	11.50	0.30
Longest distance traveled until the exit	46.95	80.60

Table 10 shows the results of the evacuation times identified in the simulated drill and in the computer simulation. Since scenario was simulated in the Pathfinder software with the pre-movement time equal to zero, the exit time of the first occupants were much lower when compared with the times of the first to exit in the fire drill. Although the participants of the fire drill were aware of the day in which it would be held, there was still a pre-movement time toward the exit. This observed pre-movement time consists of the time people needed to identify the alarm, assimilate the situation and initiate the movement toward the exit.

Table 10: Comparison of the times spent between the simulated drill and computer simulation

Description	Time spent (s)	
	Simulated Drill	Computer Simulation
The first to leave through exit 1	19.00	1.95
The first to leave through exit 2	33.00	0.80
The last to leave through exit 1	173.00	146.20
The last to leave through exit 2	127.00	94.70
Total evacuation time	173.00	146.20

This delay to begin moving was reflected in the times of the last people to leave the building, 26.80 and 32.30 seconds more, respectively, than the last occupants in the computer simulation of scenario, as seen in Table 5. The pre-movement time was therefore estimated with a mean of 29.5 seconds.

V. CONCLUSION

This article presented the evacuation times of an educational building in Brazil using two methods: a simulated drill and a computer simulation. The evacuation times observed in the computer simulation were slightly

lower than the times in the simulated drill. Two situations led to this difference in the times. The first situation was due to the shorter distance traveled by the people in the computer simulation as a result of the random distribution performed by the Pathfinder software. The second situation is the fact that there was a pre-movement time toward the exit in the simulated drill even with the participants being aware of the day in which it would be held. This time was estimated at around 30 seconds, while the software was configured for a pre-movement time equal to zero.

When considering the simulated evacuation drill, the importance could be observed of developing and applying emergency plans in buildings. For a safe evacuation, the population must know the emergency plan and the escape routes, and participate in trainings through fire drills, among other actions to facilitate the evacuation of the building in the case of an emergency. Despite being the best way to train the building occupants for a fire situation and to identify the strengths and weaknesses of the emergency plans, fire drills require an extensive mobilization of people and a great expenditure of time to organize and carry them out.

To improve the emergency plans, the use of the computer simulation proved to be an effective solution to replace the simulated drill, since it allows for the identification of design failures and for the simulation of different scenarios in less time and without the need to mobilize people. When complex buildings like university campuses, multipurpose arenas and shopping centers are considered, the use of computer simulations are essential for the evaluation of emergency plans, since fire drills in these spaces become infeasible. In addition, the use of computer evacuation simulations becomes even more advantageous when it comes to the development of the design, since it enables the analysis in its initial phase.

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Effects of an Exercise Program on the Levels of Arterial Blood Pressure Older Women, Hypertension and Sedentary in Pharmacological Treatment Process

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Abstract—The objective of this study was to investigate the changes caused by a program of physically-based physical exercises in the arterial blood pressure (SBP) values of elderly, hypertensive and sedentary women undergoing pharmacological treatment. Two study groups were formed, totalizing 33 subjects with ages ranging from 60 to 75 years, which were constituted as

follows: a) an experimental group (EG), composed of 18 hypertensive and sedentary students, under pharmacological treatment and attending the Center of Physical Activity of the Banco do Brasil Athletic Association of Itaberaí, Goiás, Brazil, which during the experiment were regularly submitted to physical exercise routines (Age: 63.8 ± 14.8 , Body Weight: 74.7 ± 13.8 ,

Height: 165.8 ± 12.6); and b) a control group (CG), composed of 15 students also hypertensive and sedentary, under pharmacological treatment, who during the study were not submitted to physical training routines (Age: 71.6 ± 15.1 ; Body Weight: $68, 3 \pm 13.8$, Height: 160.3 ± 12.8). The experimental procedure had a total duration of 10 weeks, in which the EG was submitted to aerobic physical exercises controlled by the perceived effort index, associated with resistance exercises aimed at localized muscular resistance, and the training sessions were performed on Mondays, Wednesdays and Fridays 60 minutes each. At the end of the procedures the statistical analysis allowed to observe that the PASS scores presented by the SG and GC accounted for $p = 0.000$ and $p = 0.150$, indicating statistical significance only for SG, whose mean values were reduced by 6.5 mmHg, differently from the scores of CG, which decreased by only 0.5 mmHg, representing 5.16% and 0.36% of functional improvement in the variable in question. A similar behavior was found when analyzing the PASD values, which at the end of the experimental procedure had a $p = 0.017$ and $p = 0.051$ for the EG and CG, respectively. Likewise, statistical significance was detected only in the EG, whose mean scores decreased numerically by 4.0 mmHg, distinct from the CG that involved only 0.7 mmHg, meaning 4.60% and 0.82 % of physiological improvement in the variable under discussion. These findings suggest that a physical exercise program built on a scientific basis may be a valuable tool in nonpharmacological therapy for arterial hypertension.

Keywords— *hypertension, older women, physical training, Exercise Program, Pharmacological treatment.*

I. INTRODUCTION

According to Pollock & Wilmore (1993), Hypertension (HBP) is an occurring pathological condition inside the arterial blood vessels, characterized by a chronic elevation of blood pressure above considered desirable levels or healthy for the person's age, during the cardiac cycle.

To Abernethy and Andrawis (1997) the pathophysiology of hypertension is not fully defined, with some risk factors associating the same and increasing their probability of occurrence, such as diet, physical inactivity, obesity, metabolic and hormonal changes, trophic phenomena (hypertrophy heart and vascular), alcoholism, smoking, race, age, among others.

Corroborating the ACMS (1995) adds that the HAS curve has increased in recent decades throughout the world, reaching global epidemic proportions, since, alone or together with other organic complications change the

morbidity statistics and global mortality rates alarming, raising spending on health at very high values.

According Osiecki (1996), HAS is constituted a problem occurring public health in developed countries, but also in the lower evolution, a ratio of 25 to 30% of the adult population, with Brazilian studies showing a prevalence between 12 and 35% in different national regions, which is in our country about 20 million individuals affected by this disease.

According Farinattietalli (2005), this condition is widely regarded as the main cause the onset of cardiovascular diseases, and is an important precursor in death occurrences within the next decades. Sgambatti, Pierin and Mion Jr (2005), published in Brazil this disease has a high social cost, accounting for about 40% of cases of early retirement and work absenteeism.

On this subject, Ramos and Miranda (1999) complement stating that in Brazil this disease has a secular trend of growth since the mortality from this disease was less than 12% in 1930, reached 30.5% in 1980, and currently reaches about 15 to 20% of the adult population over 18 years, reaching levels of 55% in individuals older than 50 years. For Neri (2000), in the case of elderly people, though in different scales, the changes that occur with aging are found in all individuals are suitable for this normal physiological process.

Neto and Bridge (2000) found that the interaction of aging own modifications, as well as those resulting from pathological processes, are responsible for the clinical presentation of various diseases, among them hypertension, which, according Dorea and Lotufo (2001) it becomes more severe in this population, since acts speeding own changes of senescence, which can generate as well as functional disabilities also social dependence.

To Shoji and Forjaz (2000), the control of this disease is made using the pharmacological and non-pharmacological treatments. Drug therapy is indicated for moderate / severe hypertension, and for those with risk factors for cardiovascular diseases and / or injury to important target organs. While effective in reducing blood pressure values, it is costly and can have side effects motivating abandonment of treatment.

According to Da Silva (2004), non-pharmacological interventions such as alcohol restrictions, abandoning smoking and regular physical activity, because they pay to changes in personal lifestyle in order to prevent or deter the development of hypertension, have been reported for its effectiveness, low cost and low risk, and Surinam cherry (1999), reports the latter being present as main prophylactic tool against hypertension.

Such statements do not necessarily constitute academic news regarding the subject, Amado (1993) stating that studies of the time have demonstrated the efficacy of

physical activity in lowering arterial blood pressure levels, however, the ideal intensity not being well established for realization of this physical activity in order to bring more significant results in the decrease in their scores.

On this subject, Rodrigues de Almeida (1999) warns of the importance of detailed planning of physical activity, showing for this, four basic aspects during its execution: intensity or quality, volume or duration, frequency and repetition of stimuli. Said authors suggest that an optimal state of systemic functional organic condition of an individual can only be achieved when the variables mentioned above are suitably designed and bandaged a working system scientifically systematized regarding the prescription and control of training loads, it the author calls "physical exercise".

On the foregoing and considering that hypertension is a major risk factor for cardiovascular complications, accounting for 40% of deaths in the elderly population (Brandao et ali, 2003), is intended to contribute to the development of non-drug strategies that may be effective in prophylaxis or therapy, extending to this line of research, investigating what changes caused by a scientifically metodizados exercise program, the values of arterial blood pressure of hypertensive elderly women and not subjected to pharmacological treatment.

II. MATERIAL AND METHODS

Population and Sample

The study population consisted of older female, regularly enrolled and attending the project "Seniors in Action", developed by the Municipal Itaberai Education, Goiás, Brazil, with the sample consisting of 33 subjects aged 60 75 years.

Initially it conducted a first personal contact with the Secretary of Municipal Education mentioned above, to explain the nature of the study and the relevance of research and request the authorization to carry out the data collection. Thereafter, two were randomly structured study groups: a) one experimental group (EG) composed of 18 students pharmacological treatment and regularly during the experiment underwent the exercise routines; b) a control group (CG) consisted of 15 students also pharmacological treatment, which, during the study of exercise routines were not submitted.

Study variables, equipment and standardization of measures

In this first study measured the anthropometric parameters: a) Total Body Weight (PCT); b) Height (EST), which along with the reported age were used only to characterize the sample. Then it was performed the measurement of arterial blood pressure (PSA), which is

the dependent variable of this study, and used for this patterning and the following equipment:

1. The PCT, understood as the resultant of system forces exerted by gravity on the total body mass (Matsudo, 1987), was measured using an electronic balance Filizola with a capacity of 150 kg and an accuracy of 1g and values are expressed in kg - kg. The measurement was performed with the equipment placed on level ground, with the evaluating standing in the center of the platform, an upright position and back to the measurement scale, with the horizontally shaped head, the legs slight lateral clearance and arms relaxed at along the body (PETROSKI, 1999).
2. EST understood as straight vertical length between the plantar region and the vertex (highest point of the head) (cherry, 2008), was measured using a portable estadiometer the Avanutri make and accurate to 1 mm, and its values expressed in cm - cm. The measurement was performed with the subject barefoot, heels, buttocks, the shoulder girdle and occipital discrete contact strip perpendicular. According recommends standardizing a transverse cursor was slipped by the ruler to support vertex forming a right angle. The reading was performed with evaluating at maximal inspiration and the head directed to the Frankfurt plane (PETROSKI, 1999).
3. PSA, defined as the pressure exerted by the blood inside the blood vessels, due to the cardiac ventricular systole and opposite vascular resistance to blood flow (ROBERGS & Roberts, 2009), was measured using a stethoscope model Dusonic and two sphygmomanometers model aneroid both the HEIDJI marks, one for individuals with arm circumference measuring 27-34 cm and the other for subjects measured in said segment between 35 and 44 cm, and their amounts expressed in millimeters of mercury - mmHg .

To measure we used the protocol MionJr&Marcondes (1986), by which before physical activity and without having ingested caffeine in the last 60 minutes the individual is initially positioned sitting for 5 minutes with a straight and supported back, left forearm being extended half the palm open, relaxed and upward, both on a height-adjustable table with the naked completely left arm and the height of the chest region. Then the evaluator positions the occluder cuff of the sphygmomanometer on the left brachial artery closes the valve of the pump to inflate and the index and middle fingers together palpating the brachial artery to realize the cardiac pulse. Then inflates the cuff occluderto no longer feel the heartbeat, then positions when the headset terminal ears

of the stethoscope, with the olives facing forward, placing the hood in said apparatus antecubital fossa approximately 2.5 cm from the elbow crease, on the brachial artery, and slowly opens the valve air control gently lowering the pressure of the cuff. The first and the last heard sound corresponding to the systolic and diastolic components of arterial blood pressure, respectively, must be measured twice at intervals of 60 seconds between them, adopting the lowest measured value as a final result of the measurement. and slowly opens the air control valve smoothly decreasing the cuff pressure. The first and the last heard sound corresponding to the systolic and diastolic components of arterial blood pressure, respectively, must be measured twice at intervals of 60 seconds between them, adopting the lowest measured value as a final result of the measurement. and slowly opens the air control valve smoothly decreasing the cuff pressure. The first and the last heard sound corresponding to the systolic and diastolic components of arterial blood pressure, respectively, must be measured twice at intervals of 60 seconds between them, adopting the lowest measured value as a final result of the measurement.

Treatment of the independent variable

Preceding the application of Physical Exercise Program (PEF) was established a period of three (3) days to allow the students to familiarize themselves and learning the mechanical aspects of the exercises, posture and breathing to be used in training routines. Aiming to reduce and even prevent possible failures during the process control of training loads, as well as data collection, counted on the collaboration of two (2) physical education professionals, which preceding the execution of the work of the day were responsible for checking the condition of the materials to be used, noting the internationally agreed standards in kinanthropometry.

The AEP had a total duration of 10 weeks, being composed of three training weekly sessions on alternate days (2^a, 4^a and 6^a shows), lasting 60 minutes each, which were divided into 3 teaching parts, discrimination as follows:

1) Preparatory Part Initially aiming to activate the circulation and increase blood supply to muscle tissue in general, we used a dynamic stimulation of the continuous type, which was executed in the form of brisk walking for three (3) minutes. Subsequently in order to stretch the muscle groups to be further used during the workout, as well as, improve joint mobility of the subjects, for seven (7) minutes was used stagnant exercises located in the volutivamente individuals seeking functional mobility threshold articulate multidirectional joints of the wrist, elbow, shoulder, hip, knee and ankle, remaining in this position for a while 10-12 seconds and repeats the

procedure for each joint by 2 times sequenced (NUNES, 1998).

2) Main Part: First, to promote morphological and functional improvements in the neuromuscular system, the subjects were positioned statically and performed resistance exercises using sticks made of plastic pipe, measuring 5 mm in diameter and 1 m long, and also leggings napa made with a Velcro fastener, both implements being filled with 1 kg of sand.

Then, aiming to develop muscular endurance more functional muscle groups in the routine of subjects obeyed to Dantas suggestion (1995) being prescribed ten (10) years circuit, which were performed in ten (10) minutes, running the same alternating segments of conducting the following order: 1) flexion of the carpus; 2) ½ squat; 3) partial trunk flexion; 4) bending the forearm; 5) extension plant; 6) dorsiflexion; 7) extension of the carpus; 8) bending the leg; 9) the back-extension; and 10) bench press. Subjects began PEF realizing the largest possible number of uninterrupted repetitions of these exercises in unit time of twenty (20) seconds, this time enhanced with ten (10) seconds to each training week, up to one (1) minute, this time maintained until the end of the experiment. From the first week of training was set to be no break in the transition between these, with individuals carrying two (2) passes through the circuit, across which it is imposed a liability range of one (1) to two (2) minutes of rest .

Continuing, in order to promote morphological and functional improvements in the cardiovascular system, we used a dynamic stimulation of the continuous type, which was executed in the form of brisk walking for thirty (30) minutes, being the intensity of effort controlled by the sense subjective fatigue (ACSM, 1995), with the subject standing perception of fatigue in the first week of work at level 6 (moderate), which progressed weekly in a drive to reach level 8, remaining this for four (4) weeks , reaching the level 9 (strong) in the eighth week of training and continued until the end of the experiment.

3) Final Part: Ending the training session and auxiliary aim at removing exudates cell combustion, immediately following the close of the thirty (30) minutes for the front, the subjects continued to walk for three (3) minutes now moderately, gradually decreasing the intensity to make the smooth ride. Later in order to stretch the muscle groups most requested in training for seven (7) minutes the same stagnant years in the beginning of the training session were repeated, repeating the same procedures and the same joints.

Statistical analysis

In this experiment, the data were analyzed by the following procedures: a) initially descriptive statistics was performed to characterize the sample; b) subsequently

possible to detect statistically significant differences in scores for the physical characteristics of the experimental and control groups, the test was used "t" test for independent samples; c) finally, to compare the values of SBP pre and post-test during the experimental period was using the Student "t" test for dependent samples.

Data were processed and analyzed using computerized statistical package Statistica for Windows, version 4.3 Incorporation Starsoft, seeking a significance of $p < 0.05$.

III. RESULTS AND DISCUSSION

With characterize the sample order, is shown in Table 1 Analysis test "t" test for independent samples, the average values and their standard deviations for the variables: age, height and body weight of the experimental groups (EG) and Control (GC) at the beginning of the experiment. The statistical significant differences between treatment accused scores, demonstrating the heterogeneity of the sample.

Table.1: Physical characteristics of the sample.

VARIABLES	EXPERIMENTAL GROUP	CONTROL GROUP	t	p
AGE (years)	63,8 ± 14,8	71,6 ± 15,1	0,85	0,041*
STATUS (cm)	165,8 ± 12,6	160,3 ± 12,8	2,93	0,033*
WEIGHT (kg)	74,7 ± 13,8	68,3 ± 13,8	4,55	0,037*

* Significant at the level of $p < 0.05$

In accordance with the objectives of this study are presented in Table 2 Analysis test "t" test for dependent samples the average values and their standard deviations for the variables Arterial Blood Pressure Systolic (PASS),

and Blood Pressure Blood Diastolic (DSAP), the experimental and control groups at the beginning and end of the experiment.

Table.2: Values in mm / Hg of Blood Pressure Blood components of the experimental and control groups, the pre - and post-test.

STUDY GROUPS	BLOOD PRESSURES YSTOLIC BLOOD - PASS - mmHg -				BLOOD PRESSURE DIASTÓLICA BLOOD - PASD - mmHg -			
	PRE TEST	POST TEST	T	P	PRE TEST	POST TEST	t	p
GE	132,42 ±6,36	125,92 ±5,31	10,51	0,000*	86,89 ±3,88	82,84 ±3,26	2,73	0,017*
GC	136,64 ±4,53	136,14 ±4,62	1,52	0,150	84,85 ±3,50	84,07 ±3,14	2,14	0,051

* Significant at the level of $p < 0.05$

IV. CONCLUSIONS

According to the questioning of this research, as well as considering the analysis and discussion of these results, we can see a statistically significant behavior of the sample scores for the test and retest ($p < 0.005$), suggesting that an exercise program built on foundations scientific, it can be a valuable tool in the non-drug treatment of hypertension.

Thus, it is concluded that the methodology used in this study for the prescription of training loads allowed a qualitative control of these, a fact that reflected in the efficiency of the same. Given these findings suggest the new studies analyzing the effects of aerobic training and resistance in senile population in different intensities of physical exertion, with a larger sample and grouped by

age group, aiming only ratifies the results of this research also extend this line of research.

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Physical-Chemical Properties of Strawberry Pseudofruits Submitted to Applications of Zinc Oxide Nanoparticles

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Abstract—Strawberry cultivation is appreciated in many countries because of the fruit's well-defined, attractive and nutritional sensorial characteristics. As such, it is of great commercial value. The flavor and nutritional properties of the fruit are characteristics that have been developed and gaining importance, both in breeding programs and in productive systems. In this sense, this work proposes the application of nanotechnology for the improvement of the physicochemical characteristics of strawberry crops, with the main objective of analyzing the influence on nutritional performance of different fruit treatment doses with zinc oxide nanoparticles. The physicochemical analyses of the strawberry pseudofruits were carried out from November to June 2016. The experimental design was in randomized complete blocks, in a factorial scheme, with 7 replicates. The collected data were submitted to analysis of variance with the F-test and the differences between means were compared by the Tukey test ($P \leq 0.05$). The treatment process of the strawberry crop with zinc oxide nanoparticles was shown to be efficient for anthocyanin nutrients and soluble solids. The method for analyzing vitamin C, which consisted in freezing the raw material, was ineffective, probably because of the reduction of ascorbic acid levels by the freezing and crystallization of the sample. Climatic factors significantly influence the nutritional composition of anthocyanins and soluble solids. The application of nanoparticles at 100% of the recommended dose proved to be more effective than zinc oxide in its natural form in increasing the soluble solids values.

Keywords— Nanotechnology. Physicochemical properties. Pseudofruits. Strawberry. Nutrition.

I. INTRODUCTION

Strawberry cultivation is appreciated in many countries because of its attractive and well-defined sensory and nutritional characteristics, which gives it great commercial

value. The quality of foods consumed today, both regarding physicochemical and nutritional aspects, has raised great concern, mainly because certain foods are related to the prevention or control of certain diseases because of the presence of bioactive compounds [1].

The physicochemical and nutritional quality of strawberries is genetically determined and may be influenced by the cultivation environment as a function of such edaphoclimatic factors as light, temperature and relative air humidity, types of agricultural cultivation systems, fertilization, soil type, ripeness at harvest, storage, transport and packaging conditions [2].

As such, several factors should be considered to improve the quality characteristics, because combining quality and high productivity results in the best consumer products and is an important stimulus to the producer. Nutrition and fertilization stand out among these factors. One of the most important nutrients required for the growth and development of strawberries is Zinc. It should be noted that, in recent years, technological innovations in agriculture are mostly geared to reductions in production costs, increases in productivity, improvements in the final products and in yields [3].

In this context, some practices still need to be better studied and improved, such as the use of the science of nanotechnology in agribusiness.

For there are great opportunities for research and innovation in associating this field with nanotechnology. In particular, improvements can be obtained in the physicochemical characteristics of oleraceous crops with nanoparticles containing the elements that are natural nutrients of the plant, such as zinc oxide nanoparticles. In this sense, this study proposes to apply nanotechnology for the improvement of the physicochemical characteristics of the strawberry crop, with the main objective of analyzing the influence on nutritional performance of different fruit treatment doses of zinc oxide nanoparticles.

II. MATERIALS AND METHODS

This study was conducted in a plastic greenhouse at the seedling nursery of the Universidade Comunitária da Região de Chapecó in the municipality of Chapecó. The greenhouse, set up in the north-south direction, has a structure of galvanized iron and an arch cover with low density polyethylene (LDPE) with a thickness of 150 μm . The local climate is of the Cfa type in the Köppen classification, characterized as subtropical with well distributed rainfall in the summer [4]. The chemical analysis of the substrate of the bags to which the strawberry pseudofruits were transplanted was performed in September 2015 at the Soil Laboratory of Epagri-Cepaf in Chapecó, following the methods proposed by Tedesco et al. (1995) [5].

2.1 Environmental Control and Management

Data was collected on temperature, relative air humidity, wind speed and the Lux index using a digital Termo-Higro-Anemometer, model THAL-300, installed at a height of 1.20m in the inner part of the protected environment. The measurements were carried out in two periods of the day, in the morning (09:00AM) and afternoon (16:00PM). The monthly temperature, relative air humidity and Lux means were taken for these periods.

2.1.1 Treatments

The treatments of the experiment were allocated into two factors:

Factor A referring to the applied doses, namely: recommended zinc dose (RD), which was composed of N: 9%; - P: 48%; - K: 9%; Mg: 0,5%; - B: 0.02%; - Cu: 0.05%; Mn: 0.05%; - Mo: 0.02%; - Zn: 0.01%.; 50% of Nano Zn equivalent to the Zn RD; and 100% of Nano Zn equivalent to the Zn RD;

Factor B referring to the harvest period:

1st Period (29/10/2015 to 14/12/2015); 2nd Period (15/12/2015 to 21/01/2016); 3rd Period (22/01/2016 to 18/02/2016); 4th Period (19/02/2016 to 21/03/2016); 5th Period (22/03/2016 to 17/06/2016).

2.1.2 Experimental Design

The experiments used a factorial (3 x 5), randomized complete block design (RCB), with factor A (fertilizer) and factor B (harvest period) and 7 repetitions. Each plot was made up of four plants along the line. Based on the number of bags and plants, an outline was made to demonstrate the treatments of each plot.

2.1.3 Performance of the Experiment

The seedlings of the strawberry cultivar San Andreas were acquired on August 29, 2015, and the transplant in to the bags was performed on August 31, 2015, at 15:30. The

bags with seedlings measured 1.35m in length and 0.29m in width. The phytosanitary treatments were performed according to the needs of the respective crops through daily observations.

The irrigation was performed manually with distilled water and with the aid of a 60ml syringe, applying 50ml per plant. Depending on the environmental conditions (temperature and relative air humidity), the procedure was performed one or two times per day. It should be noted that the nursery has an automatic irrigation system in the inner part of the greenhouse using sprinklers, but it does not have a standardized frequency.

The zinc oxide nanoparticles used in this work were provided by the Kher Chemical Research and had an average particle size of 25nm and a degree of purity of 99.5%. The nanoparticles were weighed weekly in Unochapecó's chemical and food science laboratories at the concentrations of 100%, 50% of nano-zinc as recommended dose (RD) of zinc oxide, with the values of: 0.0017g of nanozinc at 100% and 0.00085g of nanozinc at 50%.

For the application, 1.3ml (measured in a 3ml syringe) of fertilizer free of Zn, 200ml of distilled water, the masses of 100%, 50% of nanozinc and the zinc oxide solution were mixed in a 200ml beaker. The components were weighed using a precision scale. Subsequently, the fertilizer without the Zn nutrient was mixed with the nanoparticles at the doses of 50 and 100% and then placed in agitators just before the application, allowing for the homogenization of the nanoparticles at the time of application.

The pseudofruits for analysis were selected considering the viable and completely healthy ones. As such, strawberries of different sizes and weight were chosen. Pseudofruits harvested throughout the plot were picked when 3/4 of them were in the dark red stage. The pseudofruits were frozen immediately after harvesting, from the beginning to the end of the crop cycle.

After the selection and removal of the peduncles, the samples were washed with deionized water and placed in a small plastic bag with the identification of the period, plot, quantity and treatment. Afterwards, the samples were stored in a freezer at a freezing temperature. The pseudofruits were removed from the freezer on the day prior to the laboratory analyses and put in a refrigerator for defrosting. They were then crushed in a Britânia Black Pus mixer and immediately submitted to analysis at ambient temperature ($\pm 25^{\circ}\text{C}$). The physicochemical analyses of the pseudofruits from the strawberry cultivar of the San Andreas species submitted to the application of ZnO nanoparticles were carried out in the Chemistry and Food Sciences laboratories of the Universidade Comunitária da Região de Chapecó (Unochapecó) from November to June 2016. The tests

were performed in six fold. And the procedures for the physicochemical analyses followed the methodologies proposed by authors [5].

2.1.4 Statistical analysis

The collected data was submitted to an analysis of variance with the F-test (Table 1), and the differences between means were compared through the Tukey test ($P \leq 0.05$). The computational application used was the SISVAR - system of analysis of variance for unbalanced [6].

III. RESULTS AND DISCUSSION

3.1 Weather Conditions

3.1.1 Air temperature

According to Figure 3, in the first period comprising of the months of October to December, the average temperatures were 22.99°C in the morning and 25.30°C in the afternoon. In the months of December and January, an average temperature of 26.65°C was obtained in the morning and 26.34°C in the afternoon, which were the highest recorded temperatures during the experiment. This phenomenon coincides with the occurrence of over 518.6 hrs of insolation [7], for the period. In the months of January and February, which were part of the third period,

the findings for the morning and afternoon periods were 26.17 °C and 25.69°C, respectively. In the penultimate period, in the months of February and March, the average values were 24.08°C in the morning and 24.43°C in the afternoon. And in the fifth and last period, the average temperature values found in the months of March, April, May and June were 17.31°C in the morning and 17.98°C in the afternoon. It should be noted that this period had the lowest averages along the day, with the lowest recorded temperature (9.15 °C) (Figure 3). This correlates with the hours of sunshine according to the respective weather agency, which indicated that these months had the lowest sunshine rate of the experiment (155 hours), in line with the normal climatologic average of 159.8 hrs for this time of year [7]. This last period also registered a big difference between the minimum and maximum temperatures, reaching a variation of 14.6°C in four months. The protected environment can be cited as a conditioning factor, with the shaded area with dirt, the black screen over the roof and the irrigation made at irregular intervals and without frequency influencing the respective climatic data. That is, the black screen had a direct influence on the solar radiation conditions because of the imposed barrier and because the color tends to absorb and not reflect the photosynthetically active radiation (PAR).

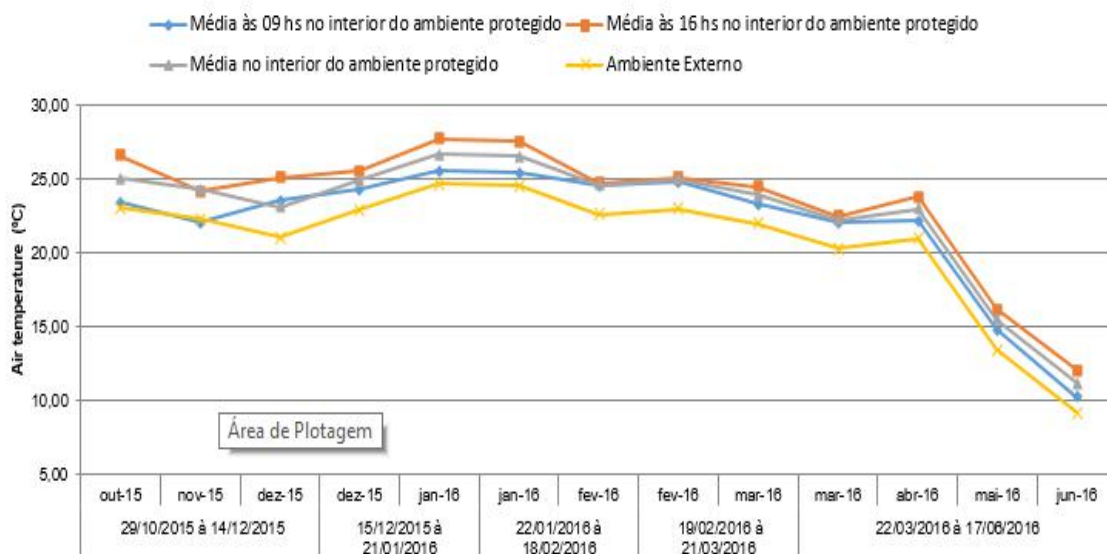


Fig.1: Air temperature recorded inside the protected environment and in the external environment (Chapecó, SC - 2015/2016 cycle)

3.1.3 Relative humidity

The average recorded relative air humidity values inside the greenhouse are shown in Figure 4, revealing values in the morning and afternoon period of 71.90% and 70.23%, respectively. In the second period, the values were 71.57% in the morning period and 72.51% in the afternoon. In the following period, the percentages were 70.53% and 70.48%

in the morning and afternoon, respectively. It should be noted that this period is considered the apex of the hottest season of the year, and the relative air humidity values were the lowest of the whole experiment. In the fourth period, the mornings had an average air humidity value of 71.05%, while in the afternoon it reached 71.77%. In the last period, the findings for the months of March to June were 76.70% in

the morning and 74.62% in the afternoon. These months correspond with the fall and winter seasons and they had the highest air humidity percentages. A concomitant factor that should be taken into consideration is the rainfall of the four months, which amounted to 543 mm [7], and it should be noted that the highest level of rainfall of the experiment occurred in the respective period. The results of this work are in line with the study by [8], who pointed out that the optimal relative humidity for the cultivation of strawberries lies between 70 and 80%. As such, one could state that the humidity values presented lie inside the proper range for the development of the crop, preventing the emergence of diseases. The relative air humidity inside the greenhouse is directly related to the ambient temperature. At 16 PM, when

the ambient temperature is highest, the relative air humidity had the lowest values in the four periods, while at 09 AM, when the ambient temperature is lowest because of the sharp drop in temperature during the night, the humidity values could reach 100% before sunrise. The relative air humidity inside the greenhouse proved to be higher, mainly in the fifth period, at the start of the fall and winter seasons. These results are associated with the fact that the water vapor values inside the greenhouse are extremely influenced by evapotranspiration, which increases the amount of water vapor in the air and, combined with the low permeability of the plastic film and lower rate of air renovation inside the greenhouse, leads to a greater accumulation of water vapor inside [9].

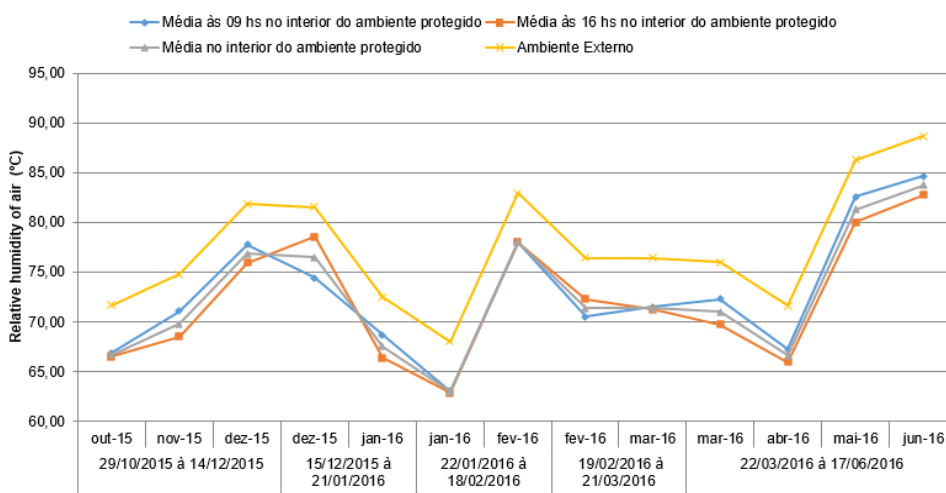


Fig.2: Relative humidity of air recorded inside the protected environment and in the external environment (Chapecó, SC - 2015/2016 cycle)

3.1.4 Light Intensity

Figure 5 reveals that the first period of the experiment had an average solar radiation in the morning period of 164.91 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ and 212.89 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ in the afternoon. During these months, the solar radiation rates were the most intense of the experiment, a fact that is associated with the total number of hours of sunshine, 421.2 hrs. As such, this was the period with the greatest insolation and lowest air humidity values. In the second period, the findings were 176.84 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ and 162.14 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$. In the next period, the morning averaged 151.23 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ of radiation and the afternoon 160.56 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$. It should be noted that the lowest solar

radiation rates were obtained during this period. This correlates with the rainfall levels, which reached 388.20mm according to the data of [7], totaling 27 days of rain in the two months that make up this period. In the second-to-last period, the findings were 164.56 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ and 162.14 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$. And in the fifth and last period, the morning had an average radiation value of 149.92 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$ and the afternoon of 179.40 $\mu\text{mol.m}^{-2}.\text{s}^{-1}$. The solar radiation levels can also be associated with the presence of a the black shading screen, which was placed above the shade net in the greenhouse and therefore reduced the harmful effects of high solar radiation rates and temperatures on the plants.

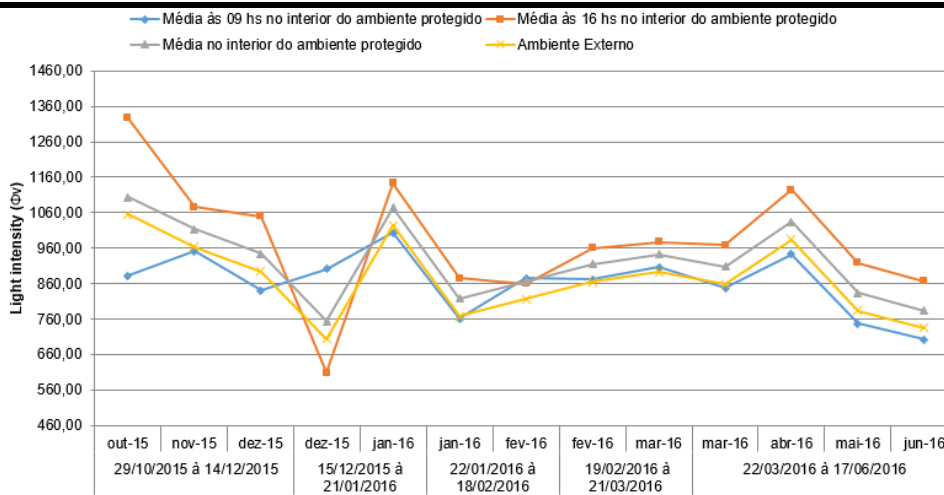


Fig.3: Light intensity recorded inside the protected environment and in the external environment (Chapecó, SC - 2015/2016 cycle)

3.1.1 Physico-Chemical Properties

of application of the zinc oxide nanoparticles regarding the response variable pH (Table 2).

3.2 Ph

The analysis of variance revealed no significant effect ($P < 0.05$) of the interaction between the concentration x period

Application Period	Recommended Dose (RD)	Concentration	
		50% RD from Nano ZnO	100% RD from Nano ZnO
1 ^o Period (29/10/2015 à 14/12/2015)	3,66 aA	3,52 bB	3,55 abB
2 ^o Period (15/12/2015 à 21/01/2016)	3,38 aD	3,35 aC	3,45 aBC
3 ^o Period (22/01/2016 à 18/02/2016)	3,56 aAB	3,60 aB	3,53 aBC
4 ^o Period (19/02/2016 à 21/03/2016)	3,50 abCB	3,55 aB	3,42 bC
5 ^o Period (22/03/2016 à 17/06/2016)	3,65aA	3,76 aA	3,72 aA
CV (%)		2,50	

Means followed by the same lowercase letter in the row and upper case in the column do not differ by Tukey test ($p \leq 0.05$). Table 2 - pH of strawberry pseudofruits submitted to applications of zinc oxide (ZnO) nanoparticles in a protected environment (Chapecó, SC - 2015/2016 harvest)

The pH values found were statistically equal ($P > 0.05$) and showed no significant difference as a function of doses, period and their interaction, as can be seen in Table 2. The zinc oxide nano-structures don't influence the pH parameter because it is related to the fruit maturity, genotype, climatic condition, soil and fertilization parameters. The low pH can be associated with the growth speed of the plant, reiterating that zinc is a precursor of the auxin Indole-3-acetic acid (IAA), a growth hormone that promotes cell elongation and acts as a regulator of plant growth. As such, the increased speed of growth will influence the plant's degree of ripeness, making it have a limited availability to climatic factors, such as luminosity and temperature. This means pH does not accompany the ripening of the fruit, and consequently its rate goes down. The pH of strawberries ranges between 3.50 and 3.70 [10]. The findings in this experiment are in alignment with other studies. For the nano-zinc oxide concentrations of 50%

and 100%, the mean of the five periods was 3.55, and for the nano-zinc oxide concentration of 100% it was 3.53. The results were similar to those found by the authors Françoso et al. (2008:11), who found mean values of 3.46. The results found here are close to those reported by Camargo (2008:12), which ranged between 3.50 and 3.77. Cantillano et al. (2003:13), on the other hand, found a pH of 3.23 for the cultivar Camino Real, 3.58 for the cultivar Ventana and 3.3 for the cultivar Aromas. Another study conducted in the city of Passo Fundo-RS also registered lower pH values, with Mendonça (2011:14), evaluating the quality of strawberry fruits in protected cultivation. For the cultivars Albion, Camarosa and Festival, he observed pH values equal to 3.23, 3.18 and 3.22, respectively. The results obtained in the present study corroborate those obtained by Pallamin (2007:15), who evaluated the cultivars Camarosa, Dover, Oso Grande and Sweet

Charlie, obtaining average pH values between 3.22 and 3.35.

of application of the zinc oxide nanoparticles regarding the response variable Anthocyanin (Table 3).

3.3 Anthocyanin

The analysis of variance revealed a significant effect ($P < 0.05$) of the interaction between the concentration x period

Application Period	Concentration		
	Recommended Dose (DR)	50% RD from Nano ZnO (mg/100g)	100% RD from Nano ZnO
1° Period (29/10/2015 à 14/12/2015)	23,29 aC	25,53 aD	24,32 aD
2° Period (15/12/2015 à 21/01/2016)	45,35 bB	54,49 aB	60,90 aA
3° Period (22/01/2016 à 18/02/2016)	62,08 aA	63,83 aA	49,16 bB
4° Period (19/02/2016 à 21/03/2016)	24,89 aC	28,82 aD	29,85 aD
5° Period (22/03/2016 à 17/06/2016)	29,95 bC	39,97 aC	39,87 aC
CV (%)		13,32	

Means followed by the same lowercase letter in the row and upper case in the column do not differ by Tukey test ($p \leq 0.05$).
Table 03 - Strawberry pseudofruit anthocyanins submitted to zinc oxide (ZnO) nanoparticle applications in protected environment (Chapeçó, SC - 2015/2016 harvest)

Regarding the treatment with zinc oxide nanoparticles, the analysis of variance revealed a significant effect ($P < 0.05$) of the interaction between the concentration x period of application of the zinc oxide nanoparticles regarding the response variable. It should be noted, however, that the values obtained for period 3 were substantially above those found in other periods of the study, reiterating that, according to Clifford (2000:16), the levels can vary from 15 to 35 mg.100g⁻¹ of fresh fruit, thus demonstrating values substantially above those found in the literature. The increased anthocyanin levels can be correlated with the plant's glucose concentrations, which is related to the factor that sugar plays in the central structure of anthocyanins, in addition to the fact that the zinc micronutrient directly influences the metabolism of carbohydrates. The atomic absorption spectroscopy technique reveals the incorporation of very small, but still higher quantities of zinc than present inside the seeds of the fruit. The results reveal that the zinc oxide nanoparticles are absorbed by the fibrous pericarp cells, forming nano-structured clusters on the surface, preferably anchored in the interfaces of the cells. Because of their nanometric dimensions, the nanoparticles form clusters that can serve as nano-nutrient reserves for the seed in the germination and following stages, and they are incorporated in small quantities by the seed. This is an indication that a large part of the zinc oxide nanoparticles is available on the surface and inside the pericarp of the strawberries [18]. In a study by the authors Weber et al. (2015:18), who compared the cultivars Camarosa, Camino Real and San Andreas, values of 55.92 and 56.34 mg/100 g of fresh fruit were obtained, respectively, with no

significant difference between them. The cultivar San Andreas, on the other hand, differed significantly from the others, with 41.23 mg.100 g⁻¹ of fresh fruit, similar results to those found in the present study, but in our case there was no statistically significant difference ($P > 0.05$). The superior results of this study can also be correlated with Chaves (2014:19), who studied the same cultivar in the city of Passo Fundo/RS and obtained total anthocyanin values of 18.69 mg/100 g. This value is relatively low when compared to the results found in this study. In the same way, Maro et al. (2004:20) observed differences when comparing the total phenolic contents of the strawberry fruits of the cultivars Guarani, Dover and Sweet Charlie in the state of Minas Gerais. The cultivar Guarani had the highest anthocyanin content (19.5 mg 100 g⁻¹), while Dover (14.3 mg 100 g⁻¹) and Sweet Charlie (13.3 mg 100 g⁻¹) had the lowest levels, with concentrations below those obtained in the study of Calvette et al. (2008:21) and the present study. Buendia et al. (2010:22) evaluated the chemical composition of phenolic compounds in 15 strawberry cultivars and demonstrated that total anthocyanins ranged from 20.2 to 47.4 mg100g⁻¹ of fresh fruit, with a small variation in the concentration range. In the studies carried out by Castro et al. (2002:23) and by Pinto, Lajolo and Genovese (2008:24) with the cultivar Camarosa, the anthocyanin contents found were 48.2 and 43 mg.100g⁻¹, respectively. This decrease in the levels may be related with the incidence of sunlight [26]. Strawberries are demanding when it comes to light, requiring high insolation during the growing period, an important factor in the photosynthesis process as well as in the definition of the chemical composition of

the fruit. According to Klimov et al. (2008:26), anthocyanins may be influenced by temperature and radiation, so high temperatures and greater solar radiation are associated with higher concentrations of this compound. For this study, one could mention that the concentrations in the same period of peak of the anthocyanin rates (third period) coincided with extremely hot temperatures (Figure 3) and with quite significant insolation rates (378.6h) (Figure 5), but it should be reiterated that it wasn't the period with the highest solar radiation rates, according to the climate statistics. Folegatti et al. (1997:27) noted that the plastic cover changes the

amount of overall radiation within protected environments, with mean values close to 63% of the total overall radiation outside. According to the aforementioned authors, these variations are strongly related to micro-climatic factors, the degree of ripeness, seasonality, and the cultivar variety.

3.4 Vitamin C

The analysis of variance revealed no significant effect ($P \leq 0.05$) of the interaction between the concentration x period of application of the zinc oxide nanoparticles regarding the response variable vitamin C (Table 4).

Application Period	Concentration		
	Recommended Dose (DR)	50% RD from Nano ZnO ------(mg/100g)-----	100% RD from Nano ZnO
1° Period (29/10/2015 à 14/12/2015)	23,29 aC	25,53 aD	24,32 aD
2° Period (15/12/2015 à 21/01/2016)	45,35 bB	54,49 aB	60,90 aA
3° Period (22/01/2016 à 18/02/2016)	62,08 aA	63,83 aA	49,16 bB
4° Period (19/02/2016 à 21/03/2016)	24,89 aC	28,82 aD	29,85 aD
5° Period (22/03/2016 à 17/06/2016)	29,95 bC	39,97 aC	39,87 aC
CV (%)		13,32	

Means followed by the same lowercase letter in the row and upper case in the column do not differ by Tukey test ($p \leq 0.05$).
Table 4 - Vitamin C of strawberry pseudofruits submitted to zinc oxide (ZnO) nanoparticle applications in a protected environment (Chapeçó, SC - 2015/2016 harvest)

The vitamin C values found were statistically equal ($P > 0.05$) and showed no significant difference as a function of doses, period and their interaction, as can be seen in Table 4. There is a peak in the vitamin C levels in the first period (Table 4), which corresponds to spring, with high temperatures, higher insolation rates and lower humidity. This corroborates the findings by the authors Lee and Kader (2000:28), adding that higher light intensities during the growth phase of plants consequently entail greater quantities of vitamin C in plant tissues.

It should be noted that the values found are far below those found by other authors. According to Domingues (2000:29), strawberries are a rich source of vitamin C, oscillating between 39 and 89mg/100g of fruit, with the average value being 60 mg.100g⁻¹ of fruit.

Pinelli et al. (2011:38) evaluated the chemical characteristics of strawberries at different stages of maturation and found values for vitamin C of 23.16; 46.88 and 31.45 mg/100g of fresh pulp for the green, pink and mature Oso Grande cultivar, respectively. Campos et al. (2011:30), on the other hand, studied different post-harvest strawberry conservation techniques and observed values of 44.05 mg100g⁻¹ of pulp in the fruits at harvest.

Webber (2015:18) found results of 69.31 and 42.29 mg100g for the cultivars Festival and San Adreas,

respectively. In the following study, superior vitamin C values were found for the cultivars Oso Grande and Camarosa. For the cultivar Camarosa, on the other hand, Rocha et al. (2008:31) registered 73.14 mg.100 g⁻¹. Lower vitamin C values were also found by Campos et al. (2011:30), who analyzed the post-harvest quality of strawberry fruits in Maringá-PR and obtained 44.05 mg100g⁻¹ for the cultivar Camarosa at harvest.

The levels may vary depending on the ripeness, cultivar, season, conditions of cultivation, and storage conditions and duration post-harvest, which may decisively influence the levels of this compound [32].

The study developed by Portela, Peil and Rombaldi (2012:33) evaluated the effect of the nutrient solution concentration on the characteristics of the phytochemical compounds found in strawberries. They found higher levels of vitamin C when there was an increase of the salt concentration in the nutrient solution. In the present study, there was no change in the salt concentration and the doses followed the recommendations of the fertilization and liming manual.

According to Smirnoff (1996:34), the incidence of solar light is a factor that stimulates the synthesis of L-ascorbic acid by plants. In the photosynthetic mechanism, L-ascorbic acid - the main active form of vitamin C - acts in

the dissipation of excess light energy absorbed in the form of heat (when there is an excessive increase in luminosity) and also in the elimination of many reactive oxygen species [2].

In the study by Agar; Streif and Bangerth (1997:35), the authors noted that the activity of ascorbate oxidase, which promotes the oxidation of ascorbic acid to dehydroascorbic acid, can be seen as responsible for the loss of ascorbic acid. For the authors, the proposal of using treatments with nano-ZnO could reduce the diffusion of O₂, decreasing the breathing rate, which should delay the oxidation of the ascorbic acid in the fruit. On the other hand, it has been reported that the loss of water can accelerate the loss of ascorbic acid due to increased oxidation [37]. This way, the treatments with nano-ZnO could probably affect the vitamin C levels in strawberries, changing the water content of the fruit.

Lee and Kader (2000:28) emphasize that losses in vitamin C may occur due to its sensitivity regarding low humidity conditions. As such, the findings in this study corroborate those of the aforementioned authors, since the periods with the lowest vitamin C levels - the fourth and fifth periods - had the lowest temperature and humidity averages, around 75.66% and 17.97°C, respectively.

According to Ferreira (2012:37), substantial losses of nutrients may occur with the storage of strawberries, especially of vitamin C, because of physiological and biochemical processes and because vitamin C is very

sensitive and unstable, susceptible to degradation by light and heat.

In this work, the physicochemical analysis of vitamin C followed the methodology proposed by Tedesco (1995:5), who recommends the freezing of fruits in some analyses for the subsequent performance of the tests. The demands were collected daily in accordance with the periods, and the fruits were stored in freezers with temperatures below 0°C for periods exceeding 20 days in most cases. It should also be noted that in some tests a minimum number of fruits was needed for the reading, which maintained them for an even longer time, until reaching the number of the sample. The low doses of vitamin C could therefore be associated with the possible losses in this process.

Pinelli (2005:38) raises very important considerations regarding the post-harvest storage of strawberries. In studies conducted by the author, he reports that the levels of vitamin C decrease when the fruits are stored at higher cooling temperatures. In his study regarding the amount of vitamin C in juices submitted to storage processes of 26 hrs,

3.6 Soluble Solids - Brix

The analysis of variance revealed a significant effect ($P \leq 0.05$) of the interaction between the concentration x period of application of the zinc oxide nanoparticles regarding the response variable Soluble Solids - Brix (Table 5).

Application Period	Concentração		
	Recommended Dose (RS)	50% RD from Nano ZnO	100% RD from Nano ZnO
1° Period (29/10/2015 à 14/12/2015)	5,18 bAB	5,58 Bab	7,00 aA
2° Period (15/12/2015 à 21/01/2016)	6,00 bB	6,27 bA	7,18 aA
3° Period (22/01/2016 à 18/02/2016)	5,27 bAB	4,78 bB	7,35 aA
4° Period (19/02/2016 à 21/03/2016)	4,78 cC	5,77 bA	6,55 aA
5° Period (22/03/2016 à 17/06/2016)	7,25 aA	6,40 bA	7,25 aA
CV (%)		9,53	

Means followed by the same lowercase letter in the row and upper case in the column do not differ by Tukey test ($p \leq 0.05$).

Table 5 - °Brix of strawberry pseudofruit submitted to applications of zinc oxide (ZnO) nanoparticles in protected environment (Chapecó, SC - 2015/2016 harvest)

In this study, the 100% concentration of nano zinc oxide differed significantly from the other doses, reaching a value of 7.35°Brix, indicating that the fruits with the addition of nano zinc oxide at a concentration of 100% had more sweetness in the fourth period than the nano zinc oxide doses at a concentration of 50% and also regarding the recommended dose of zinc in the fourth and other periods of the experiment (Table 5).

The zinc oxide nanoparticles influenced the sugar levels of the pseudofruits because the micronutrient participates as a component in a large number of enzymes, including dehydrogenases, proteinases, proteases and phosphohydrolases, with the basic functions in the plant being related to the metabolism of carbohydrates, thus influencing the amount of sugar in the fruit.

Since the nanoparticles have nanometric dimensions, they can easily be absorbed by cellular membranes and be

carried through the micro channels in the cellular structures of the plant. Under these conditions, the zinc oxide nanoparticles are carriers of the zinc nanonutrients to the cell regions that are still not serviced by traditional treatment methods, which explains the effectiveness of the nanoparticles in comparison to the zinc oxide particles as an effective and efficient absorption method of nanonutrients.

The zinc oxide nanoparticles are absorbed in the fibrous cells in the pericarp of the seed and anchored in the form of clusters, preferably on the edges of the cells. As such, clusters are formed in the cavities of the cell interfaces and composed of zinc oxide nanostructures with smaller dimensions than the cavities. These characteristics favor the migration of the zinc oxide nanostructure to the inside of the pericarp of the strawberry seed, transforming the clusters into viable zinc reserves for the seed, with the availability of zinc oxide throughout its development stage.

The results show that the treatment process of strawberries with zinc oxide nanoparticles is efficient in increasing the °Brix concentrations of the fruit.

When compared with other studies, one can see that the results are similar to the °Brix levels of this study. In the study by Borsatti et al. (2009:39), who studied strawberries in the southwestern region of Paraná, the authors obtained soluble solid values for the cultivars Oso Grande, Festival, and Camarosa of 6.27; 7.08 and 6.76 °Brix, respectively. The authors Resende et al. (2010:40) evaluated the soluble solids content of the fruits of four strawberry cultivars in Guarapuava-PR, and they found SS values for the cultivars Camarosa and Oso Grande equal to 4.43 and 4.80 °Brix, respectively.

Scolforo (2014:41) found values for the cultivars Camino Real and Sweet Charlie of 6.74°Brix and 7.31°Brix. Françoso et al. (2008:11), on the other hand, obtained °Brix values of 7.0 and 9.5 for the same varieties, while Cordenunsi et al. (2002:42) reached the values of 5.4 °Brix and 6.0 °Brix for the cultivars Dover and Capineiro.

The sugar content of the fruits of the cultivar Oso Grande were evaluated by Figueiredo et al. (2010:43) in the municipality of Lavras-MG, who obtained the average value of 4.4%. Superior sugar values were obtained for the cultivar Camarosa by Camargo et al. (2009:12), who evaluated the chemical characterization of fruits in different cultivation systems in the city of Guarapuava-PR and observed mean values of 5.65% and 5.92% of total soluble sugars in the organic and conventional cropping system, respectively. As can be seen, the findings are significantly below the values obtained in this study. Associating the sugar levels in the fruits with the climate parameters, Rios (2007:45) affirms that the quantity of

sugars is directly related to the intensity of light and independent of the temperature and photoperiod.

In the period with the greatest Brix intensity (3rd period), the temperatures were considerably high, but within the recommended range for the cultivation of strawberries, which grow best in subtropical or temperate climates with mild temperatures between 15°C and 26°C, since excess heat and humidity leave the strawberry plants more susceptible to pests and diseases. In this case, the humidity in the period was considered low as a result of the temperatures reached. It should be noted that excess humidity can restrict the productive potential of plants. The insolation rates are also related to the temperature variable, the hours of solar radiation were significant, but it should be emphasized that it was not the period with the highest values. Longer days with higher average temperature favor the emergence of stolons and, consequently, new plants, while shorter days and lower temperatures favor blooming, especially of short-day varieties.

IV. CONCLUSION

Under the conditions in which the experiment was conducted, the results allow for the following conclusions:

- the treatment process of the strawberry crop with zinc oxide nanoparticles is efficient for the nutrients anthocyanins and soluble solids.
- the method for the analysis of vitamin C, which consisted in freezing the raw material, is probably ineffective because it reduces the levels of ascorbic acid by freezing and crystallizing the sample.
- The climatic factors significantly influence the nutritional composition of anthocyanins and soluble solids.
- The 100% nanoparticle composition of the recommended dose proves to be more effective than zinc oxide in its natural form for the increase of the soluble solids values.

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The Influence of Human Quality Index and Supporting Facilities through Electrical Supply in Humbang Hasundutan Regency

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Abstract— Humbang Hasundutan Regency is one of the regencies in North Sumatera, has 10 (Ten) subdistricts, 153 villages 1 (one) Urban Village. Total Population 176,429 inhabitants, 40,783 household heads, average Electrical Energy Supply 14, 7021 MW, Human Development Index an average of 71,353 points. The growth of Human Quality Index is a needed supporting facility of HDI, enormous energy, as for problem that as follows:

1. What is the effect of human quality index and supporting facilities trough electrical energy in Humbang Hasundutan Regency.
2. What model is suitable to measure the availability of electrical energy in Humbang Hasundutan Regency is seen from the human quality index and supporting facilities ten years later.

Supporting theories in this study are theories of human resources, especially theories relating to the index of human development, electrical energy. The effect of human resource quality index and supporting means on the availability of electrical energy in Humbang Hasundutan district with available data (10) ten years of regional autonomy can be used equation model $\bar{Y} = a + b\bar{X}$ and measuring the quantity of energy supply intake can use formula $(E) = f(t) = A \cdot e^{bt}$. The results of this study showed an increase in Human Development Index of 0.62%, improvement of supporting facilities 4, 24% and increased availability of electrical energy 34%, correlation of human energy index with 94.41% energy availability and electricity supply availability for the ten years later 242,281MW the impact of human development index increase from 2004 to 2013.

Keywords—Human Quality Index, Supporting Facilities, Electrical Supply

I. INTRODUCTION

All districts increase that generates resources to promote life. At this time many countries are shaken by the energy and human resources crisis, the Indonesian government has not escaped.

Based on Law No. 34 in 2004 states that local governments have broad authority to manage the resources in their area.

Human Development is formulated as an extension of choice for the population (enlarning the choises of people) which can be seen as a process of effort towards expanding options (UNDP, 1990).

Human resources are very vital organizational assets, therefore their roles and functions cannot be replaced by other resources, however modern of technology used, how much funds are prepared, but without professional human resources, everything becomes meaningless (Prihantin Lumban Raja 2013 , p .; 1).

Supporting facilities that support human quality index such as hospital facilities; school, employment; housing and the environment, household spending and consumption are crucial in raising the human resource quality index.

The addition and improvement of facility buildings in quantity must be considered, Electrical energy is an inevitable global problem, the economy and human activities will be totally paralyzed without energy therefore demands the energy supply and planning as early as possible. Electrical energy supply can be seen from how much the demand by customers and how much the quality index of human resources and supporting facilities.

1.1 The problems of the Study

Based on the description above the problems of this study are:

- a. What is the effect of human quality index and supporting facilities through electrical energy in Humbang Hasundutan Regency
- b. What model is suitable to measure the availability of electrical energy in Humbang Hasundutan Regency is seen from the human quality index and supporting facilities ten years later.

1.2 The Objectives of the Study

In relation to the problems of the study, the objectives of this study are:

- a. To find out the effect of human quality index and supporting facilities of electricity energy that available in Humbang Hasundutan Regency.
- b. To find out how much the influence of human quality index and supporting facilities that available of electricity ten years later.

1.3 The Significances of the Study

The findings of the study are expected to be beneficial and give contribution theoretically and practically, as follows.

- a. For the Humbang hasundutan district government, they know how much the human quality index and supporting facilities increase that available of electricity and able to predict the availability of electricity in ten years later.
- b. Furthermore, the results of this study are useful to add academic value as a function of Tridarma Perguruan Tinggi and to add knowledge about the development of human resources and the availability of electricity.
- c. This research can be useful as a theoretical material to be developed in the area of knowledge.

II. REVIEW OF LITERATURE

2.1 Human Resources

Human resources one of the most vital sources. Humans are the creatures that have the highest nature have values that can manage resources, adaptability, make changes and are able to answer the challenges of every change. Human resources are very vital organizational assets, therefore their roles and functions cannot be replaced by other resources, however modern of technology used, how much funds are prepared, but without professional human resources, everything becomes meaningless (See Lumbanraja Hal; 1. MSDN 2013).

The concept of human development by UNDP (1995: 12) defines human development is a process to expand choices for the population in the concept that the population is placed as the ultimate and development efforts

are seen as a principal means to achieve goals. The quality index of human resources is the amount of value that is formed by the human development process. To ensure the achievement of human development objectives, there are 4 (four) main things that need to be considered, namely:

- a. Productivity
- b. Equalization Continuity
- c. Empowerment
- d. Productivity

a. Productivity

Productivity of the population must be empowered to participate fully in the process of income generation and employment.

b. Equalization

Residents must have the same opportunity to gain access to all economic and social resources. All obstacles that minimize the opportunity to gain access must be removed so that residents take advantage of the opportunities that exist and participate in productive activities that can improve the quality of life.

c. Continuity

To Access economic and social resources must be addressed not only for future generations. All physical, human and environmental resources must always be replenished.

d. Empowerment

Residents must participate fully in decisions and processes that will determine the shape or direction of their lives and participate in benefiting from the development process.

2.2 Human Quality Index

Human quality index is the value of the human development process that is formed Life Expectancy Index (eo), school average, and literacy and purchasing power. According to the Republic of Indonesia government regulation No.8 in 2008 concerning guidelines for evaluating the administration of local government, it is stated that Evaluation of the Implementation of Regional Autonomy (EKPOD) is a systematic process of collecting and analyzing data on the performance of regional autonomy covering aspects of community welfare, public services and power regional competitiveness. In this case the human development index is used to measure the end result of regional autonomy.

The analogy of the availability of electricity rises exponentially, and then slowly decreases after consumption.

The value as a function of time follows a logistic curve, namely the curve S, and the reserve decreases with the end of the energy source. The consumption curve K on its

principle follows the curve S but lags behind time compared to the curve A. (Abdul Kadir: Energi, 1989).

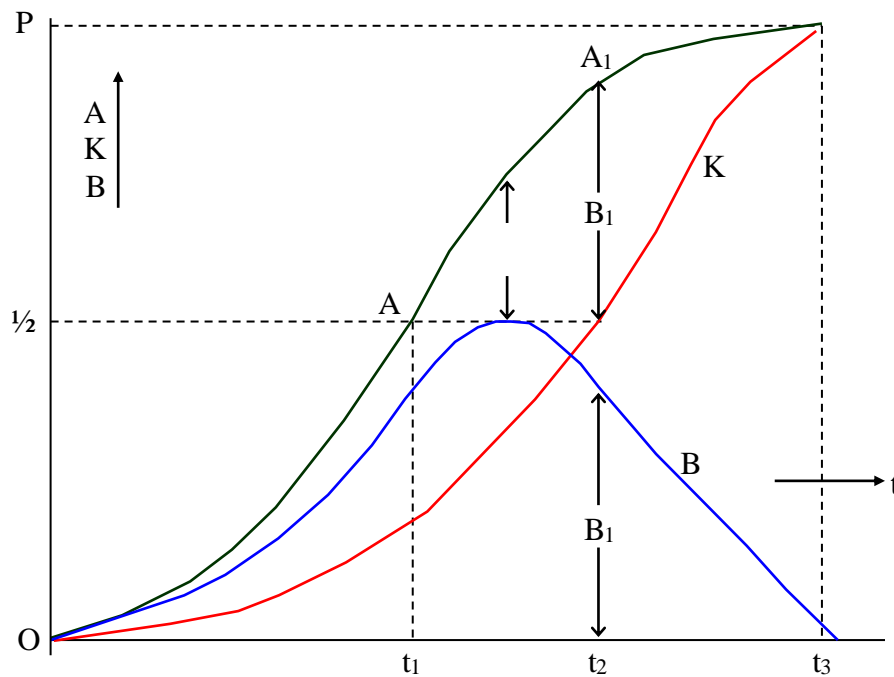


Fig.2.1: Energy Supply and Consumption

The use of electrical energy (E) for many years ago is recorded as a function rather than time, then generally seen the growth of E is greater than the function E is linear. Mathematically, the curve is expressed in the form of an exponential function formulated: $E = f(t)$ in $E = A \cdot e^{bt}$

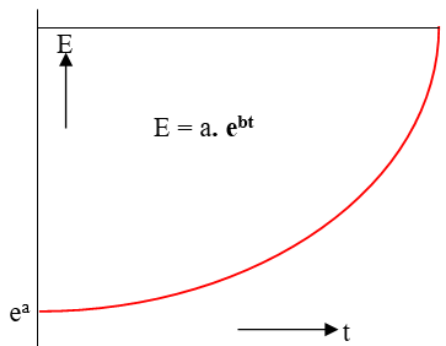


Fig.2.2: Electric Energy Demand with Logarithmic Scale

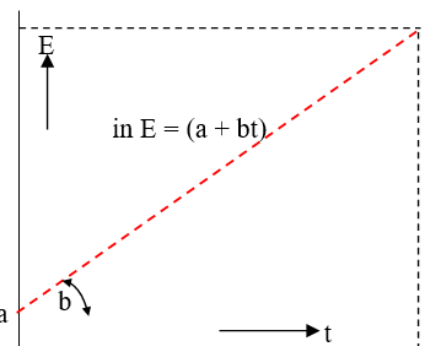


Fig.2.3: Availability of Electric Energy with Linear Scale

By using the magnitude of the energy in this logarithmic scale the curve is a straight line, and then the quantity "a" can be found in the early years, whereas "b" is the growth coefficient to determine the required function of the data as thoroughly as possible and the time period needs to be noted as parameter limitation.

III. RESEARCH METHODOLOGY

3.1 Research Design

This study aims to measure the influence of human quality index and supporting facilities on the availability of electrical energy therefore the research method used by researchers is quantitative method, which is explanatory research. According to Pontas H. Pardede Operations and Production Management CHAPTER IV (2007, p.129) when the sequence shows the relationship between a particular

element and the time points the explanatory method involves measuring the relationship between the elements. Because it is an estimate, it is certain that forecasting results can and usually always deviate from the actual numbers will be realized. The first step in predicting the value of an element to be a future being is to recognize as much as possible the element that influences it, especially its change. The second step is to measure the level and shape of each determinant's influence of the number that is forecasted. Regression analysis is a statistical technique that measures the level of dependence between one magnitude and one or several other quantities. Since it can determine the relationship between the quantities then this analysis can be used to estimate the value of the magnitudes and parameters contained in an equation or function such as a demand function.

3.2 Population and Sample

According Sudjana (2005: 6) suggests that the population is the totality of all possible values, the results of calculating or quantitative or qualitative measurements of certain characteristics of all collected data that are complete and clear source.

According to Sugiono (2010: 72) the population is an area of generalization consisting of objects or subjects that have certain qualities and characteristics set by the

researcher. In this case the data population is the index of human quality, supporting facilities, energy availability in Humbang Hasundutan regency.

Research Sample is part of the number and characteristics possessed by the population. In this case the sample is taken from the human quality index, supporting facilities, energy availability for ten years later in Humbang Hasundutan District. An important step in educational research is to define the study population, researchers make research samples are data for ten years the human quality index and supporting facilities and electrical energy installed, the sample taken in the study is data in the form of numbers for ten years according to the title of research in the district Humbang Hasundutan. To obtain data regarding the presence or absence of the influence of the Index of Human Quality and Supporting Facilities on Electricity Supply, researchers conducted observations in several departments, offices, BPS offices, PLN Offices in the Humbang Hasundutan Area.

3.3 Source of Data

Data sources are obtained from Agencies, Health, Education, Economy, Housing and Environment, Bappeda, Central Statistics Agency, PLN Rayon Dolok Sanggul and Siborongborong and, as well as the Office of Natural Resources and Energy in Humbang Hasundutan District.

IV. RESULT AND DISCUSSION

4.1 Research Data

The Data of Human Development Index (HDI)

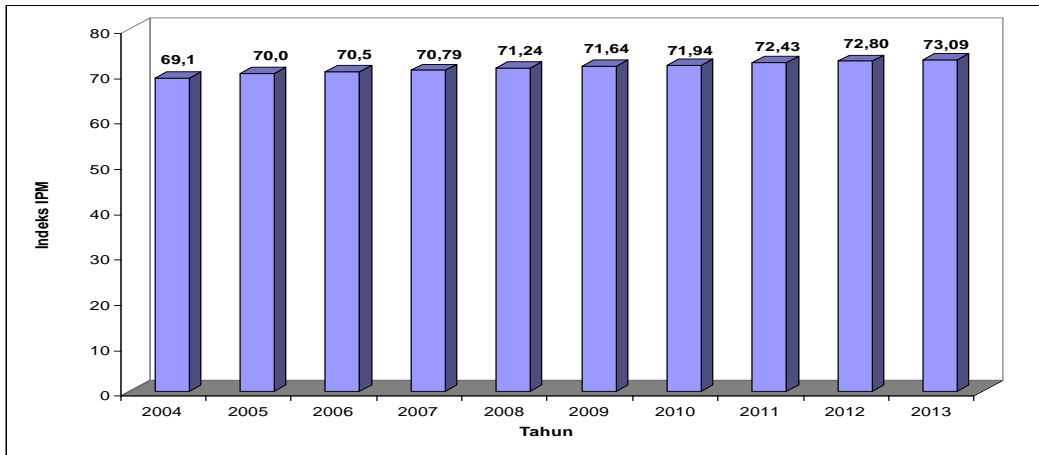
Table.4.1: The Data of HDI Kabupaten Humbang Hasundutan in 2004-2013

Description	Years									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Life expectancy	62,2	67,2	67,5	67,8	67,69	67,78	67,87	67,96	68,08	68,09
Literacy	97,7	98,2	98,2	98,2	98,22	98,21	98,21	98,22	97,59	98,23
Average old school	8,5	8,6	8,6	8,6	8,74	9,05	9,05	9,31	9,34	9,38
Purchasing Power	597,2	598,5	602,4	604,99	609,62	611,20	614,37	617,64	621,32	624,50
IPM	69,1	70,0	70,5	70,79	71,24	71,64	71,94	72,43	72,80	73,09

Data: BPS Humbang Hasundutan

From the above data can be illustrated the growth chart of the Human Quality Index for 10 years in the Humbang Hasundutan District from 2004-2013.

Picture.4.1: Graph of Human Development Index (HDI) Population of Humbang Hasundutan Regency Ten Years



Source: Data BPS Humbang Hasundutan

4.1.1 Supporting facilities

Supporting Facilities the Human Quality Index can be described, namely health, education, employment, housing and environmental facilities, as well as expenditure and consumption.

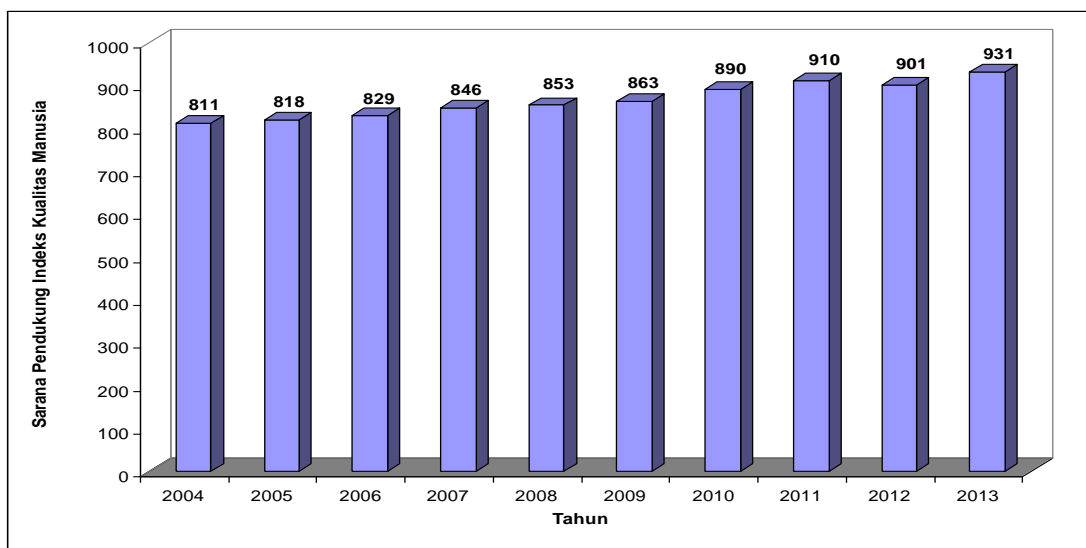
Table.4.2: Supporting Facilities Human Quality Index in 2004-2013

Description (1)	Year									
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Educational facilities	282	287	291	295	297	299	301	303	305	307
Health facility	435	436	439	451	452	458	479	489	471	490
Employment Facilities	16	16	19	19	20	22	23	24	28	31
Housing and Environmental Facilities	10	11	11	11	11	11	13	16	17	19
Spending and Consumption Facilities	68	68	70	70	73	73	74	78	80	84
Supporting facilities	811	818	829	846	853	863	890	910	901	931

Source: Data BPS Humbang Hasundutan

From the temporary data above, the average Support Facility for 10 years = 427.1 units

Picture.4.2: Chart of Supporting Facilities Human quality index Population of Hasundutan District in Tenth Years



Source: Data BPS Humbang Hasundutan

4.1.2 Electrical Energy Supply

Below will be described on the availability of electricity for 10 (ten) years in Humbang Hasundutan District.

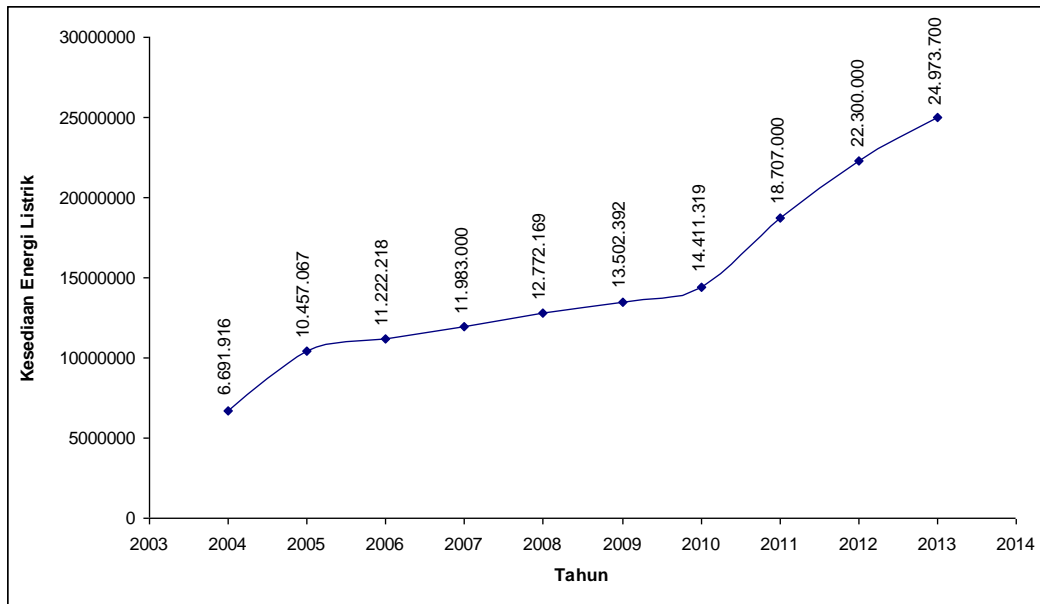
Table.4.3: Electrical Energy Supply in Humbang Development in 2004-2013

Years	Number of Customers	Power Installed	Electrical Energy Production	Electricity Sold
(1)	(2)	(3)	(4)	(5)
2004	17.492	6.691.916	884.729	
2005	19.159	10.457.067	1.084.822	
2006	20.830	11.222.218	1.098.284	717.486
2007	21.637	11.983.000	1.298.377	7.959.291.855
2008	22.552	12.772.169	1.389.104	8.645.826.000
2009	23.592	13.502.392	1.496.914	10.829.833.000
2010	24.227	14.411.319	1.917.182	22.979.000.000
2011	32.181	18.707.000	52.085.000	21.484.062
2012	33.512	22.300.000		
2013	36.467	24.973.700		

Sumber : Data BPS Humbang Hasundutan

From the above provisional data, the average electricity supply availability for 10 years = 14, 7021. From the data above, it can be illustrated the 10-year the Energy is Growth based on graph in Humbang Hasundutan District from 2004-2013

Picture.4.3: Graph of Electrical Energy Supplies in Humbang District of ten years



Source: Data BPS Humbang Hasundutan

4.2 Hypothesis testing

The Effect Analysis of Human Quality Index on Electrical Energy facilities . Hypothesis Testing by using the statistical formulas presented in the previous chapter the influence of Human Quality Index (X1) and Supporting Facilities (X2) trough Electrical Energy Supply (Y) is depicted with equation = $\bar{Y} = a + b\bar{X}$.

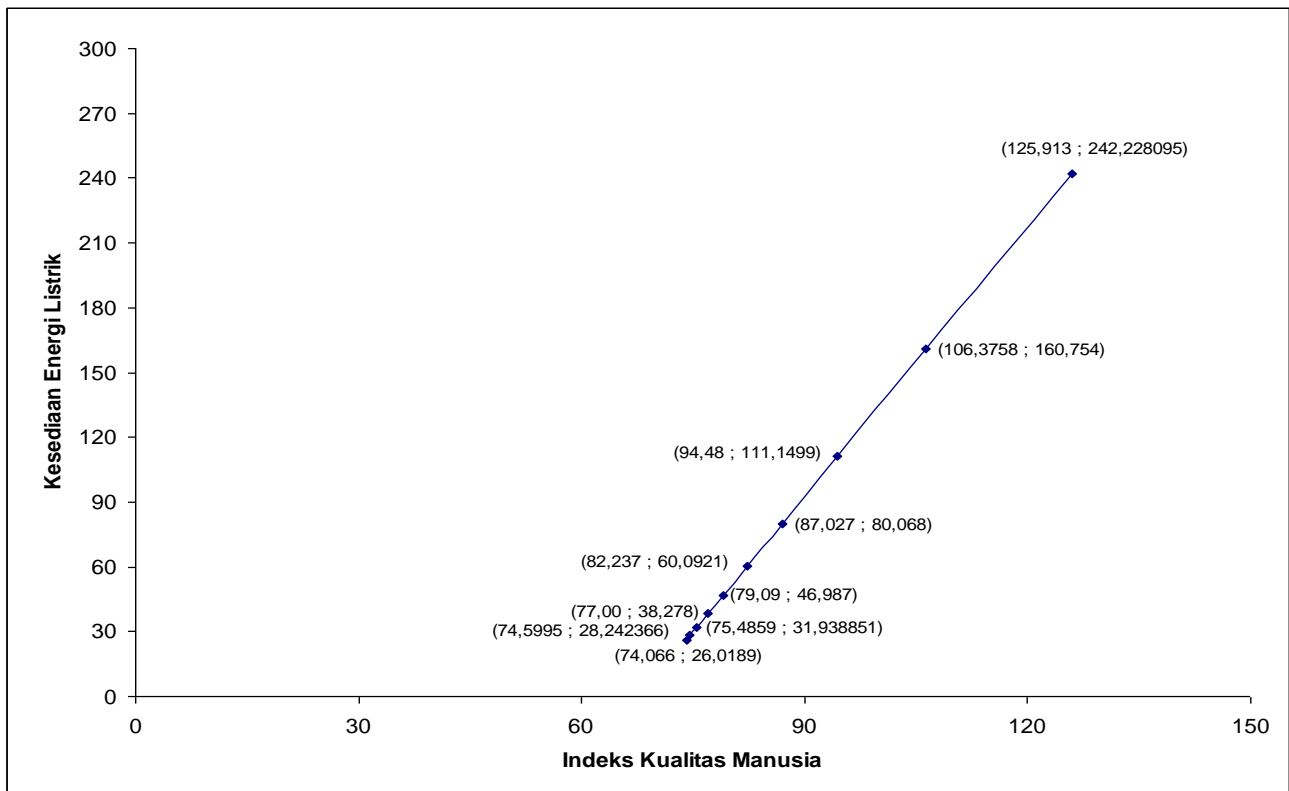
4.2.1 Relation of Human Quality Index with Electrical Energy Facilities

The relationship between the Human Quality Index and Electrical Energy facilities can be described by the equation $\bar{Y} = a + b\bar{X}_1$ where a and b can be calculated using a simple linear regression formula

$$b = \frac{n \sum XY - \sum X \sum Y}{n \sum X^2 - (\sum X)^2} \quad a = \bar{Y} - b\bar{X}$$

From the results of the equation obtained the value of $b = 4.17$ and $a = -282.84$, from the results of the calculation of a and b it can be described the regression equation as follows: $Y = -282.84 + 4.17X_1$ or $X_1 = 67.827 + 0,2398Y$ it means that electricity supply for 10 years 242,2280951, the estimated increase in the Human Quality Index is $X_1 = 67,827 + (0,2398)(242,2281) = 125$ points (the calculation is attached).

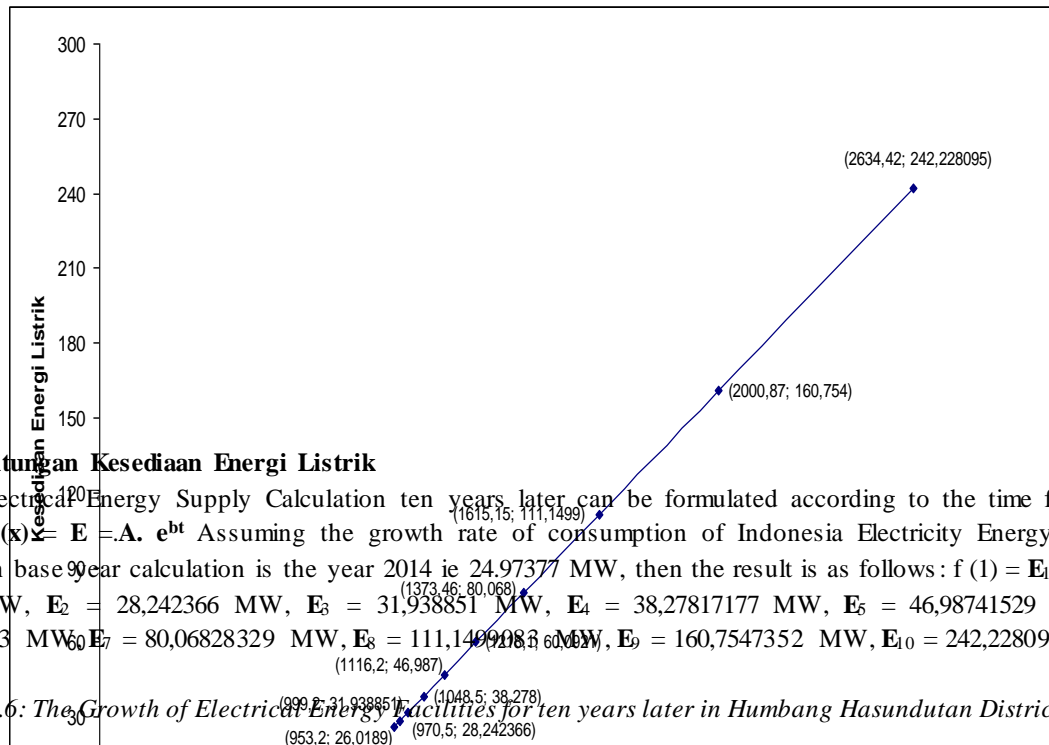
Picture.4.4: Graphs of Human Quality Industry Relationships and Electrical Energy Supplies ten years in Humbang Hasundutan district



4.2.2 Relation of Supporting Facilities to Electrical Energy Supply

The relation of supporting means with the availability of electric energy can be illustrated by the following equation: $\bar{Y} = a + b\bar{X}_2$ where the values of a and b can be calculated as the above equations so that b = 0,1286 is obtained and a is obtained by the equation $a = \bar{Y} - b\bar{X}_2$ so, a = a = 14,7021 - 0,1286(865,2) = -96,56. From the results of calculations a and b it can be written regression equation as follows: $Y = -96,56 + 0,1286X_2$ atau $X_2 = 750,855 + 7,776Y$ it means if the availability of Electrical Energy 10 years later 242,2281 then it is estimated that the increase of facilities The support is $X_2 = 750,855 + 7,776(242,2281) = 2634,42$ unit.

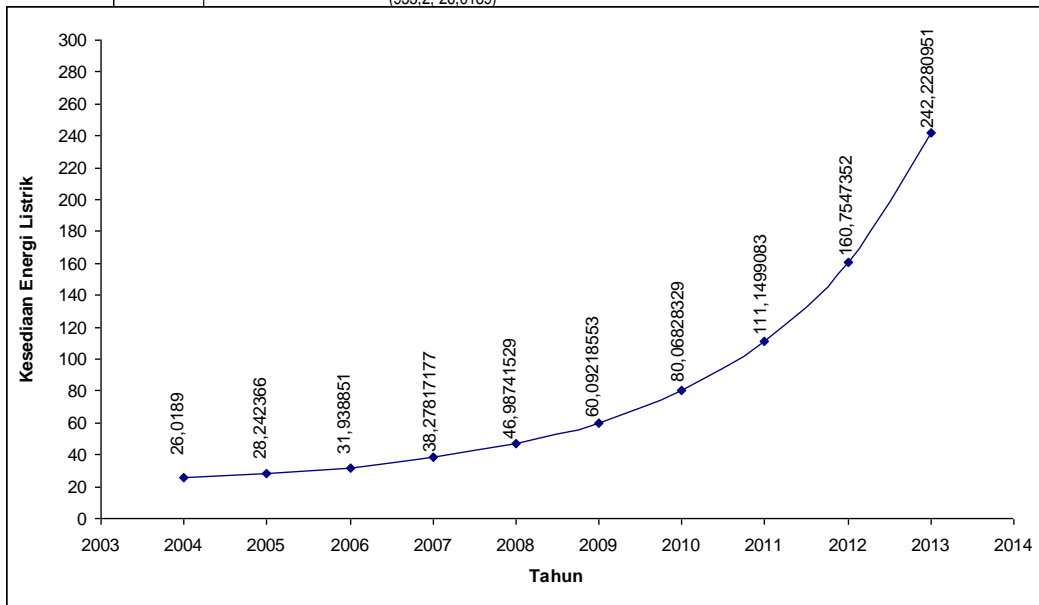
Picture.4.5: Graph Connection of Supporting Supply and Electrical Supply Energy Support in Humbang Hasundutan Regency



4.2.3 Perhitungan Ketersediaan Energi Listrik

Electrical Energy Supply Calculation ten years later can be formulated according to the time function as follows: $f(x) = E = A \cdot e^{bt}$ Assuming the growth rate of consumption of Indonesia Electricity Energy 4.1% and assumption base year calculation is the year 2014 ie 24,97377 MW, then the result is as follows: $f(1) = E_1 = A \cdot e^{bt} = 26,0189$ MW, $E_2 = 28,242366$ MW, $E_3 = 31,938851$ MW, $E_4 = 38,27817177$ MW, $E_5 = 46,98741529$ MW, $E_6 = 60,09218553$ MW, $E_7 = 80,06828329$ MW, $E_8 = 111,1499083$ MW, $E_9 = 160,7547352$ MW, $E_{10} = 242,2280951$ MW.

Picture.4.6: The Growth of Electrical Energy Facilities for ten years later in Humbang Hasundutan District



4.2.4. Significant Test of Simple Correlation

To know the level of influence (coefficient of determination) between 2 variables used a simple correlation test that can be calculated using the formula as follows:

- a. Correlation between Human Quality Index (X1) with Electrical Energy (Y)

$$r = \frac{n(\sum X_1 Y) - \sum X_1 \sum Y}{\sqrt{[n \sum X_1^2 - (\sum X_1)^2][n \sum Y^2 - (\sum Y)^2]}}$$

$$r = \frac{10(1055153) - (713,53)(147,021)}{\sqrt{[10(50927,16) - (427)^2][10(2447,70) - (147,021)^2]}}$$

$$r = \frac{105515,3 - 1049038941}{\sqrt{[509.271,6 - 5091250609][24.477 - 21615,17444]}}$$

$$r = \frac{611,4059}{\sqrt{[146,5391][2861,8256]}} = \frac{611,4059}{\sqrt{419.369,3478}} = \frac{611,4059}{647,5873293}$$

$$r = 0,9441 = 94,41\%$$

The calculation results show that the level of influence for improving the Index of Human Quality Index is 0.9441 it means that 94.41% change in the value of the Human Quality Index is due to changes in Electricity Supply Increase. This figure is quite large so it can be concluded that only a small part of the change in the cause of other factors. In other words the electrical energy supply function with the Human Quality Index is closely related.

- b. Correlation between Supporting Facilities (X2) with Electrical Energy (Y)

$$r = \frac{n(\sum X_2 Y) - \sum X_2 \sum Y}{\sqrt{[n \sum X_2^2 - (\sum X_2)^2][n \sum Y^2 - (\sum Y)^2]}}$$

$$r = \frac{10(129161345) - (8652)(147,021)}{\sqrt{[10(7500942) - (8652)^2][10(2447,70) - (147,021)^2]}}$$

$$r = \frac{129161345 - 1272025692}{\sqrt{[(75009420) - (74857104)][(24477,0472) - (21615,17444)]}}$$

$$r = \frac{19587,758}{\sqrt{[152.316][2861,872]}} = \frac{19587,758}{\sqrt{435909011,3}} = \frac{19587,758}{20878,43412}$$

$$r = 0,93818 = 93,818\%$$

4.2.5 Multiple Regression Test

To test whether each coefficient can give an illustration of Y for X and vice versa it is necessary to do multiple linear regression calculations. Testing the coefficients with the assumption that the regression has been accepted is expressed by the following equation:

$$Y = a_0 + a_1 X_1 + a_2 X_2$$

$$\frac{(\sum X_2^2)(\sum X_1 Y) - (\sum X_1 X_2)(\sum X_2 Y)}{(\sum X_1^2)(\sum X_2^2) - (\sum X_1 X_2)^2}$$

$$a_1 = \frac{(7500942)(1055153) - (61780347)(129161345)}{(50927,16)(7500942) - (61780347)^2}$$

$$a_1 = \frac{7914641454,26 - 7979632713,87}{38200167334,72 - 38168112754,04}$$

$$a_1 = \frac{-64991258961}{32054584068}$$

$$a_1 = -2,0275$$

$$a_2 = \frac{(\sum X_1^2)(\sum X_2 Y) - (\sum X_1 X_2)(\sum X_1 Y)}{(\sum X_1^2)(\sum X_2^2) - (\sum X_1 X_2)^2}$$

$$a_2 = \frac{(50927,16)(129161345) - (61780347)(10551,53)}{(50927,16)(7500942) - (61780347)^2}$$

$$a_2 = \frac{65778204826302 - 65187718478091}{38200167334,72 - 381681127544,041}$$

$$a_2 = \frac{59048634,8211}{320545840,6791} = 0,184$$

$$a_0 = \bar{Y} + a_1 \bar{X}_1 + a_2 \bar{X}_2$$

$$a_0 = (14,7021) + (-2,0275 \bar{X}_1) + (0,184 \bar{X}_2)$$

$$a_0 = (14,7021) + (-2,0275 \cdot 71,353) + (0,184 \cdot 865,2)$$

$$a_0 = 14,7021 - 144,668 + 159,12 = 29,1541$$

$$\bar{Y} = 29,1541 - 2,0275X_1 + 0,184X_2$$

Thus multiple linear regression equations can be written as follows: $Y = 29,1541 - 2,0275X_1 + 0,184X_2$

4.2.6 Multiple Correlation Test

$$r_{12} = \sqrt{\frac{r^2 y_1 + r^2 y_2 - 2r y_1 \cdot r y_2 \cdot r}{r - r_{12}^2}}$$

$$r_{12} = \sqrt{\frac{(0,9441)^2 + (0,93818)^2 - 2(0,9441)(0,93818)(0,9679)}{1 - (0,9679)^2}}$$

$$r_{12} = \sqrt{\frac{0,89132481 + 0,880181712 - 1,714607242}{1 - 0,93683041}}$$

$$r_{12} = \sqrt{\frac{0,05689928}{0,06316959}} = \sqrt{0,900738472}$$

$$r_{12} = 0,9490 = 94,90\%$$

V. CONCLUSION

After analyzing data the following conclusions are derived.

- In terms of the growth of human quality index for 10 (ten) years between 2003 and 2013 increased 0.62%, supporting facilities increased 4.24%, energy needs 34.85%
- There is a correlation between human quality index on electricity supply for 10 (ten) years 94, 41%.
- There is a correlation between index of human quality to supporting facilities for 10 (ten) years is 11, 46%.
- Assuming the growth rate of consumption of Indonesia Electricity Energy 4, i% and assumption based on calculation in 2014 i.e 24,97377MW, then the result is as follows : $f(1) = E_1 = A.e^{bt} = 26,0189 \text{ MW}$, $E_2 = 28,242366 \text{ MW}$, $E_3 =$

31,938851 MW, $E_4 = 38,27817177$ MW, $E_5 = 46,98741529$ MW, $E_6 = 60,09218553$ MW, $E_7 = 80,06828329$ MW, $E_8 = 111,1499083$ MW, $E_9 = 160,7547352$ MW, $E_{10} = 242,2280951$ MW.

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The Level of Students' Creative thinking Skills in Solving Probability Problem through Scientific Approach

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Abstract— This study aims at describing Mathematics students' creative thinking skills through scientific approach. This study employed descriptive study with qualitative approach and the data collection employed test to determine the levels of students' creative thinking skills. Three indicators of creativity comprised of fluency, flexibility, and novelty. Those indicators determined the five levels of the students' creative thinking, *inter alia* (0) not creative, (1) hardly creative, (2) fairly creative, (3) creative, and (4) very creative. The research findings have found that there are four levels of student' creative thinking. Every group of creative thinking level in completing the test through scientific approach are able to accomplish the test using divergent stages. The creativity indicator is evident in every step of scientific approach. The steps of scientific approach are observing, asking, trying, reasoning, and communicating.

Keywords— Levels of Creative Thinking, Scientific Approach.

I. INTRODUCTION

Education is an important issue inseparable from human life. The education quality in Indonesia is considered still not good enough as measured by the learning process or the students' learning outcomes. To date, students' competence, which is deemed essential for students, is in fact given only peripheral priority [1].

In order to improve those qualities, the government always makes improvements to every curriculum across education levels and, these days, they take into consideration the curriculum of 2013. According to Hosnan, learning activities in 2013 curriculum are directed to empower every student's potential in order to achieve expected competencies through the efforts to grow and improve their attitude, knowledge, and skill [2]. Scientific approach is one of the approaches applied in 2013 curriculum. The learning process using scientific approach is a learning system designed in such a way to empower students to actively construct concepts, judgements, or principles through observing stages (to identify and discover problems), propose or formulate

hypothesis, collect data using various techniques, analyse problems, draw conclusion and communicate learnt concepts. Therefore, they can solve problems at hand. Applying the scientific approach requires particular conditions and learning environments, which ensure that students play an active role in every learning process [3]. The scientific learning process is a combination of learning processes focusing on exploration, elaboration, and confirmation complemented by observing, examining, trying, reasoning, and communicating [4].

A fun learning process is not understood merely the extent to which students feel interested in it but also to what extent they are capable of searching and finding out learning information and then constructing it into a new comprehension [3]. The process of searching and finding the information independently by the students in order to construct the understanding becomes the hallmark of the implementation of scientific approach. Recently, the scientific learning process has been implemented in the schools that apply the curriculum 2013 but it focuses only on the scientific learning process but it has not been able to improve creative thinking ability.

The urgency of creative thinking ability is stipulated in Government Regulation Number 19 of 2005 concerning National Education Standard Article 19 Section 1. It states that learning process in educational unit is held interactively, inspiring, fun, challenging, and motivating to learners in order to take active role in learning. What is more, the learning process is to provide enough space for initiative, creativity, independence with talent, interest, and the physical as well as psychological development of learners [5]. This study applied three components frequently used according to Silver, which include fluency, flexibility, and novelty. Silver states that to assess the creative thinking ability of children and adults The Torrance Tests of Creative Thinking (TTCT) oftentimes comes into use. The three key components of creativity assessed by TTCT are fluency, flexibility, and novelty [6]. According to Siswono, fluency refers to a students' ability in generating the right solution to various problems, and flexibility refers to students' ability in

solving the problems using divergent solutions. Another concept, novelty, refers to a students' skill in proposing various right solutions or one "unusual" answer beyond their knowledge level [7].

Table.1: The indicators of creative thinking skills

The Characteristic of Creative Thinking	The Creative Thinking Indicators
Fluency	The students are able to solve problem correctly and fluently.
Flexibility	The students are able to solve problems with various solutions.
Novelty	The students are able to create a new problem or different ideas from problems in general.

Furthermore, those three indicators determined the five levels of students' creative thinking, namely (0) not creative, (1) hardly creative, (2) fairly creative, (3) creative, and (4) very creative. The Levels of Mathematical Creative Thinking (LMCT) are a stage of hierarchy thinking ability categorized based on fluency, flexibility, and novelty. Using LMCT in learning Mathematics, teachers can measure the levels of students' creative thinking. Furthermore, they can improve students' creative thinking skills. This study applied the Levels of Mathematical Creative Thinking (LMCT) s proposed by Siswono, comprising of level 4, level 3, level 2, level 1, level 0 as presented in table 2 below.

Table.2: Levels of Creative Thinking

Levels of Creative Thinking	Indicators		
	Fluency	Flexibility	Novelty
4 (very creative)	√	√	√
3 (creative)	-	√	√
	√	-	√
2 (fairly creative)	√	√	-
	-	√	-
1 (hardly creative)	-	-	√

1 (hardly creative)	√	-	-
0 (not creative)	-	-	-

Based on the explanation above, this study deems necessary to conduct a study entitled "The Level of Students' Creative Thinking Skills in Solving Probability Problem through Scientific Approach".

II. METHODS

This study employed descriptive research with qualitative approach. The participants consisted of four students selected from each of creative group, creative group, hardly creative group, and non-creative group in Class VIII-B of SMPT Madinatul Ulum Jenggawah Jember. The participants were not selected randomly because the subjects were selected from each group level of creative thinking by testing the participants prior to conducting the study.

The tests were given to all students in class VIII-B who worked in groups available. Based on the test, the students were classified into four levels of creative thinking, namely LCT 0, LCT 1, LCT 2, and LCT 3. From these 9 (nine) groups, one group was chosen to be selected as research subject; therefore, there were four groups of research subject. The test included tasks deploying scientific approach. The tasks included open-ended questions that gave the students the opportunity to generate divergent solutions and answers. Afterward, four groups were classified based on the levels of creative thinking skills.

The task given to the students are presented as follows:

Sebuah dadu bersisi empat dilemparkan sebanyak 600 kali. T
muncul mata dadu 1 sebanyak 200 kali, mata dadu 2 sebanyak 150 ka
mata dadu 3 sebanyak 25 kali.

- Tentukan peluang teoritik muncul mata dadu 4 pada percobaan ter
- Tentukan peluang empirik muncul mata dadu 4 pada percobaan te
Berilah alternatif penyelesaian lebih dari satu.
- Bandingkan hasil (a) dan (b), kemudian buatlah kesimpulan
percobaan tersebut!

III. FINDINGS AND DISCUSSION

The results of test given to 36 students of the grade VIII-B are presented in the pie chart as follows.



Fig.1: The Data of Student's Creative Thinking Level in Class VIII-B

After grouping the levels of creative thinking, one group was selected respectively from each level of creative thinking as the research subject. The results of scientific approach test based on the levels of creative thinking are presented as follows.

1. The Level of Students' Creative Thinking of LCT 0
 - a. In the observing stage, group LCT 0 was not able to explain the task using their own sentences. The students understood the meaning of the task because they could write and mention what were known and asked in the questions.
 - b. In the stage of questioning, group LCT 0 did not write anything on their test sheet.
 - c. In the stage of trying/collecting the information, group LCT 0 answered only as requested, while in the process of doing the test, this group seemed to joke and did not put serious efforts on the task. Only one student seemed busy reading the question, even though this student could not solve it.
 - d. In the stage of reasoning, group LCT 0 answered questions as requested. Only one student were actively trying to solve the question. There was no interaction in this group.
 - e. In the stage of communicating, group LCT 0 wrote the result as requested. They spent more time on talking more than working on their task when the other groups were busy working on their test.
2. The Level of Creative Thinking of LCT 1

These findings showed that the process of scientific approach was not performed in detail and just simply dealt with answering the questions. Therefore, group LCT 0 was categorized on the non-creative level because in the stage of reasoning, the works of the group did not fulfil the creative thinking indicators.

- a. In the stage of observing, group LCT 1 wrote the initial information as requested without translating it into mathematical terms although they 1 comprehended the question purpose. They 1 could explain the meaning of the question using simple sentence.
 - b. In the stage of questioning, group LCT 1 wrote down one question they had not understood and then given simple answers to the questions.
 - c. In the stage of trying/collecting the information, group LCT 1 answered the questions correctly and they properly collected required information.
 - d. In the stage of reasoning, group LCT 1 could solve the problems correctly, even though they were only able to write down one solution. They did not seem to be trying to find another idea to solve it while there was an instruction to generate more alternative solutions. Therefore, they only produced one way of completion.
 - e. In the stage of communicating, group LCT 1 could conclude the discussion with simple sentence.
- According to the explanation above, the process of scientific approach was in performed in its entirety, although they just provided simple answers. In the stage of reasoning, this group had written down one alternative solution correctly; thus, they had fulfilled the fluency indicator. Therefore, they were categorized into the *hardly creative* level.
3. The Level of Creative Thinking of LCT 2.
 - a. In the stage of observing, group LCT 2 wrote down the initial information as requested, even though they could explain the initial information using their own sentences fluently.
 - b. In the stage of asking, group LCT 2 could answer the teacher question correctly and wrote down one question they had not understood.

- c. In the stage of trying/collecting the information, group LCT 2 did it correctly but their work was still imperfect.
- d. In the stage of reasoning, group LCT 2 could solve the problem with two alternative solutions, one of which was finished correctly and completely and the other of which was made with imperfect answer.
- e. In the stage or communication, group LCT 2 wrote down the answers well and correctly. In addition, the results of their discussion were correct.

These findings revealed that the process of scientific approach was performed in detail, regardless of incomplete stage. In this reasoning stage, the group had written down two alternative solutions even though the second solution was not complete. This group fulfilled the flexibility indicator because they could write more than one solution. Therefore, group LCT 2 was categorized as the *fairly creative* level.

4. The Level of Creative Thinking of LCT 3
 - a. In the stage of observing, group LCT 3 could explain the question using their own sentences and they could write down and mention what was known and asked in the question.
 - b. In the stage of asking, group LCT 3 wrote one question they had not understood and solved the questions well and correctly.
 - c. In the stage or trying/gathering the information, group LCT 3 could finish the tasks well and correctly.
 - d. In the stage of reasoning, group LCT 3 could solve the problem well and completely. LCT 3 was able to generate more than one alternative solution.
 - e. In the stage of communicating, group LCT 3 wrote the discussion result well and fluently.

From the explanation above, the process of scientific approach was performed in detail. In the stage or reasoning, this group had written down two alternative solutions well and correctly. Thus, this group fulfilled the indicator of fluency and flexibility because they could write more than one solution. Therefore, group LCT 3 was categorized in the *creative* level.

IV. CONCLUSION

The study has concluded that LCT 0 group in the stage of observing could not explain the task using their own sentences even though the students in LCT 0 understood the purpose in the questions because they could write down and mention what was known and asked in the question. In the stage or trying/gathering the

information and reasoning, group LCT 0 just answered as requested. Upon doing the test, the group seemed to be cracking jokes quite often and did not put serious efforts on their task. Only one student seemed busy reading the question even though the student could not solve it. Therefore, group LCT 0 was categorized on the *non-creative* level because the group work did not fulfil the creative indicators In the stage of reasoning.

Group LCT 1, In the stage of observing wrote down the initial information as requested without translating it using mathematical terms even though these students comprehended the purpose of the question. LCT 1 could explain the task purpose using simple sentences. In the stage of questioning, trying, and reasoning, group LCT 1 wrote one unintelligible question and then they answered the available questions using simple responses. In the stage of reasoning, this group had written one correct solution. Thus, this group met the indicator of fluency. It could be concluded than LCT 1 was in the *hardly creative* level.

Group LCT 2, in the stage or observing, wrote down the initial information as requested, although LCT2 could explain the initial information using their own sentences fluently. In the stage of trying/collecting the information, group LCT 2 utilized the collected information correctly but it was incomplete. In the stage of reasoning, LCT2 could elaborate the problems and provided two alternative solutions, one of which was finished correctly and completely. Another solution was written incompletely. Therefore, this group fulfilled the indicator of flexibility because they could write down more than one solution. In conclusion, group LCT 2 was categorized in the *creative enough* level.

Group LCT 3, in the stage of observing could provide elaborate responses to the task using their own sentences. They could write down and mention what was known and asked in the questions. In the stage of trying/collecting the information, reasoning and communicating. In addition, group LCT3 could finish the task properly, correctly, and fluently. The explanation indicated that the process of scientific approach was performed in detail. In the stage or reasoning, this group had written two alternative solutions well and correctly. This group fulfilled the indicator of fluency and flexibility because they could write down more than one solution. Therefore, group LCT 3 was in the *creative* level.

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The Analysis of Extremely Low Frequency (ELF) Electric and Magnetic Field Exposure Biological Effects around Medical Equipments

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Abstract—Naturally, we have been exposed to electric fields and natural magnetic fields emitted by the Sun, Earth and objects in nature. The process of life will proceed normally in conditions exposed to electric fields and natural magnetic fields. However, the intensity of electric field and magnetic field Extremely Low Frequency (ELF) in the environment always increases along with the development of the electric-powered equipment utilization. This study will describe the increase of electric field and ELF magnetic field around the medical equipment in the hospital. The results of measuring the intensity of the electric field and the ELF magnetic field at a distance of more than 100 cm are not significantly different than the natural intensity. The exposure to the electric field and the ELF magnetic field at the operator position (more than 40 cm) of medical equipment, the ELF electric field is in the range of intensity (2.75 - 166) V/m and the ELF magnetic field is in the range of intensity (0.021 - 3.26) μ T. Until now, there has been no reference results of research that proves exposure to the intensity of the ELF electric field and the ELF magnetic field resulted in a real biological impact. The results conclusion of this study is that the exposure to electric fields and magnetic fields ELF by medical equipment does not have the potential to cause biological effects.

Keywords—Extremely Low Frequency (ELF), Electric and Magnetic Field, Biological effect.

I. INTRODUCTION

The need of electric energy in life is always growing rapidly along the development of electric power equipment technology. The utilization of electric-powered equipment especially medical equipment is proven to improve service

quality and healing of patient. However there are fears of possible biological effects by exposure to electric fields and magnetic fields around these medical devices. Based on Hans Christian Oersted's experiments in 1820, it is proved that in the vicinity of the wire that the electric currents will generate magnetic fields (Halliday and Resnick, 1997: 296). While Maxwell has proven that in the vicinity of the wire flowing by AC will arise electric fields and magnetic fields that propagate to form electromagnetic waves (Young, 2012: 762). The exposure of electromagnetic waves that arise around electrical devices is classified as the spectrum of Extremely Low Frequency (ELF) electromagnetic waves. ELF Electromagnetic wave is a spectrum of electromagnetic waves with a frequency of 0 - 300 Hz. Considering that the source of electrical energy in Indonesia comes from the power plant by the State Electricity Company (PLN) with a frequency of 50 Hz, then the electric field and magnetic field exposed is ELF electromagnetic wave component.

Therefore, the electric field and magnetic field in the exposure of electric powered equipment with the source of PLN is the electric field and ELF magnetic field.

The main source of exposure to electric fields and natural magnetic fields comes from the radiation of electromagnetic waves emitted by the Sun and by the Earth's surface. Yet, the intensity of electric fields and magnetic fields in the environment is increasing as the use of electric-powered equipment in human life increases. Electromagnetic waves consist of different spectrum of different wave types according to λ wavelength and frequency (f).

Figure. 01 provides an overview of the type of spectrum of electromagnetic waves based on their frequency.

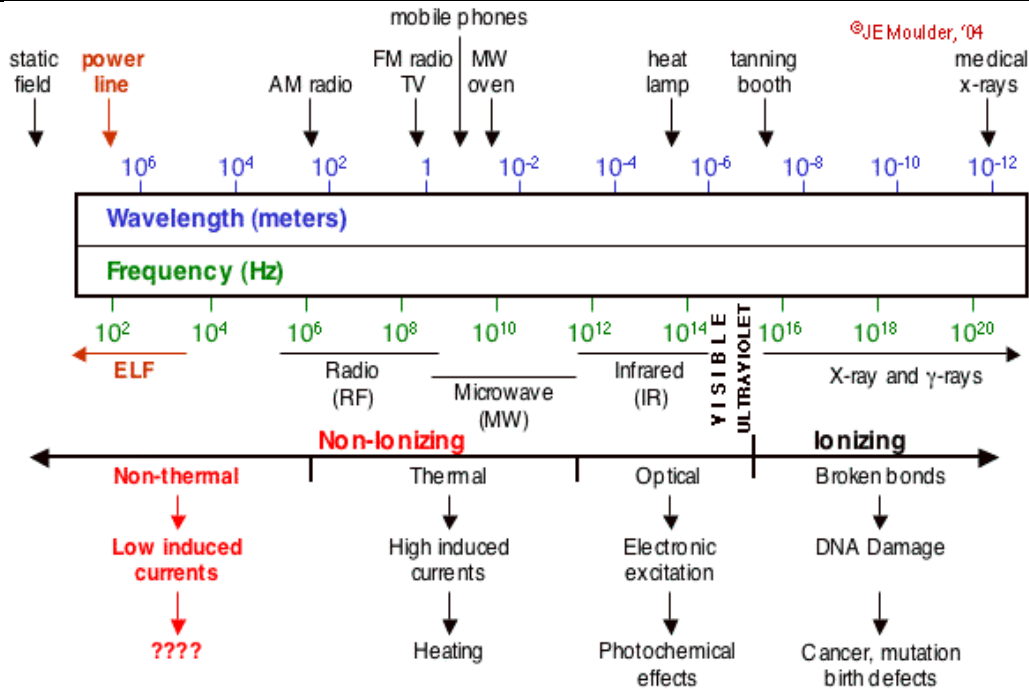


Fig.1: The spectrum of electromagnetic waves (Source: Moulder, 2006)

Based on the figure, it shows that ELF electromagnetic wave spectrum is at the lowest frequency (0 - 300) Hz. The energy contained is also weak, so the effect is non ionizing radiation and non thermal. This means that ELF electromagnetic wave radiation does not cause ionization effects on the atoms of a material, and does not cause a rise in temperature when interacting or inducing a material.

Naturally we subconsciously immersed in a place full of electric fields and magnetic fields, both by radiation exposure to the magnetic field by Earth and by the Sun. At the intensity of the electric field and the natural magnetic field, the process of life takes place normally. The presence of electric energy equipment will have an impact on increasing the intensity of exposure to the electric field and the surrounding ELF magnetic field.

The results of Sudarti's measurements, 2002, prove that the intensity of the electric field and the ELF magnetic field in the residential population about 500 kV High Voltage Transmission Line increased significantly compared to the natural intensity. The intensity of the ELF magnetic field increased 21 times compared to the intensity of the natural electric field, while the intensity of the ELF magnetic field increases 9 times compared to the intensity of the natural magnetic field. However, the exposure to electric field and magnetic field ELF by 500 kV High Voltage Transmission Line is still far below the exposure value recommended by INIRC.

The characteristics of the electric field and magnetic field are very different. The electric field is obstructed, which means that the intensity of the electric field will decrease by the presence of a barrier. However, the magnetic field is unhindered, which means that the intensity of the magnetic field is relatively not decreased by the barrier or is capable of penetrating various barriers including biological materials such as the human body and animals (Grotel 1992).

The exposure to the ELF's magnetic field from the environment in the body directly interacts with the cell through the cell membrane (Shimizu, 1995), therefore it is suspected that the magnetic field as the dominant factor that can cause biological effects.

Normal cells are microcosms containing ions and nonstop molecules undergoing geophysical processes while constantly changing their structure and function to react to their environmental conditions. The exposure to the ELF's magnetic field in the environment can force the ion and molecules in the cell resulting in a change in cell membrane potential, which may cause cellular alterations, either beneficial or detrimental changes to the cell. This is called biological effects.

The results of biological effect research by exposure to electric fields and ELF magnetic fields are still unclear. Valberth PA, 1997, states that exposure to the ELF magnetic field at an intensity greater than 10 uT allows for a biological effect, but Sudarti's research results, 2013, prove that

exposure to electric and magnetic fields by SUTET 500 kV is not a factor causing public health problems who live there.

Therefore, this article presents the analysis results of exposure to electric field and ELF magnetic field in the environment around electric-powered medical equipment. The results of this study are expected to add knowledge and explain scientifically possible biological effects by exposure to electric fields and ELF magnetic fields around medical equipment.

II. RESEARCH METHOD

This study is a descriptive study aimed at describing and analyzing the intensity of exposure to electric fields and magnetic fields around medical devices and the risk of biological effects that they may cause.

The sample of this research is 12 medical equipments that use electrical energy and often used in the framework of medical service in Hospital. ELF field and electric field measurements were performed using the HI-3604 ELF Field Strength Measurement System.

The samples were 15 kinds of electric powered medical equipments commonly used in hospital such as X-ray, CT-Scan, Infant warmer, Photo Terapy, Atom Infant Incubator, Electro Miography, Ultrasonic Diathermy, Cervical Traction (Tracy), Electrical Stimulation, Embitron, Short Wave Diathermy, Laser Therapy, ASA Magnetic Fields, Ultrasonography (USG), Magnetic Resonance Imaging (MRI). The measurements were made by variation of measuring distance (10 - 20) cm, (40 - 60) cm, and 100 cm from medical equipment in ON condition (when electric current flowed).

Based on the data from the measurement of electric field and magnetic field, it will be analyzed descriptively by comparing the intensity of electric field and natural magnetic field. Moreover, it would be done an analysis on possible risks of biological effects that may be generated by exposure to electric fields and magnetic fields from medical devices based on the results of biological effects research from various scientific journals.

III. RESEARCH RESULTS

As a reference analysis of the results from this study, we conducted measurements of electric fields and natural magnetic fields on the grass field during the day. This intensity of the electric field and the natural magnetic field measurement was the accumulation of the intensity of the electric field and the magnetic field generated by the surface of the Earth and by the radiation of the Sun.

The average measurements of the intensity of the electric field and the natural magnetic field are presented in Table 1 below.

Table.1: Intensity of the Natural Field

Natural Field	Intensity
Electrical Field (V/m)	2,1480 ± 0,7632
Magnetic Field (μT)	0,0265 ± 0,0023

Tabel.1 menunjukkan bahwa intensitas medan listrik alamiah berada pada range 2,1258 V/m – 3,5522 V/m, dan intensitas medan magnet alamiah berada pada range 0,0242 – 0,0288 μT. Hal ini berarti bahwa secara alamiah semua makhluk hidup mengalami proses tumbuh kembang secara normal dibawah paparan medan listrik dan medan magnet alamiah tersebut.

In addition to the Earth, the increasing intensity of the electric field and the natural magnetic field in the environment was strongly influenced by the radiation of electromagnetic waves from the Sun. Utilization of electric energy equipment in life will also increase the intensity of electric field and magnetic field in the environment. This makes us realize that human beings on the surface of the Earth are immersed in a sea of electric fields and magnetic fields. Therefore, the exposure to ELF electric fields in the environment at high intensity is suspected to cause biological effects or potentially cause health effects. Therefore the International Non Ionizing Radiation Committee (INIRC), 1990, set the threshold value of electric field and magnetic field exposure 50/60 Hz during the working day, for exposure of electric field of 10 kV / m and magnetic field of 500 μT.

The average ELF field measurement result around medical equipment is presented in the following table.

Table.2: Intensity of Electrical Fields ELF around Medical Equipment

Medical Equipments	Intensity of Electric Field At Distance x (V/m)		
	(10-20) cm	(40-60) cm	(100-200) cm
X-ray	3,45	3,4	1,5
CT-Scan	2,35	2,75	2,3
Infant warmer	14,0	18,0	2,5
Photo Terapy	138,5	76,0	3,5
Atom Infant	10,1	6,8	2,7

Incubator			
Electro Miography	5,35	3,0	2,6
Ultrasonic Diathermy	6,35	4,0	1,6
Cervical Traction (Tracey)	280	52,5	4,5
Electrical Stimulation	8,34	7,85	3,32
Embitron	300	166	2,75
Short Wave Diathermy	16,25	10,95	2,25
Laser Therapy	6,24	4,32	3,25
ASA Magnetic Fields	280	177	7,25
Ultrasonography (USG)	61,5	11,64	2,45
MRI	10,4	5,2	1,7
Natural Average	Field	Magnetic	2,148

Based on the results of these measurements, it proved that the intensity of exposure to electric fields at a distance of 100 cm from all medical equipment was not different from the intensity of the natural electric field. The intensity of the electric field at a distance of 100 cm from both Cervical Traction (Tracey) and ASA Magnetic Fields was higher than the natural intensity, but it is due to the wiring of other electrical equipment. The intensity of the electric field at a distance of 100 cm from the X-ray, Ultrasonic Diathermy, and MRI looked lower than the intensity of the natural electric field. This was given that the measurement of the intensity of the natural electric field was done during the day which was the accumulation of natural electric field intensity coming from the Earth and the Sun.

The intensity of the electric field around the X-ray, CT-Scan, Ultrasonic Diathermy, Atom Infant Incubator, and MRI at more than 10 cm apart proved to be different, but not significant compared to the intensity of the natural electric field. While the intensity of the electric field around the medical equipment of Photo Therapy, Embitron, Tracey and ASA Magnetic Fields was more than 100 V / m, this intensity was still far from the threshold value recommended by the International Non Ionizing Radiation Committee (INIRC) 10 kV for exposure throughout the working day.

For next, the intensity measurements of ELF magnetic field exposure by medical equipment were presented in Table.03as follows.

Table.3: Intensity of ELF Magnetic Fields around Medical Equipment

Medical Equipments	Average Intensity of Magnetic Field At Distance x (µT)		
	(10-20) cm	(40-60) cm	(100) cm
X-ray	125	3,26	0,850
CT-Scan	0,290	0,450	0,320
Infant warmer	0,089	0,035	0,021
Photo Therapy	1,475	0,021	0,0155
Atom Infant Incubator	0,157	0,028	0,018
Electro Miography	0,113	0,117	0,133
Ultrasonic Diathermy	0,028	0,028	0,025
Cervical Traction	9,650	3,075	0,019
Electrical Stimulation	0,88	0,045	0,023
Embitron	5,715	0,500	0,154
Short Wave Diathermy	2,550	1,864	0,015
Laser Therapy	0,415	0,0356	0,095
ASA Magnetic Fields	8,150	1,256	0,350
Ultrasonography (USG)	1,243	0,215	0,0356
MRI	2,453	0,144	0,0405
Natural	0,031		

The intensity measurement of ELF magnetic field exposure at a distance of 100 cm from all medical equipment in this study proved not significantly different from the intensity of the natural magnetic field. The magnetic field intensity around Infant warmer and Ultrasonic Diathermy ranged from 10 cm from the tool was very low and no different from the natural intensity. This meant that the two tools had no impact on increasing the intensity of the magnetic field in the environment.

The intensity of the magnetic field at a distance of more than 20 cm from the Photo Therapy tool, Atom Infant Incubator, Electrical Stimulation, and Laser Therapy was also

no different from the intensity of the natural magnetic field. The intensity of the magnetic field at a distance of 10-20 cm from the four medical devices was slightly less than natural. This indicated that the four devices only had an effect of increasing the magnetic field that was very weak only up to a distance of 20 cm. The intensity of the magnetic field around CT-Scan, Electro Miography, Short Wave Diathermy, Ultrasonography (ultrasonography) and ultrasound devices reached less than 3 μT at 20 cm, and reached less than 2 μT at 60 cm, while the intensity of the highest magnetic field at a distance of 10-20 cm caused by X-ray reached 125 μT, by Cervical Traction (Traccy) reached 9,650 μT, by ASA Magnetic Fields reached 8,150 μT, and by Embitron reached 5,715 μT. But this intensity was still far from the ELF magnetic field exposure limit value recommended by the International Non Ionizing Radiation Committee (INIRC), which is 500 μT for exposure throughout the working day.

IV. DISCUSSION

As a basis for analyzing the health effects of exposure to electric fields and ELF magnetic fields by medical equipment, it was based on the recommendation of the International Non Ionizing Radiation Committee (INIRC) of the International Radiation Protection Association (IRPA), 1992, that the limit of exposure to electric fields and magnetic fields of 50/60 Hz (ELF) as follows:

Table.4: Threshold Value of Electric Field Intensity and ELF Magnetic Field

Field for	Electric Field Intensity (kV/m)	Magnetic Field Intensity (μ T)
Group of Worker:		
All Day Long	10	500
Short Time	30*	5000**
General Group:		
Until 24 hours/day	5	100
Several hours/day	10	1000

(Sources: IRPA,WHO, 1990)

* = The duration of exposure to the electric field between 10 and 30 kV / m shall be calculated from the formula $t < 80 / E$,

t = Time (hour/day)

E = Strong Field (kV/m)

** = Maximum time exposure of 2 hours / day.

This indicated that the intensity of ELF field exposure in humans during maximum working hours reached 10 kV and the intensity of ELF field exposure was maximum of 500 μT.

The United Nations Environmental Program (UNEP), the World Health Organization (WHO) and IRPA in 1987 issued a statement about the induced current density value with its biological effects caused by exposure to 50/60 Hz magnetic fields on the whole body as follows :

- a) Between 1 and 10 mA / m², there was no significant biological effect.
- b) Between 10 and 100 mA / m², there was a proven biological effect, including effects on the vision and nervous system.
- c) Between 100 and 1000 mA / m², stimulates a stimulated tissue and there was a potential of health hazard.
- d) Above 1000 mA / m², it may cause extrasystole, and ventricular fibrillation of the heart (acute danger of health).

The results of Sudarti measurements, 2012, that the intensity of the electric field and the ELF magnetic field in the residential population about 500 kV High Voltage Transmission Line increased significantly compared to the natural intensity. When compared to the intensity of the natural electric field, the intensity of the electric field outside the house increased 21 times and the intensity of the electric field inside the house increased 7 times. While the intensity of the ELF magnetic field outside the home was not significantly different with the intensity of the ELF magnetic field inside the house, but there was an increase of 8-9 times compared to the natural.

The average intensity of electric field exposure by 500 kV High Voltage Transmission Line was 90 V / m and the average intensity of the magnetic field was about 0.4 to 3 μT and it didn't become as a contributing factor to the public health problems who live near the place (Sudarti, 2013).

The results of the biological effects of exposure to electric fields and the ELF magnetic field reported Sudarti, 2002, that the number of leucocytes in Norwegian Wistar Ratus maintained below 500 kV High Voltage Transmission Line with ELF field intensity (1,1620-2,148) kV and field intensity ELF magnets (1.6693 - 1.7168) μT continuously for 8 weeks are shown to significantly decrease compared to controls. The results of spermatozoa examination in Norwegicus also found the number of defective spermatozoa in the mouse group maintained just below 500 kV of High Voltage Transmission Line for 8 weeks, but not significantly

different from the control group (Sudarti, 2003). It was also evident that the number of leucocyte that experienced apoptosis significantly increased in wistar white rats maintained under 500 kV of High Voltage Transmission Line intermittently 8 hours / day for 14 weeks (Sudarti, 2004).

The exposure to an ELF magnetic field with intensity (20-40) μ T intermittently 8 hours / day for 15 days significantly increased the percentage of IL-10-producing lymphocytes in the Balb / C mice lymph nodes, and decreased significantly after day 30 at Said the ELF magnetic field, but still significantly higher than the control (Sudarti, 2005). In contrast, the percentage of IgG-production by lymphocytes in lymph nodes of Balb / C mice decreased after exposure to the intensity ELF magnetic field (20-40) μ T intermittently 8 hours / day for 15 days, and increased significantly after day 30 being exposed by the ELF magnetic field, but still significantly lower than the control (Sudarti, 2005). While the percentage of IFN-gamma-producing lymphocytes in lymphocytes of Balb / C mice decreased significantly after exposure to the intensity ELF magnetic field (20-40) μ T intermittently 8 hours / day for 15 days, and increased significantly after day 30 in the ELF magnetic field, but significantly lower than the control (Sudarti, 2006).

The results showed that exposure to the ELF magnetic field (20-40) μ T intermittently 8 hours / day for 15 days and 30 days was able to suppress Th1 cell activation so that it resulted in a decrease IFN-gamma production. The decrease in IFN-gamma production resulted in increased Th2-set activation, so that producing IL-10 was increased. The increased production of IL-10 would activate B cells to produce IgG. This showed that exposure to the ELF magnetic field (20-40) μ T affected the immunological balance in Balb / C mice.

Several studies of magnetic field effects by various equipment were reported, among others, Huss A, et al, 2017, reported that exposure to magnetic fields by MRI can not be proven to cause health effects on operators. Brodic Darko & Amelio Alessia, 2015, reported that the highest exposure to the magnetic field by the laptop is at the bottom of the laptop. Lv X, et al, 2014, proved that exposure to the 0.86 μ T magnetic field did not cause problems on the patient's blood vessels. Petri et al., 2017, stated that exposure to static magnetic fields is not proven to cause biological effects.

Vijay *at al*, 2012, they concluded that the CRT TV/PC screen is harmful for the blood tissue of the human beings at least the given distances and heights of the CRT TV/PC screen from earth surface. Kaushal M et al, 2012, concluded that people living near cell tower receive strong signal strength but at the expense of health. Calderon et al, 2017,

They concluded that the number of phantoms was not large enough to provide definitive evidence of an increase of induced current density with age, but the data that are available suggest that, if present, the effect is likely to be very small. Woelders H, et al, 2017, They concluded that biological effects of radiofrequency electromagnetic fields (RF-EMF) in modern wireless telecommunication, there is not conclusive evidence was found for induced embryonic mortality or malformations by exposure to the used EMFs to eggs.

While Taheri M et al, 2017, proved that wi-fi and radiofrequency radiation can inhibit the growth of E coli bacteria. Istiaque Ahmed, et al, 2013, concluded that all irradiated *S. aureus* bacteria showed decrease in their growth rate compared to control samples, after exposure by ELF PEMF at 150-500 Hz, are more effective than exposures at 3-100 Hz in reducing the viability of *S. aureus* in broth. Tayebbeh Barsam, et al, 2012, the results in this paper showed a positive correlation coefficient between occupational exposures to ELF electromagnetic fields and sleeping quality score, cannot reject the impact of the fields on sleep quality. Since other finding indicated the weak electromagnetic fields can have the biological effects and reducing work hours can prevent their biological effects.

While the exposure to UF magnetic field (100-150) μ T intermittently 8 hours / day for 7 weeks had a significant effect on the increase of Germinal Cell Calcium on Mice Bulb / C (Sudarti, 2010). Furthermore, the development of research towards the utilization of ELF magnetic field by Sudarti, 2016, that exposure of ELF magnetic field at an intensity of 700 μ T can be utilized as a sterilization method of salmonella in Gado-gado food.

Therefore, based on the results of this study indicated that exposure to electric fields and ELF magnetic fields by medical equipment could be said to have no potential biological effects for operators, considering the position of the average operator was at a distance of more than 40 cm from medical equipment. While the exposure of electric field and magnetic field ELF to the position of medical equipment operators for the ELF electric field was in the range of intensity (2.75 - 166) V / m and the ELF magnetic field was in the range of intensity (0.021 - 3.26) μ T. There was no reference to the results of research that proves exposure to the intensity of the ELF electric field and the ELF magnetic field has resulted in a real biological impact.

V. CONCLUSIONS AND SUGGESTIONS

Based on the above measurements, it can be stated that the intensity of the ELF electric field and the ELF magnetic field in the working environment with medical equipment

was still at a safe level. The exposure to the electric field and the ELF magnetic field at the position of the medical equipment operator for the ELF electric field was in the range of intensity (2.75 - 166) V / m and the ELF magnetic field was in the range of intensity (0.021 - 3.26) μ T. There was no reference to the results of research that proved exposure to the intensity of the ELF electric field and the ELF magnetic field has resulted in a real biological impact. The conclusion from the results of this research is that the exposure to electric fields and magnetic fields ELF by medical equipment did not have the potential to cause biological effects.

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Determinants of Intention to Recommend WeChat Mobile Payment Innovation in China to be Implemented in Indonesia

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Abstract— Mobile payment has received its importance recognition from the global society including government and businesses. It can lead to operation cost reduction on the cash-paper production on the Bank. Additionally, to familiarize the mobile payment utilization to the society has found to be a tough task for businesses and government. Therefore, the current study has objective to examine the determinants of intention to recommend mobile payment technology on the society. Hence, the authors picked WeChat mobile payment innovation in China as the mobile payment innovation method used to analyze the intention to recommend the utilization of mobile payment. The collected data were analyzed by the utilization of Partial Least Square (PLS)- Structural Equation Modelling (SEM) v. 3.2.7 and IBM SPSS Statistic 24. UTAUT 2 Theory, perceived technology security, and customer satisfaction were employed to examine the issues appear in the current study but hedonic motivation, price value, habit and the moderators role were excluded. Therefore, the findings indicate that perceived technology security have a positive significant relationship while performance expectancy, effort expectancy, facilitating conditions, and social influence have a positive insignificant relationship on behavioral intention to adopt WeChat mobile payment. Moreover, Behavioral intention to adopt WeChat mobile payment and customer satisfaction have a positive significant relationship on the intention to recommend the designated technology. It also signified that perceived technology security is having indirect effect to behavioral intention to recommend WeChat mobile payment innovation.

Keywords— UTAUT 2 Theory, Perceived Technology Security, Customer Satisfaction, Behavioral intention to recommend.

I. INTRODUCTION

Digital era is a popular term in present society. It is not only popular among the society at the national level but also among international level. This phenomenon happened with the development of Information and Communication Technology (ICT) that keep upgrading its performance. Currently, there are various sources and channels of information available online. It is defined by Senthil Kumar, Saravanakumar, & Deepa (2016) that the internet emerged as the development of ICT is now widely used by information seekers in order to satisfy their information needs. Social media is one of many other online platforms that occur as the result of internet technology usage. The development of social media grows very fast from year to year. Social media has become an integral part of modern society. There always has a virtual space that gains the users' interests. The social media accounts provide many utilities where users are able to share photos, videos, recent status, greet each other, and meet virtually (Rohm, Kaltcheva, & Milne, 2013).

In emerging society, Social media is a means to meet the need for a variety of communications that appear in the community. Moreover, social media defines a platforms run by the means of mobile communication technology use which has been one of the vast growth in internet technology consumption (Kaplan & Haenlein, 2010). Indonesia, Singapore, India, Malaysia, and the Philippines signifies less than four percent of the

utilization of mobile payment technology. Some supporting factors behind these low utilization of mobile payment occur because of the immature local regulation presence in Asia countries. The emerged of great business model promotes by countries and companies to the society has been big challenges for practitioners. Moreover, the behavior that has become a habit on the society regarding cash payment where they can feel and see the item physically for decades lead to less recognizable of cashless payment on the society (KPMG Indonesia, 2017). Fairly said, the critical factors to outspread the benefit of mobile payment do not only come from the activities introduced by the countries or companies rather than the intention of the individual itself to utilize mobile payment. Individual or society mindset or point of view must be adjusted with the advance knowledge to increase ones intention to embrace mobile payment (Gaurav & Sharma, 2017).

The major reasons for less awareness by the society to embrace mobile payment for their daily transaction activity is because they feel unfamiliar with the technology. The absence of convenience for the payee to do transaction by the utilization of mobile device with small phone screen leads to another reason that supports the society less awareness. Additionally, perceived security has been society basic consideration to conduct a cashless payment once the payee wants to commit a transaction activity (Purwanegara, Apriningsih, & Andika, 2014).

Currently, there are 21 companies (provider) specializing in mobile payment with various services granted in Indonesia. The services vary from e-Wallet, prepaid cards, payment gateway, prepay cards, switching remittance, m-Wallet, and other payment services (KPMG Indonesia, 2017). China itself has two key mobile payment applied by the society Aveni & Roest, (2017); Ali Pay powered by Alibaba's Financial Affiliate and WeChat Pay powered by Tencent and Ant Financial. It is written in the report of Boellstorff et al. (2013) that the presence of social media platforms in line with the rising mobile payment lead to be challenging among practitioners. The penetration growth of users on social media platforms around the globe keeps increasing annually (Kemp, 2018). Additionally, the leveraged growth on social media platforms is expected to lead to high penetration of mobile payment on the behalf of social media platforms. However, a report issued by Agusta & Hutabarat (2018) clearly defined that mobile payment on the behalf of social media platforms does not has a major influence on Indonesia's market. It clearly stated as not even a single mobile payment in the form of social media chat such as Line Payment and Blackberry e-Wallet reached the top ten most used mobile payment in

the country. Line Payment is a social media messaging platforms collaborate with PT. Bank Mandiri (Persero) Tbk to offers mobile payment features. Meanwhile, Blackberry e-Wallet is a mobile payment feature that provides by Blackberry Messenger in the representation of social media chat platforms powered by PT. Bank Permata.

Interestingly, China is the one and only country that has received its mass recognition from the society on the utilization of mobile payment in Asia. While most developing countries in Asia including Indonesia have their battles on the market to receive recognition from the online community concerning the mobile payment utilization. Mobile payment provider in China is owned by only two giant providers that are Tencent and Ant Financial and Alibaba's Financial Affiliate. Alibaba's Financial Affiliate with its Ali Pay was first launched to the society in 2008 while Tencent and Ant Financial with its WeChat Pay was first launched to the community in 2013 (Aveni & Roest, 2017). Moreover, despite the first recognition received on mobile payment in China by Ali Pay with its eCommerce application features, WeChat pay with its social media chat feature is able to race the performance of Ali Pay. Ali Pay has taken the second world rank on the utilization of mobile payment after WeChat Pay (Statista, 2017; Gaurav & Sharma, 2017).

Moreover talk, Kemp (2018) published a surprising fact on their work paper that China was not even categorized on the world top ten social media users by growth. China was categorized on the seventeenth world rank on social media users by growth once Indonesia took the third place. It such an impressive work of WeChat Pay as the services can perform great ability on the mobile payment utilization compare to the remaining country with a higher number of social media users by growth. Therefore, authors put high interests to learn and explore in depth regarding WeChat Pay launched and run until the present time in China. Authors found WeChat pay as an interesting issue that must be explored to gain the secret recipe of the trick in promoting mobile payment features with social media platforms as the mediator in a country with lower rank on social media users' growth compare to Indonesia. Additionally, WeChat pay can even surpass the country with a higher number of social media users by growth as the service has taken the first world rank on the leading mobile payment. WeChat mobile payment innovation can be a solution for the employment of mobile payment with social media platforms as the mediator. It is expected that Indonesia may perform better in term of mobile payment by the means of social media platforms utilization as the country has taken the third world rank on social media users' by growth. Indonesia market offers high opportunities for companies and

government in the recognition of mobile payment by the use of social media platforms. However, as it has been stated in the previous paragraph that the influential mobile payment method in Indonesia does not arise from the social media platform utilization. The current study is not classified as the first research paper on mobile payment as the topic relates to mobile payment has been discussed across the worldwide practitioners (Dahlberg et al., 2008; Dahlberg, Guo, & Ondrus, 2015; Woetzel et al., 2014; Wang & Gu, 2017; Rajanna, 2018; Ferreira et al., 2017). Prior studies have discussed mobile payment more to the use on eCommerce platforms. There are view researchers (Aveni & Roest, 2017; Matemba & Li, 2017; W. Xu, 2017) that have discussed the opportunities and challenges of mobile payment through the use of social media platforms. Hence, the authors intended to discuss regarding mobile payment powered by social media chat platforms. Authors have high interest to know more and portray whether the mobile payment innovation powered by WeChat pay in China is a recommendable mobile payment innovation to be adopted toward economic purposes of Indonesia.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

UTAUT 2 is one of the latest theory published by Venkatesh, Thong, & Xu (2012) concerning the presence of technology development in emerging economies around the world. Therefore, it is taken by authors as the theory adopted to assist authors in examining particular issues arise in the research paper. Additionally, the authors of UTAUT 2 Theory have done some breakthrough by combining prior studies that discuss the theory related to the technology movement. Given statement by Chang (2012) the mixed up theories consisting of Innovation Diffusion Theory (IDT), Theory of Reasoned Action (TRA), the Model of PC Utilization (MPCU), Motivational Model, Technology Acceptance Model (TAM), Combined TAM and TPB, Social Cognitive Theory, and Theory of Planned Behavior (TPB). Therefore, authors build the hypotheses refers to UTAUT 2 Theory with some adjustment to fit the current study. Performance expectancy, effort expectancy, social influence, and facilitating conditions are the independent variable measuring the dependent variable of behavioral intention to adopt WeChat mobile payment innovation. Additionally, Behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction are the independent variable to measure the dependent variable of behavioral intention to recommend WeChat mobile payment innovation. Hence, the authors will describe the proposed hypothesis development to satisfy issues arise in the current study.

The purpose of the establishment of UTAUT 2 Theory is to provide a better understanding of the mentioned factors in the previous paragraph toward practitioners and academician. It can assist practitioners in a company and academician to frame out the issues that can affect the user in utilizing a particular technology. However, moderator effect have been excluded from the current study.

2.1. The Relationship of Performance Expectancy toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

Performance expectancy refers to the extent of an individual trust that using a technology give the individual some benefits related to the activity performed by them. Once an individual demand on having a better performance has been satisfied, it will be more likely that the individual will generate their behavioral intention to use a particular technology. In this term, Jackson, Yi, & Park (2013) certify that an individual will generate the behavioral intention to adopt WeChat mobile payment innovation once the individual has experienced usefulness of using the mentioned technology. The relationship of performance expectancy generating the behavioral intention to adopt particular technology has also been discussed by various academicians (Venkatesh et al., 2012); Venkatesh et al., 2003; Oliveira et al., 2016). Hence, the authors proposed the hypothesis development as mentioned below.

H1: Performance Expectancy (PE) has positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.2. The Relationship of Effort Expectancy toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

The level of easiness gain by an individual once the individual utilizes a technology is somehow defines the essence of effort expectancy. Ease of use on a particular technology may generate one's individual's interests and lead to satisfying one's comfort. It was defined by Sung, Jeong, Jeong, & Shin, (2015), Chen & Huang (2012), and Nikou & Economides (2017) in their study that once persons are able to feel the easiness offers by particular technology while they are consuming it, it leads to the leveraging on the behavioral intention to apply particular technology. It is in line with the former theory of UTAUT (Venkatesh et al., 2003) and UTAUT 2 (Venkatesh et al., 2012). In this case, Wechat mobile payment innovation is the technology to be discussed. WeChat mobile payment innovation may be one of the breakthrough technology in the field of mobile payment. Therefore, it is expected WeChat mobile payment contain easiness in it where it may lead to the behavioral intention of the

aforementioned mobile payment. Hence, authors proposed the hypothesis development as mentioned below.

H2: Effort expectancy (EE) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.3. The Relationship of Social Influence toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

A human being is born to be a social life being. In general occasion, every individual on an environment regardless of the location, race, ethnic, and country, will experiences a social life being. In such a simple example, most of individual will lean on their family as their inner circle on a social life being. Most of individual usually will be easily affected by their environment. It is reinforced in the finding of Oliveira et al (2016) and Yu, Lin, & Liao (2017) that the opinion expressed by someone close to a person will more likely encourage ones' behavioral intention to adopt mobile payment. In this case, it signifies the behavioral intention to utilize WeChat mobile payment innovation. It has definitely been proved under the study of Venkatesh et al (2003) and Venkatesh et al (2012) that people who are important, people who influence, and people shared opinion are the major factor in leveraging the behavioral intention to adopt a technology. Pertaining to these, the proposed hypothesis development will be mention below.

H3: Social Influence (SI) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.4. The Relationship of Facilitating Conditions toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

Facilitating conditions refers to the extent to which one believes that the presence of particular technology supports their performance. Once an individual has decided to utilize a particular technology, the supporting infrastructure is a major needed in order to fully achieve the utilization of a technology. It has come with the idea that, one's interest in employing a particular technology will be useless if it lack of supporting facilities as one's interests cannot be channeled elsewhere. It is implied in the study of Venkatesh et al (2012) and Chen & Huang (2012) that in order to leverage the behavioral intention to adopt a particular technology, facilitating conditions must be boosted. In complying with current research, it discusses that the facilitating conditions leverage the behavioral intention to adopt WeChat mobile payment. Therefore, the authors proposed the hypothesis development as mentioned below.

H4: Facilitating conditions (FC) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.5. The Relationship of Perceived Technology Security toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

A study of Mohammed & Tejay (2017) acknowledged that perceived technology security plays a major role in determining ones' behavioral intention to adopt a particular technology. Perceived technology security is related to a person's judgments on their technology experience. Once a person has consumed a technology, a person will put high concern on the security provides on particular technology services. Therefore, once the person has experienced the technology security, it is able to affect one's intention to utilize the current technology (Oliveira et al., 2016). The discussed current technology in this section concern the mobile payment innovation that originated from WeChat, a social media chat platforms. Hence, the authors build the proposed hypothesis development as mention below.

H5: Perceived technology security (PTS) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.6. The relationship of Behavioral Intention to Adopt WeChat Mobile Payment Innovation on Behavioral intention to recommend

It is not a figment among the society where the behavioral intention to recommend happened as the effect given by the high intention of someone in adopting particular technology (Oliveira et al., 2016). It is because once a person has a high intention to adopt a particular technology and find it helpful to them, they will be more likely to share their experiences with others. Moreover, as the present society has been savvier with the presence of social media chat platforms, sharing experience will be much easier for them to do (Zhang et al (2015). In comply with the current study, C. Xu et al (2015) stated that the high interest of ones' behavioral intention to adopt WeChat mobile payment innovation will lead to ones' willingness to endorse the adopted technology to others. Therefore, the below sentence is drawn to build the hypothesis development.

H6: Behavioral Intention to Adopt WeChat Mobile Payment Innovation (IA) has a positive significant effect on behavioral intention to recommend (IREC) WeChat mobile payment innovation.

2.7. The relationship of customer satisfaction on Behavioral intention to recommend

Basically, the essence of having a business is to create and gain a satisfied customer. Customer satisfaction is

related to the means of the desire of a person that has been fully fulfilled. Customer satisfaction plays an important role in the market as it is one of the determinants that defines a success of businesses. Once practitioners are able to achieve customer satisfaction from the potential customers or customers, practitioners may get some benefit affection. The individual will be more likely to form a recommendation concerning particular services utilized by them to others. Customer satisfaction will occur as the responses given by the customers once the expectation has met the actual performance of the perceived services or products. The occurrence of recommendation to others is not only happening due to the good services quality but because the customer satisfaction has met. Prior studies (C. Xu et al (2015), Suchánek, et al (2017), and Finn, Wang, & Frank (2009) has strengthened that once a customer satisfaction satisfied, the individual intention to recommend particular services or products will increase. Hence, authors have drawn the proposed hypothesis development as written below.

H7: Customer satisfaction (CS) has a positive significant effect on behavioral intention to recommend (IREC) WeChat mobile payment innovation.

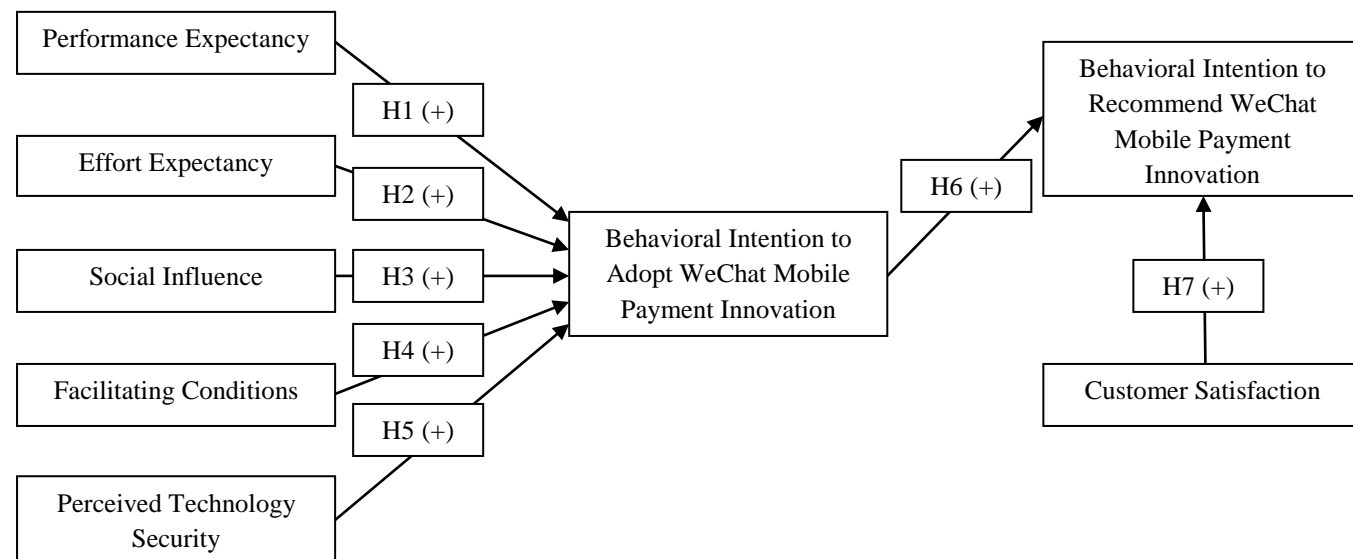


Fig. 1: Proposed Research Model

III. METHODOLOGY

3.1. Sampling and Data collection

The study approach is based on a questionnaires survey of Indonesian users on WeChat mobile payment in China. The questionnaires were distributed through the online platform with the assistance of Google Forms. The Indonesian version of the questionnaires was adopted for

the study purposes due to the aimed of respondents are Indonesian. However, the establishment of the questionnaires was designed based on the prior study that was written in an English version (refer to Appendix A). The Indonesian version of the questionnaires has passed some experts review before it was distributed to the respondents. The collected respondents vary from the various city in China. Moreover, the questionnaires were administered within 22 to 31 May of 2018. The study has gained 208 respondents, however, authors must eliminate 10 respondents because the answers did not meet the study purpose.

3.2. Measurement Model

The study applied a confirmatory factor analysis (CFA) approach under the processing data tool of Partial Least Square (PLS) – Structural Equation Modelling (SEM). PLS-SEM was used to analyze the issues arisen in the study including the hypothesis testing. Additionally, IBM SPSS Statistic 24 was adopted to analyze the demographic data. The distributed questionnaires consist of two approach method that is based on multiple choice and 7 Likert Scale questions (*Strongly Disagree to Strongly Agree*).

Moreover, a pilot study was first implied to examine the reliability and validity consistency on the questionnaires. A study can have its further evaluation once a pilot study

Table 1. Quality Criterion (Cronbach's Alpha, Composite Reliability, AVE) and Factor Loadings

Constructs	Cronbach's Alpha	Composite reliability	AVE	Item	Loadings
Performance Expectancy	0.977	0.983	0.936	PE1	0.977
				PE2	0.944
				PE3	0.969
				PE4	0.980
Effort Expectancy	0.968	0.977	0.913	EE1	0.955
				EE2	0.960
				EE3	0.953
				EE4	0.953
Social Influence	0.926	0.953	0.871	SI1	0.955
				SI2	0.903
				SI3	0.942
Facilitating Conditions	0.974	0.981	0.927	FC1	0.964
				FC2	0.967
				FC3	0.966
				FC4	0.954
Perceived Technology Security	0.959	0.970	0.891	PTS1	0.931
				PTS2	0.952
				PTS3	0.929
				PTS4	0.963
Behavioral Intention to Adopt WeChat	0.980	0.987	0.962	IA1	0.985
				IA2	0.983
				IA3	0.974
Customer Satisfaction	0.987	0.992	0.975	SAT1	0.987
				SAT2	0.993
				SAT3	0.982
Behavioral Intention to Recommend WeChat	0.990	0.993	0.971	IREC1	0.995
				IREC2	0.986
				IREC3	0.981
				IREC4	0.978

Source: Table derived from survey data

of a questionnaires indicates a proper value of the reliability and validity test.

Nineteenth-19th respondents were collected for the pilot study. The pilot study signified that the questionnaire construct has proper models to be distributed to a large number of participants (refer to Table 1). According to the standard value to obtain a proper research data, factor loading and Cronbach's alpha shall be equal or more than 0.70, composite reliability shall be equal or exceed 0.60, Average Variance Extracted (AVE) shall be equal or exceed 0.50 (Fornell & Larcker, 1981; Bagozzi & Yi, 1988; Nunnally & Bernstein, 1994). Eleven respondents are counted as female respondents while the remains eight are male respondents. The pilot study indicates that most of the respondents are categorized as students consisting of postgraduates students, undergraduate student, Ph.D. students, and postdoctoral sequentially.

IV. FINDINGS AND DISCUSSIONS

4.1. Respondents Demographic

Below table is to specify the age and gender background of the collected respondents during the survey.

Table 2. Demographic data of the survey (N=198)

	Frequency	Percentage	Cumulative Percentage
Age			
≤20	28	14.1	
21-30	139	70.2	
31-40	24	12.1	
41-50	4	2	
≥51	3	1.5	100
Gender			
Male	80	40.4	
Female	118	59.6	100

The study pictured out that Wuhan is the first most city in China with 53% Indonesian users of WeChat mobile payment innovation. Moreover, the remains Indonesian users are spreading around China with the percentages of 7.1% in Beijing, 2.5% in Nanjing, 5.6% in Shanghai, 5.1% in Chengdu, 3.5% in Changsha, 2.5% in Guangzhou and Chongqing, 1.5% in Tianjin and Jingzhou, 1.0% in Hangzhou, Qingdao, and Xi'an, while the remains 0.5% in Shenzhen, Xianning, Keifang, Kashgar, Huangshi, Harbin, Incheng, Haikou, Dongguang, Meizhou, Xianning, Zhejiang, Guilin, Xiamen, Quanzhou, and Jilin (refer to Figure 2).

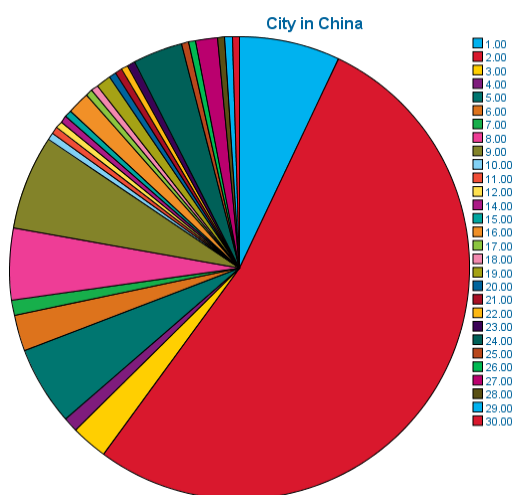


Fig. 2: Indonesian WeChat Pay users around city in China

Moreover talk, the duration used on WeChat mobile payment innovation by Indonesian are vary (refer to Figure 3). The study indicates that 29.8% of Indonesians in China are a user of WeChat mobile payment innovation for more and equal to 24.1 months. Followed by 29.3% for Indonesian WeChat Pay users for the period of 6.1 to 12 months, 19.2% for Indonesian WeChat Pay users for the period of 18.1 to 24 months, 16.2% for Indonesian WeChat Pay users for the period of 12.1 to 18 months, 5.6% for Indonesian WeChat Pay users for the period of equal or less than 6 months.

Additionally, the study released that most Indonesian users spent their expenses by the assistance of WeChat Pay for equal or less than 500 RMB (31.8%), 1001 to 1500 RMB (27.8%), 500.1 to 1000 RMB (25.8%), 1501 to 2000 RMB (8.1%), and equal or more than 2001 (6.6%) (refer to figure 4). Authors also proposed a question to the respondents about the intensity used of WeChat mobile payment for their daily expenses. Therefore, authors collected the respondents' answers with grocery shopping (33.3%), printing shop (20.7%), Others (21.2%), transfer and receive money from relatives

or friends (14.6%), and Transportation payment (10.1%) on the intensity used of WeChat mobile payment innovation in China sequentially (refer to Figure 5). Others define cellular mobile data top up, electricity payment; and all payment provided by WeChat Pay.

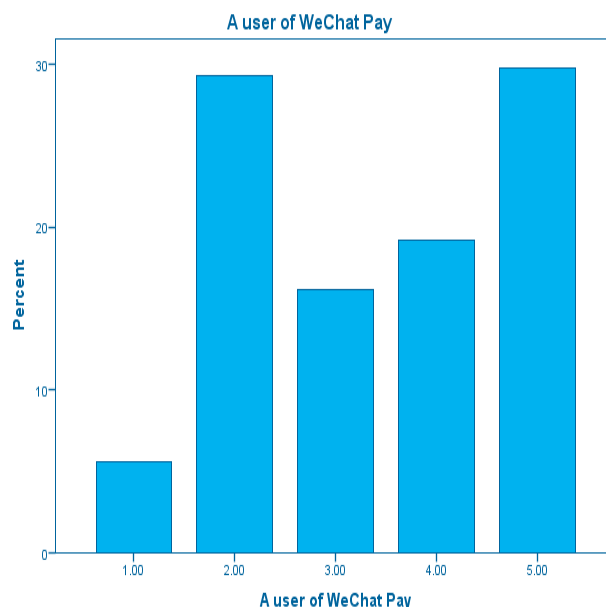


Fig. 4: Duration used on WeChat mobile payment innovation by Indonesian in China

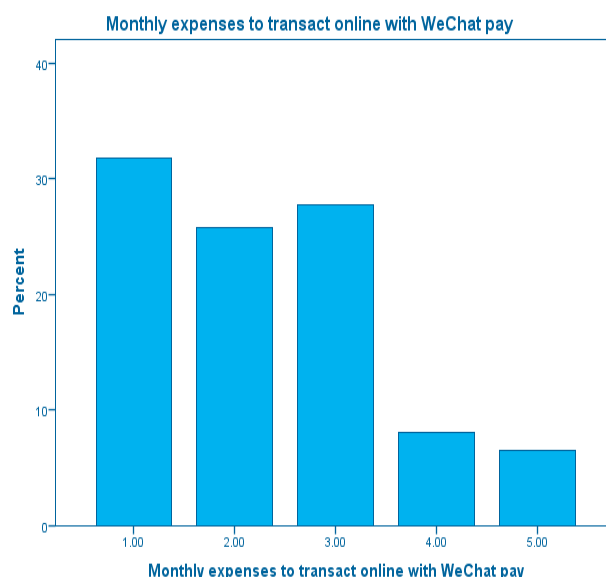


Fig. 3: Monthly online transaction expenses by the use of WeChat mobile payment

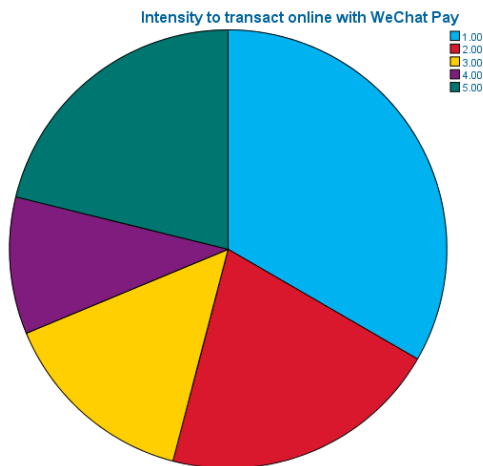


Fig. 5: Online intensity transaction with the use of WeChat mobile payment

4.2. Measurement Model and Structural Model Analysis

The study apply two approaches in determining the collected data. The approaches used consisting of measurement model and structural model.

4.2.1. Measurement model analysis

The measurement model is applied to frame the reliability and validity of a data. Convergent validity, discriminant validity, and unidimensionality are applied for the measurement model analysis. Convergent validity is defined by its loading factors and Average Variance

Table 3. Measurement Model for its Reliability and Validity Analysis (N=198)

Construct	Cronbach's Alpha	Composite reliability	AVE	Item	Loadings
Performance Expectancy	0.975	0.982	0.931	PE1	0.969
				PE2	0.974
				PE3	0.957
				PE4	0.958
Effort Expectancy	0.977	0.983	0.935	EE1	0.968
				EE2	0.974
				EE3	0.963
				EE4	0.962
Social Influence	0.958	0.973	0.922	SI1	0.949
				SI2	0.960
				SI3	0.971
Facilitating Conditions	0.952	0.965	0.875	FC1	0.954
				FC2	0.940
				FC3	0.945
				FC4	0.900
Perceived Technology Security	0.964	0.974	0.902	PTS1	0.919
				PTS2	0.968
				PTS3	0.948
				PTS4	0.963
Behavioral Intention to Adopt WeChat	0.962	0.975	0.929	IA1	0.962
				IA2	0.980
				IA3	0.949
Customer Satisfaction	0.986	0.991	0.973	SAT1	0.984
				SAT2	0.990
				SAT3	0.986
Behavioral Intention to Recommend WeChat	0.965	0.975	0.906	IREC1	0.966
				IREC2	0.979
				IREC3	0.955
				IREC4	0.904

Extracted (AVE). Discriminant validity is determined by Fornell-Larcker Criterion. Unidimensionality is defined by the value on composite reliability and Cronbach's Alpha in PLS-SEM construct reliability and validity. Therefore, the study framed out all measurement model analysis to be fully satisfied (refer to Table 3). The value on Cronbach's Alpha, Composite Reliability, AVE, and Factor Loading have exceeded the minimum limit on each criterion. All the Cronbach's Alpha, composite reliability, and factor loadings on its respective constructs signified the value above 0.90. Moreover, most of the value on the Average Variance Extracted indicates a value that also surpasses the lowest criteria to satisfy the measurement model analysis with the value above 0.90 and one construct indicates the range value of 0.875. The Fornell-Larcker Criterion in the study has been fully satisfied by the Average Variance Extracted square root value of each construct are greater than the correlation on each construct (refer to table 4).

value of 0.079.

Table 5. Variance Explains of the Endogen Latent Variable

	R Square
IA	0.676
IREC	0.497

Additionally, the variance explains indicates by R Square on behavioral intention to adopt WeChat mobile payment innovation (IA) is 0.676 (refer to Table 5). It has meaning that performance expectancy, effort expectancy, social influence, facilitating conditions, and perceived technology security have 67.6% variances explains on behavioral intention to adopt WeChat mobile payment innovation. Moreover, the remains 32.4% is determined by other factors.

Table 4. Fornell-Larcker Criterion: Matrix of Correlation Construct and the Square Root of AVE in Bold

	EE	FC	IA	IREC	PE	PTS	SAT	SI
EE	0.967							
FC	0.857	0.935						
IA	0.773	0.767	0.964					
IREC	0.728	0.678	0.673	0.952				
PE	0.835	0.776	0.739	0.794	0.965			
PTS	0.713	0.709	0.699	0.588	0.687	0.950		
SAT	0.687	0.698	0.752	0.646	0.660	0.668	0.986	
SI	0.392	0.342	0.369	0.449	0.457	0.314	0.329	0.960

4.2.2. Structural model analysis

R Square (R2) value, path coefficients, and Goodness of Fit (GoF) Index are applied to determine the structural model analysis in the current study. According to (Hu & Bentler, 1999), the value of SRMR to satisfy the model fit (GoF) of a research data shall be < .08. Therefore, the study has also satisfied the model fit with the SRMR

Furthermore, behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction signified 49.7% of the variance explains the behavioral intention to recommend WeChat mobile payment innovation (refer to Table 5). To be more detail, it also explains that the remains 50.3% is determined by other factors other than behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction.

Table 6. Hypothesis Analysis with Bootstrapping Approach

	Hypothesis	Path Coefficients	P Values	Results
PE -> IA	1	0.172	0.240	Not Supported
EE -> IA	2	0.224	0.141	Not Supported
SI -> IA	3	0.041	0.359	Not Supported
FC -> IA	4	0.277	0.052	Not Supported
PTS -> IA	5	0.212	0.014	Supported
IA -> IREC	6	0.431	0.000	Supported
SAT -> IREC	7	0.322	0.004	Supported

Additionally, path coefficients analysis was run under the bootstrapping method in the PLS-SEM to analyze the established relationship of a hypothesis. Therefore, the study signified three supported hypothesis out of seven hypothesis (refer to Table 6). The path coefficient on performance expectancy, effort expectancy, social influences, and facilitating conditions to behavioral intention to adopt WeChat mobile payment innovation indicates a positive path coefficient value. Moreover, the indicated p values of performance expectancy, effort expectancy, social influence, and facilitating conditions to behavioral intention to adopt WeChat mobile payment innovation were released as having insignificant value. It is because the p values of the proposed hypothesis exceed the lower limit of the specified measure of p values that is above .050. Hence, H1, H2, H3, and H4 defines a positive insignificant relationship which leads to the proposed hypothesis rejection. However, perceived technology security was found to signify a positive significant relationship to the behavioral intention to adopt WeChat mobile payment innovation. It can be seen by the p values that indicates a value above the lower limit of the specified p values measure. The path coefficients have also indicated a positive value of 0.212. Hence, H5 confirmed the proposed hypothesis developed in the study.

At last, the behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction denote to confirm the H6 and H7. The path coefficients on both behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction to behavioral intention to recommend WeChat mobile payment innovation give forth a positive path coefficient value. Furthermore, its p values have pinpointed a significant value as it is indicating the result of greater value than the lower limit of the specified measure on p values. Speaking of, perceived technology security found to has indirect effects on the behavioral intention to recommend WeChat mobile payment innovation. It was defined as having an indirect effect by the evidence collected under current study that perceived technology security has a direct effect on behavioral intention to adopt WeChat mobile payment innovation. Moreover, behavioral intention to adopt WeChat mobile payment innovation provide the evidence under the study of having a direct effect on behavioral intention to recommend WeChat mobile payment innovation.

V. CONCLUSIONS AND RECOMMENDATIONS

Indonesia is a startup country in the development of a cashless society. Government and practitioners have been searching and introducing cashless society in many

ways as cash payment method has been the society payment pattern for many years back. Authors expected to provide new insight to the government and practitioners in Indonesia about the mobile payment innovation as the representative of cashless society. Moreover, authors pick WeChat payment innovation in China to be the study objective with the fact that WeChat mobile payment innovation has taken over the leading mobile payment first rank around the world. Authors believe that by choosing China as the objective study to analyze the approach in introducing and marketing the mobile payment method to the society can lead to some fresh insight into Indonesia. It is because China and Indonesia are both categorized as developing countries in Asia which is believed to have some similarities.

Moreover, the study framed out that some of the proposed hypothesis appears in the study are not in line with the prior study as it has mentioned in the aforementioned proposed hypothesis. Performance expectancy, effort expectancy, social influence, and facilitating conditions are having a positive relationship but has no significant value. However, prior studies has also indicates a not significant relationship on performance expectancy (Attuquayefio & Addo, 2014), effort expectancy (Oliveira et al., 2016; Baptista 2016; Slade et al., 2015), social influence (Attuquayefio & Addo, 2014; Baptista, 2016), and facilitating conditions (Oliveira et al., 2016); Baptista, 2016) to behavioral intention to adopt particular technology. There is a possibility for the contrary of current finding with the former UTAUT 2 Theory introduced by Venkatesh et al (2012) due to WeChat mobile payment innovation in China was found to be something new for Indonesian users. Mobile payment with the means of social media chat application used is new for Indonesian. Firstly, the Indonesian government and practitioners are still searching out for the best path taken in introducing the mobile payment innovation to the society in Indonesia. However, some practitioners have performed their good existences in promoting the mobile payment method among the society in Indonesia. Hence, even though WeChat pay is ranked one over the world which made the social chat application payment as an unbreakable payment method during the current year of the present day, it cannot lead to a proper result when it comes to Indonesian users of WeChat pay in China. It might be happened due to Indonesian users in China are still learning in catching up with the present development technology of WeChat mobile payment innovation in China. Additionally, China is a country which upholds the sense of nationalism, even the WeChat mobile payment provide English version, there still have some Chinese version provide within the social chat application

used. Hence, it can lead to a lack of understanding to Indonesian in China that actually are still searching out for their second nature of using mobile payment approach. Moreover, the future study shall explore in more detail to satisfy the issues arise in the current findings.

Additionally, the study captured behavioral intention to adopt WeChat mobile payment innovation plays a major role in the intention to recommend the utilization of WeChat mobile payment innovation. The finding is consistent with the earlier research (Oliveira et al., 2016; Zhang et al., 2015; C. Xu et al., 2015). Indonesian found to have high intention to recommend WeChat mobile payment innovation in China to others. Hence, there might be some opportunities for Indonesian government or practitioners to learn the method used by WeChat enterprise in introducing the services. Even though Indonesian were found to have no significant relationship on performance expectancy, effort expectancy, social influence, and facilitating conditions, the people are testifying to have high interest to recommend WeChat mobile payment innovation. Authors found some interesting fact here which can lead to the future study of other researchers. Additionally, Customer satisfaction found to be the second influential determinant to the behavioral intention to recommend WeChat mobile payment innovation. The finding is consistent with earlier research that issued by C. Xu et al (2015), Suchánek et al (2017), and Finn et al (2009). The finding can be interpreted as a way once the satisfaction needed on Indonesian has been achieved, the person will be more likely to recommend WeChat mobile payment based on their experience.

Moreover, perceived technology security sequentially signified the remains influential determinants of behavioral intention to adopt WeChat mobile payment. The findings are in line with the prior study written by Oliveira et al (2016) and Mohammed & Tejay (2017). The supporting fact behind it, can happened from the emerged of WeChat mobile payment innovation that spreading all over the city side in China. Even to purchase in a vegetable market or street vendor WeChat pay can be used. Furthermore, once society or WeChat Pay users have applied using the mobile payment method not only in a giant market, but also street vendor, there might seems that the user experienced a perceived technology security. Hence, future researchers are able to discuss in more detail regarding the facts behind the high intention of Indonesian to adopt WeChat mobile payment in China. Overall proposed hypothesis, it seems that all of the hypothesis directed to the behavioral intention to recommend WeChat mobile payment innovation is significantly satisfied. Hence, the findings clearly defined

that there is a big chance and lesson can be learned by the Indonesian government and practitioners from WeChat mobile payment innovation in China to the development of mobile payment in Indonesia. Additionally, future research can consider to put concern on more specific targeted respondents as the current study has wider targeted respondents and resulting in unbalance collected city from one another. It is suggested that future study are able to frame other determinant factors on behavioral intention to adopt particular technology and the behavioral intention to recommend a particular digital technology.

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Appendix A. Questionnaires Items and Sources

Constructs	Items	Sources
Performance Expectancy	PE 1 - I find WeChat mobile payment innovation useful in my daily life	Venkatesh et al., (2003,2012); Oliveira et al (2016)
	PE 2 - Using WeChat Mobile Payment innovation helps me accomplish things more quickly.	
	PE 3 - Using WeChat mobile payment innovation increases my productivity	
	PE 4 - Using WeChat mobile payment innovation helps my work to be more effective	
Effort Expectancy	EE 1 - Learning how to use WeChat mobile payment innovation is easy for me	Venkatesh et al., (2003,2012); Oliveira et al (2016)
	EE 2 - My interaction with WeChat mobile payment innovation is clear and understandable	
	EE 3 - I find WeChat mobile payment innovation easy to use	
	EE 4 - It is easy for me to become skillful at using WeChat mobile payment innovation	
Social Influences	SI 1 - People who are important to me in China think that I should use WeChat Mobile Payment Innovation	Venkatesh et al., (2003,2012); Oliveira et al (2016)
	SI 2 - People who influence my behavior in China think that I should use WeChat Mobile Payment Innovation	
	SI 3 - People whose opinions that I value the most in China prefer that I use WeChat mobile Payment Innovation	
Facilitating Conditions	FC 1 - I have the resources necessary (smartphone and bank account) to use WeChat mobile payment innovation	Venkatesh et al., (2012); Oliveira et al (2016)
	FC 2 - I have the knowledge necessary to use WeChat mobile payment innovation	
	FC 3 - WeChat mobile payment innovation is compatible with other technologies I use	
	FC 4 - I can get help from others when I have difficulties using WeChat mobile payment innovation	
Perceived Technology Security	PTS 1 - I would feel secure using mobile payment innovation like WeChat for activities relates to financial background	Oliveira et al., (2016); Z. A. Mohammed and G. P. Tejay (2017)
	PTS 2 - Mobile payment innovation like WeChat is a secure means through which to send sensitive mobile	
	PTS 3 - I would feel totally safe providing sensitive information about myself over mobile payment innovation like WeChat	

	PTS 4 - Overall mobile payment innovation like WeChat is a safe place to send sensitive information	
Behavioral Intention to Adopt WeChat Mobile Payment Innovation	IA 1 - I intend to continue using WeChat mobile payment innovation in the future IA 2 - I will always try to use WeChat mobile payment innovation in my daily life	Venkatesh et al., (2003,2012); Oliveira et al (2016)
Customer Satisfaction	IA 3 - I plan to continue to use WeChat mobile payment innovation frequently SAT 1 - I feel very satisfied with the overall experience of using mobile payment innovation like WeChat SAT 2 - I am very pleased with the overall experience of using mobile payment innovation like Wechat SAT 3 - I feel very delighted with the overall experience of using mobile payment innovation like WeChat	C. Xu, D. Peak, and V. Prybutok (2015)
Behavior Intention to recommend WeChat mobile payment innovation	IREC 1 - I intend to positive things about mobile payment innovation like WeChat IREC 2 - I would like recommend mobile payment innovation like WeChat to my friend IREC 3 - I intend to encourage other people to use mobile payment innovation like WeChat IREC 4 - It will be grateful if mobile payment innovation like WeChat release in China can also be introduce and apply in Indonesia	Oliveira et al (2016)

Determinants of Intention to Recommend WeChat Mobile Payment Innovation in China to be Implemented in Indonesia

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Abstract— Mobile payment has received its importance recognition from the global society including government and businesses. It can lead to operation cost reduction on the cash-paper production on the Bank. Additionally, to familiarize the mobile payment utilization to the society has found to be a tough task for businesses and government. Therefore, the current study has objective to examine the determinants of intention to recommend mobile payment technology on the society. Hence, the authors picked WeChat mobile payment innovation in China as the mobile payment innovation method used to analyze the intention to recommend the utilization of mobile payment. The collected data were analyzed by the utilization of Partial Least Square (PLS)- Structural Equation Modelling (SEM) v. 3.2.7 and IBM SPSS Statistic 24. UTAUT 2 Theory, perceived technology security, and customer satisfaction were employed to examine the issues appear in the current study but hedonic motivation, price value, habit and the moderators role were excluded. Therefore, the findings indicate that perceived technology security have a positive significant relationship while performance expectancy, effort expectancy, facilitating conditions, and social influence have a positive insignificant relationship on behavioral intention to adopt WeChat mobile payment. Moreover, Behavioral intention to adopt WeChat mobile payment and customer satisfaction have a positive significant relationship on the intention to recommend the designated technology. It also signified that perceived technology security is having indirect effect to behavioral intention to recommend WeChat mobile payment innovation.

Keywords— UTAUT 2 Theory, Perceived Technology Security, Customer Satisfaction, Behavioral intention to recommend.

I. INTRODUCTION

Digital era is a popular term in present society. It is not only popular among the society at the national level but also among international level. This phenomenon happened with the development of Information and Communication Technology (ICT) that keep upgrading its performance. Currently, there are various sources and channels of information available online. It is defined by Senthil Kumar, Saravanakumar, & Deepa (2016) that the internet emerged as the development of ICT is now widely used by information seekers in order to satisfy their information needs. Social media is one of many other online platforms that occur as the result of internet technology usage. The development of social media grows very fast from year to year. Social media has become an integral part of modern society. There always has a virtual space that gains the users' interests. The social media accounts provide many utilities where users are able to share photos, videos, recent status, greet each other, and meet virtually (Rohm, Kaltcheva, & Milne, 2013).

In emerging society, Social media is a means to meet the need for a variety of communications that appear in the community. Moreover, social media defines a platforms run by the means of mobile communication technology use which has been one of the vast growth in internet technology consumption (Kaplan & Haenlein, 2010). Indonesia, Singapore, India, Malaysia, and the Philippines signifies less than four percent of the

utilization of mobile payment technology. Some supporting factors behind these low utilization of mobile payment occur because of the immature local regulation presence in Asia countries. The emerged of great business model promotes by countries and companies to the society has been big challenges for practitioners. Moreover, the behavior that has become a habit on the society regarding cash payment where they can feel and see the item physically for decades lead to less recognizable of cashless payment on the society (KPMG Indonesia, 2017). Fairly said, the critical factors to outspread the benefit of mobile payment do not only come from the activities introduced by the countries or companies rather than the intention of the individual itself to utilize mobile payment. Individual or society mindset or point of view must be adjusted with the advance knowledge to increase ones intention to embrace mobile payment (Gaurav & Sharma, 2017).

The major reasons for less awareness by the society to embrace mobile payment for their daily transaction activity is because they feel unfamiliar with the technology. The absence of convenience for the payee to do transaction by the utilization of mobile device with small phone screen leads to another reason that supports the society less awareness. Additionally, perceived security has been society basic consideration to conduct a cashless payment once the payee wants to commit a transaction activity (Purwanegara, Apriningsih, & Andika, 2014).

Currently, there are 21 companies (provider) specializing in mobile payment with various services granted in Indonesia. The services vary from e-Wallet, prepaid cards, payment gateway, prepay cards, switching remittance, m-Wallet, and other payment services (KPMG Indonesia, 2017). China itself has two key mobile payment applied by the society Aveni & Roest, (2017); Ali Pay powered by Alibaba's Financial Affiliate and WeChat Pay powered by Tencent and Ant Financial. It is written in the report of Boellstorff et al. (2013) that the presence of social media platforms in line with the rising mobile payment lead to be challenging among practitioners. The penetration growth of users on social media platforms around the globe keeps increasing annually (Kemp, 2018). Additionally, the leveraged growth on social media platforms is expected to lead to high penetration of mobile payment on the behalf of social media platforms. However, a report issued by Agusta & Hutabarat (2018) clearly defined that mobile payment on the behalf of social media platforms does not has a major influence on Indonesia's market. It clearly stated as not even a single mobile payment in the form of social media chat such as Line Payment and Blackberry e-Wallet reached the top ten most used mobile payment in

the country. Line Payment is a social media messaging platforms collaborate with PT. Bank Mandiri (Persero) Tbk to offers mobile payment features. Meanwhile, Blackberry e-Wallet is a mobile payment feature that provides by Blackberry Messenger in the representation of social media chat platforms powered by PT. Bank Permata.

Interestingly, China is the one and only country that has received its mass recognition from the society on the utilization of mobile payment in Asia. While most developing countries in Asia including Indonesia have their battles on the market to receive recognition from the online community concerning the mobile payment utilization. Mobile payment provider in China is owned by only two giant providers that are Tencent and Ant Financial and Alibaba's Financial Affiliate. Alibaba's Financial Affiliate with its Ali Pay was first launched to the society in 2008 while Tencent and Ant Financial with its WeChat Pay was first launched to the community in 2013 (Aveni & Roest, 2017). Moreover, despite the first recognition received on mobile payment in China by Ali Pay with its eCommerce application features, WeChat pay with its social media chat feature is able to race the performance of Ali Pay. Ali Pay has taken the second world rank on the utilization of mobile payment after WeChat Pay (Statista, 2017; Gaurav & Sharma, 2017).

Moreover talk, Kemp (2018) published a surprising fact on their work paper that China was not even categorized on the world top ten social media users by growth. China was categorized on the seventeenth world rank on social media users by growth once Indonesia took the third place. It such an impressive work of WeChat Pay as the services can perform great ability on the mobile payment utilization compare to the remaining country with a higher number of social media users by growth. Therefore, authors put high interests to learn and explore in depth regarding WeChat Pay launched and run until the present time in China. Authors found WeChat pay as an interesting issue that must be explored to gain the secret recipe of the trick in promoting mobile payment features with social media platforms as the mediator in a country with lower rank on social media users' growth compare to Indonesia. Additionally, WeChat pay can even surpass the country with a higher number of social media users by growth as the service has taken the first world rank on the leading mobile payment. WeChat mobile payment innovation can be a solution for the employment of mobile payment with social media platforms as the mediator. It is expected that Indonesia may perform better in term of mobile payment by the means of social media platforms utilization as the country has taken the third world rank on social media users' by growth. Indonesia market offers high opportunities for companies and

government in the recognition of mobile payment by the use of social media platforms. However, as it has been stated in the previous paragraph that the influential mobile payment method in Indonesia does not arise from the social media platform utilization. The current study is not classified as the first research paper on mobile payment as the topic relates to mobile payment has been discussed across the worldwide practitioners (Dahlberg et al., 2008; Dahlberg, Guo, & Ondrus, 2015; Woetzel et al., 2014; Wang & Gu, 2017; Rajanna, 2018; Ferreira et al., 2017). Prior studies have discussed mobile payment more to the use on eCommerce platforms. There are view researchers (Aveni & Roest, 2017; Matemba & Li, 2017; W. Xu, 2017) that have discussed the opportunities and challenges of mobile payment through the use of social media platforms. Hence, the authors intended to discuss regarding mobile payment powered by social media chat platforms. Authors have high interest to know more and portray whether the mobile payment innovation powered by WeChat pay in China is a recommendable mobile payment innovation to be adopted toward economic purposes of Indonesia.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

UTAUT 2 is one of the latest theory published by Venkatesh, Thong, & Xu (2012) concerning the presence of technology development in emerging economies around the world. Therefore, it is taken by authors as the theory adopted to assist authors in examining particular issues arise in the research paper. Additionally, the authors of UTAUT 2 Theory have done some breakthrough by combining prior studies that discuss the theory related to the technology movement. Given statement by Chang (2012) the mixed up theories consisting of Innovation Diffusion Theory (IDT), Theory of Reasoned Action (TRA), the Model of PC Utilization (MPCU), Motivational Model, Technology Acceptance Model (TAM), Combined TAM and TPB, Social Cognitive Theory, and Theory of Planned Behavior (TPB). Therefore, authors build the hypotheses refers to UTAUT 2 Theory with some adjustment to fit the current study. Performance expectancy, effort expectancy, social influence, and facilitating conditions are the independent variable measuring the dependent variable of behavioral intention to adopt WeChat mobile payment innovation. Additionally, Behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction are the independent variable to measure the dependent variable of behavioral intention to recommend WeChat mobile payment innovation. Hence, the authors will describe the proposed hypothesis development to satisfy issues arise in the current study.

The purpose of the establishment of UTAUT 2 Theory is to provide a better understanding of the mentioned factors in the previous paragraph toward practitioners and academician. It can assist practitioners in a company and academician to frame out the issues that can affect the user in utilizing a particular technology. However, moderator effect have been excluded from the current study.

2.1. The Relationship of Performance Expectancy toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

Performance expectancy refers to the extent of an individual trust that using a technology give the individual some benefits related to the activity performed by them. Once an individual demand on having a better performance has been satisfied, it will be more likely that the individual will generate their behavioral intention to use a particular technology. In this term, Jackson, Yi, & Park (2013) certify that an individual will generate the behavioral intention to adopt WeChat mobile payment innovation once the individual has experienced usefulness of using the mentioned technology. The relationship of performance expectancy generating the behavioral intention to adopt particular technology has also been discussed by various academicians (Venkatesh et al., 2012); Venkatesh et al., 2003; Oliveira et al., 2016). Hence, the authors proposed the hypothesis development as mentioned below.

H1: Performance Expectancy (PE) has positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.2. The Relationship of Effort Expectancy toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

The level of easiness gain by an individual once the individual utilizes a technology is somehow defines the essence of effort expectancy. Ease of use on a particular technology may generate one's individual's interests and lead to satisfying one's comfort. It was defined by Sung, Jeong, Jeong, & Shin, (2015), Chen & Huang (2012), and Nikou & Economides (2017) in their study that once persons are able to feel the easiness offers by particular technology while they are consuming it, it leads to the leveraging on the behavioral intention to apply particular technology. It is in line with the former theory of UTAUT (Venkatesh et al., 2003) and UTAUT 2 (Venkatesh et al., 2012). In this case, Wechat mobile payment innovation is the technology to be discussed. WeChat mobile payment innovation may be one of the breakthrough technology in the field of mobile payment. Therefore, it is expected WeChat mobile payment contain easiness in it where it may lead to the behavioral intention of the

aforementioned mobile payment. Hence, authors proposed the hypothesis development as mentioned below.

H2: Effort expectancy (EE) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.3. The Relationship of Social Influence toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

A human being is born to be a social life being. In general occasion, every individual on an environment regardless of the location, race, ethnic, and country, will experiences a social life being. In such a simple example, most of individual will lean on their family as their inner circle on a social life being. Most of individual usually will be easily affected by their environment. It is reinforced in the finding of Oliveira et al (2016) and Yu, Lin, & Liao (2017) that the opinion expressed by someone close to a person will more likely encourage ones' behavioral intention to adopt mobile payment. In this case, it signifies the behavioral intention to utilize WeChat mobile payment innovation. It has definitely been proved under the study of Venkatesh et al (2003) and Venkatesh et al (2012) that people who are important, people who influence, and people shared opinion are the major factor in leveraging the behavioral intention to adopt a technology. Pertaining to these, the proposed hypothesis development will be mention below.

H3: Social Influence (SI) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.4. The Relationship of Facilitating Conditions toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

Facilitating conditions refers to the extent to which one believes that the presence of particular technology supports their performance. Once an individual has decided to utilize a particular technology, the supporting infrastructure is a major needed in order to fully achieve the utilization of a technology. It has come with the idea that, one's interest in employing a particular technology will be useless if it lack of supporting facilities as one's interests cannot be channeled elsewhere. It is implied in the study of Venkatesh et al (2012) and Chen & Huang (2012) that in order to leverage the behavioral intention to adopt a particular technology, facilitating conditions must be boosted. In complying with current research, it discusses that the facilitating conditions leverage the behavioral intention to adopt WeChat mobile payment. Therefore, the authors proposed the hypothesis development as mentioned below.

H4: Facilitating conditions (FC) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.5. The Relationship of Perceived Technology Security toward Behavioral Intention to Adopt WeChat Mobile Payment Innovation

A study of Mohammed & Tejay (2017) acknowledged that perceived technology security plays a major role in determining ones' behavioral intention to adopt a particular technology. Perceived technology security is related to a person's judgments on their technology experience. Once a person has consumed a technology, a person will put high concern on the security provides on particular technology services. Therefore, once the person has experienced the technology security, it is able to affect one's intention to utilize the current technology (Oliveira et al., 2016). The discussed current technology in this section concern the mobile payment innovation that originated from WeChat, a social media chat platforms. Hence, the authors build the proposed hypothesis development as mention below.

H5: Perceived technology security (PTS) has a positive significant effect in generating the behavioral intention to adopt (IA) WeChat mobile payment innovation.

2.6. The relationship of Behavioral Intention to Adopt WeChat Mobile Payment Innovation on Behavioral intention to recommend

It is not a figment among the society where the behavioral intention to recommend happened as the effect given by the high intention of someone in adopting particular technology (Oliveira et al., 2016). It is because once a person has a high intention to adopt a particular technology and find it helpful to them, they will be more likely to share their experiences with others. Moreover, as the present society has been savvier with the presence of social media chat platforms, sharing experience will be much easier for them to do (Zhang et al (2015). In comply with the current study, C. Xu et al (2015) stated that the high interest of ones' behavioral intention to adopt WeChat mobile payment innovation will lead to ones' willingness to endorse the adopted technology to others. Therefore, the below sentence is drawn to build the hypothesis development.

H6: Behavioral Intention to Adopt WeChat Mobile Payment Innovation (IA) has a positive significant effect on behavioral intention to recommend (IREC) WeChat mobile payment innovation.

2.7. The relationship of customer satisfaction on Behavioral intention to recommend

Basically, the essence of having a business is to create and gain a satisfied customer. Customer satisfaction is

related to the means of the desire of a person that has been fully fulfilled. Customer satisfaction plays an important role in the market as it is one of the determinants that defines a success of businesses. Once practitioners are able to achieve customer satisfaction from the potential customers or customers, practitioners may get some benefit affection. The individual will be more likely to form a recommendation concerning particular services utilized by them to others. Customer satisfaction will occur as the responses given by the customers once the expectation has met the actual performance of the perceived services or products. The occurrence of recommendation to others is not only happening due to the good services quality but because the customer satisfaction has met. Prior studies (C. Xu et al (2015), Suchánek, et al (2017), and Finn, Wang, & Frank (2009) has strengthened that once a customer satisfaction satisfied, the individual intention to recommend particular services or products will increase. Hence, authors have drawn the proposed hypothesis development as written below.

H7: Customer satisfaction (CS) has a positive significant effect on behavioral intention to recommend (IREC) WeChat mobile payment innovation.

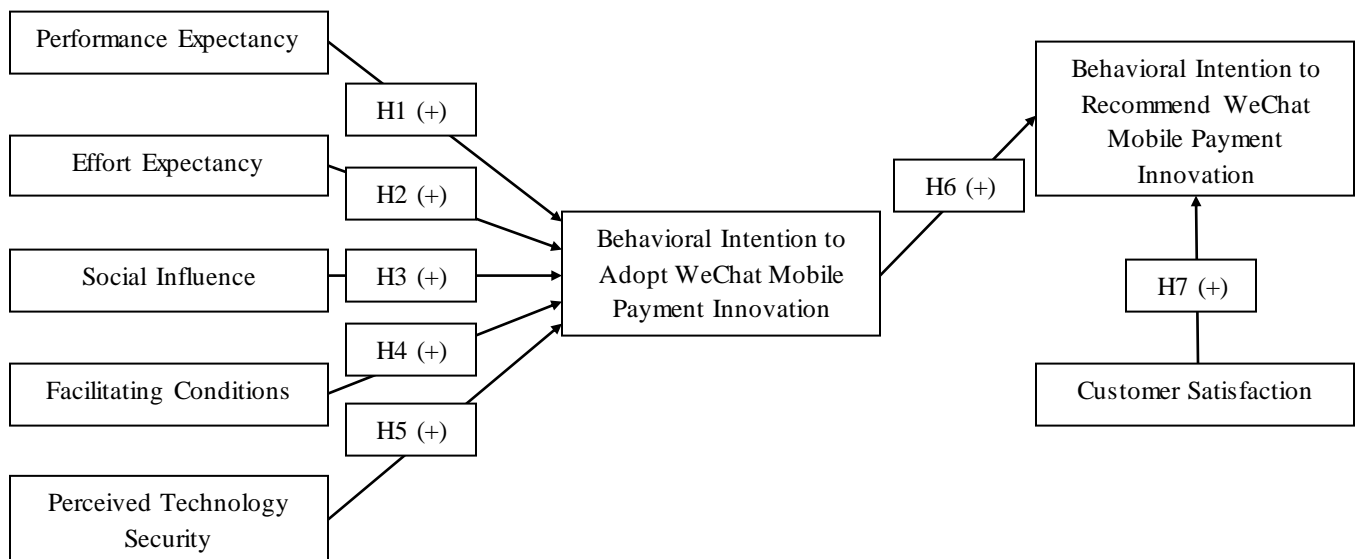


Fig. 1: Proposed Research Model

III. METHODOLOGY

3.1. Sampling and Data collection

The study approach is based on a questionnaires survey of Indonesian users on WeChat mobile payment in China. The questionnaires were distributed through the online platform with the assistance of Google Forms. The Indonesian version of the questionnaires was adopted for

the study purposes due to the aimed of respondents are Indonesian. However, the establishment of the questionnaires was designed based on the prior study that was written in an English version (refer to Appendix A). The Indonesian version of the questionnaires has passed some experts review before it was distributed to the respondents. The collected respondents vary from the various city in China. Moreover, the questionnaires were administered within 22 to 31 May of 2018. The study has gained 208 respondents, however, authors must eliminate 10 respondents because the answers did not meet the study purpose.

3.2. Measurement Model

The study applied a confirmatory factor analysis (CFA) approach under the processing data tool of Partial Least Square (PLS) – Structural Equation Modelling (SEM). PLS-SEM was used to analyze the issues arisen in the study including the hypothesis testing. Additionally, IBM SPSS Statistic 24 was adopted to analyze the demographic data. The distributed questionnaires consist of two approach method that is based on multiple choice and 7 Likert Scale questions (*Strongly Disagree to Strongly Agree*).

Moreover, a pilot study was first implied to examine the reliability and validity consistency on the questionnaires. A study can have its further evaluation once a pilot study

Table 1. Quality Criterion (Cronbach's Alpha, Composite Reliability, AVE) and Factor Loadings

Constructs	Cronbach's Alpha	Composite reliability	AVE	Item	Loadings
Performance Expectancy	0.977	0.983	0.936	PE1	0.977
				PE2	0.944
				PE3	0.969
				PE4	0.980
Effort Expectancy	0.968	0.977	0.913	EE1	0.955
				EE2	0.960
				EE3	0.953
				EE4	0.953
Social Influence	0.926	0.953	0.871	SI1	0.955
				SI2	0.903
				SI3	0.942
Facilitating Conditions	0.974	0.981	0.927	FC1	0.964
				FC2	0.967
				FC3	0.966
				FC4	0.954
Perceived Technology Security	0.959	0.970	0.891	PTS1	0.931
				PTS2	0.952
				PTS3	0.929
				PTS4	0.963
Behavioral Intention to Adopt WeChat	0.980	0.987	0.962	IA 1	0.985
				IA2	0.983
				IA3	0.974
Customer Satisfaction	0.987	0.992	0.975	SAT1	0.987
				SAT2	0.993
				SAT3	0.982
Behavioral Intention to Recommend WeChat	0.990	0.993	0.971	IREC1	0.995
				IREC2	0.986
				IREC3	0.981
				IREC4	0.978

Source: Table derived from survey data

of a questionnaires indicates a proper value of the reliability and validity test.

Nineteenth-19th respondents were collected for the pilot study. The pilot study signified that the questionnaire construct has proper models to be distributed to a large number of participants (refer to Table 1). According to the standard value to obtain a proper research data, factor loading and Cronbach's alpha shall be equal or more than 0.70, composite reliability shall be equal or exceed 0.60, Average Variance Extracted (AVE) shall be equal or exceed 0.50 (Fornell & Larcker, 1981; Bagozzi & Yi, 1988; Nunnally & Bernstein, 1994). Eleven respondents are counted as female respondents while the remains eight are male respondents. The pilot study indicates that most of the respondents are categorized as students consisting of postgraduates students, undergraduate student, Ph.D. students, and postdoctoral sequentially.

IV. FINDINGS AND DISCUSSIONS

4.1. Respondents Demographic

Below table is to specify the age and gender background of the collected respondents during the survey.

Table 2. Demographic data of the survey (N=198)

	Frequency	Percentage	Cumulative Percentage
Age			
≤20	28	14.1	
21-30	139	70.2	
31-40	24	12.1	
41-50	4	2	
≥51	3	1.5	100
Gender			
Male	80	40.4	
Female	118	59.6	100

The study pictured out that Wuhan is the first most city in China with 53% Indonesian users of WeChat mobile payment innovation. Moreover, the remains Indonesian users are spreading around China with the percentages of 7.1% in Beijing, 2.5% in Nanjing, 5.6% in Shanghai, 5.1% in Chengdu, 3.5% in Changsha, 2.5% in Guangzhou and Chongqing, 1.5% in Tianjin and Jingzhou, 1.0% in Hangzhou, Qingdao, and Xi'an, while the remains 0.5% in Shenzhen, Xianning, Keifang, Kashgar, Huangshi, Harbin, Incheng, Haikou, Dongguang, Meizhou, Xianning, Zhejiang, Guilin, Xiamen, Quanzhou, and Jilin (refer to Figure 2).

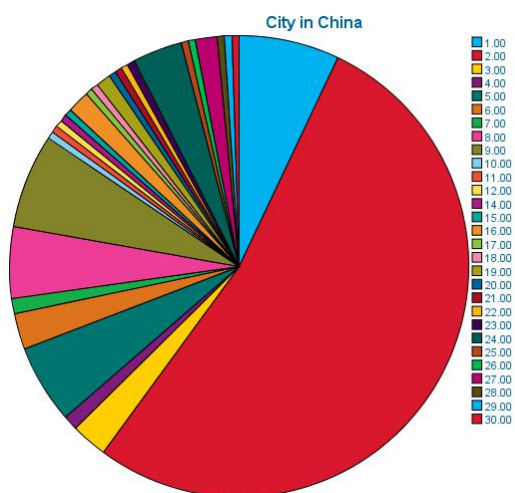


Fig. 2: Indonesian WeChat Pay users around city in China

Moreover talk, the duration used on WeChat mobile payment innovation by Indonesian are vary (refer to Figure 3). The study indicates that 29.8% of Indonesians in China are a user of WeChat mobile payment innovation for more and equal to 24.1 months. Followed by 29.3% for Indonesian WeChat Pay users for the period of 6.1 to 12 months, 19.2% for Indonesian WeChat Pay users for the period of 18.1 to 24 months, 16.2% for Indonesian WeChat Pay users for the period of 12.1 to 18 months, 5.6% for Indonesian WeChat Pay users for the period of equal or less than 6 months.

Additionally, the study released that most Indonesian users spent their expenses by the assistance of WeChat Pay for equal or less than 500 RMB (31.8%), 1001 to 1500 RMB (27.8%), 500.1 to 1000 RMB (25.8%), 1501 to 2000 RMB (8.1%), and equal or more than 2001 (6.6%) (refer to figure 4). Authors also proposed a question to the respondents about the intensity used of WeChat mobile payment for their daily expenses. Therefore, authors collected the respondents' answers with grocery shopping (33.3%), printing shop (20.7%), Others (21.2%), transfer and receive money from relatives

or friends (14.6%), and Transportation payment (10.1%) on the intensity used of WeChat mobile payment innovation in China sequentially (refer to Figure 5). Others define cellular mobile data top up, electricity payment; and all payment provided by WeChat Pay.

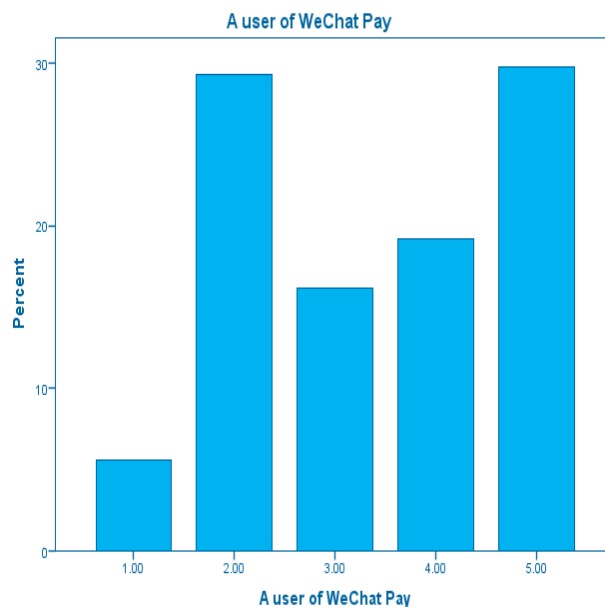


Fig. 4: Duration used on WeChat mobile payment innovation by Indonesian in China

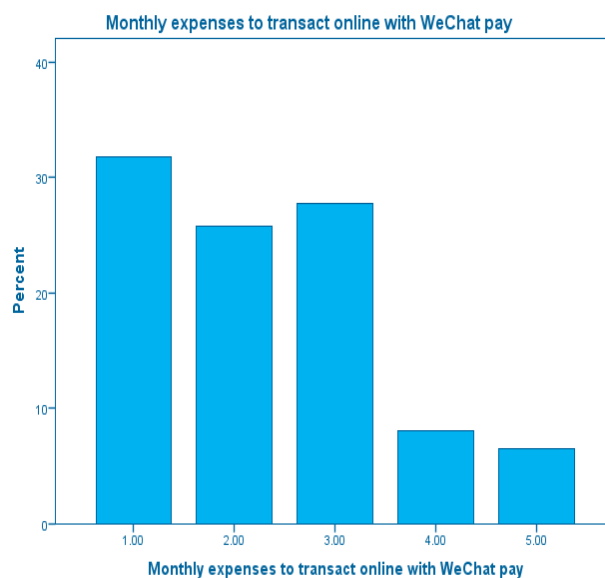


Fig. 3: Monthly online transaction expenses by the use of WeChat mobile payment

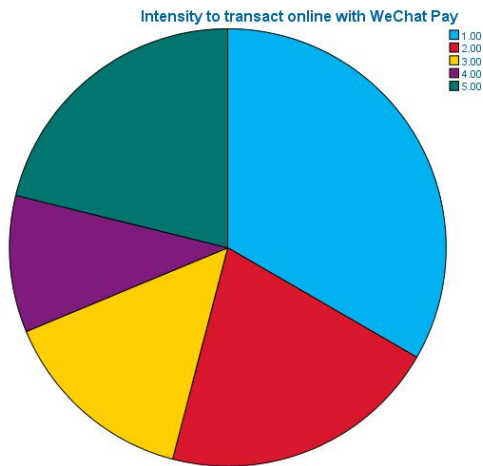


Fig. 5: Online intensity transaction with the use of WeChat mobile payment

4.2. Measurement Model and Structural Model Analysis

The study apply two approaches in determining the collected data. The approaches used consisting of measurement model and structural model.

4.2.1. Measurement model analysis

The measurement model is applied to frame the reliability and validity of a data. Convergent validity, discriminant validity, and unidimensionality are applied for the measurement model analysis. Convergent validity is defined by its loading factors and Average Variance

Table 3. Measurement Model for its Reliability and Validity Analysis (N=198)

Construct	Cronbach's Alpha	Composite reliability	AVE	Item	Loadings
Performance Expectancy	0.975	0.982	0.931	PE1	0.969
				PE2	0.974
				PE3	0.957
				PE4	0.958
Effort Expectancy	0.977	0.983	0.935	EE1	0.968
				EE2	0.974
				EE3	0.963
				EE4	0.962
Social Influence	0.958	0.973	0.922	SI1	0.949
				SI2	0.960
				SI3	0.971
Facilitating Conditions	0.952	0.965	0.875	FC1	0.954
				FC2	0.940
				FC3	0.945
				FC4	0.900
Perceived Technology Security	0.964	0.974	0.902	PTS1	0.919
				PTS2	0.968
				PTS3	0.948
				PTS4	0.963
Behavioral Intention to Adopt WeChat	0.962	0.975	0.929	IA1	0.962
				IA2	0.980
				IA3	0.949
Customer Satisfaction	0.986	0.991	0.973	SAT1	0.984
				SAT2	0.990
				SAT3	0.986
Behavioral Intention to Recommend WeChat	0.965	0.975	0.906	IREC1	0.966
				IREC2	0.979
				IREC3	0.955
				IREC4	0.904

Extracted (AVE). Discriminant validity is determined by Fornell-Larcker Criterion. Unidimensionality is defined by the value on composite reliability and Cronbach's Alpha in PLS-SEM construct reliability and validity. Therefore, the study framed out all measurement model analysis to be fully satisfied (refer to Table 3). The value on Cronbach's Alpha, Composite Reliability, AVE, and Factor Loading have exceeded the minimum limit on each criterion. All the Cronbach's Alpha, composite reliability, and factor loadings on its respective constructs signified the value above 0.90. Moreover, most of the value on the Average Variance Extracted indicates a value that also surpasses the lowest criteria to satisfy the measurement model analysis with the value above 0.90 and one construct indicates the range value of 0.875. The Fornell-Larcker Criterion in the study has been fully satisfied by the Average Variance Extracted square root value of each construct are greater than the correlation on each construct (refer to table 4).

value of 0.079.

Table 5. Variance Explains of the Endogen Latent Variable

	R Square
IA	0.676
IREC	0.497

Additionally, the variance explains indicates by R Square on behavioral intention to adopt WeChat mobile payment innovation (IA) is 0.676 (refer to Table 5). It has meaning that performance expectancy, effort expectancy, social influence, facilitating conditions, and perceived technology security have 67.6% variances explains on behavioral intention to adopt WeChat mobile payment innovation. Moreover, the remains 32.4% is determined by other factors.

Table 4. Fornell-Larcker Criterion: Matrix of Correlation Construct and the Square Root of AVE in Bold

	EE	FC	IA	IREC	PE	PTS	SAT	SI
EE	0.967							
FC	0.857	0.935						
IA	0.773	0.767	0.964					
IREC	0.728	0.678	0.673	0.952				
PE	0.835	0.776	0.739	0.794	0.965			
PTS	0.713	0.709	0.699	0.588	0.687	0.950		
SAT	0.687	0.698	0.752	0.646	0.660	0.668	0.986	
SI	0.392	0.342	0.369	0.449	0.457	0.314	0.329	0.960

4.2.2. Structural model analysis

R Square (R2) value, path coefficients, and Goodness of Fit (GoF) Index are applied to determine the structural model analysis in the current study. According to (Hu & Bentler, 1999), the value of SRMR to satisfy the model fit (GoF) of a research data shall be < .08. Therefore, the study has also satisfied the model fit with the SRMR

Furthermore, behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction signified 49.7% of the variance explains the behavioral intention to recommend WeChat mobile payment innovation (refer to Table 5). To be more detail, it also explains that the remains 50.3% is determined by other factors other than behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction.

Table 6. Hypothesis Analysis with Bootstrapping Approach

	Hypothesis	Path Coefficients	P Values	Results
PE -> IA	1	0.172	0.240	Not Supported
EE -> IA	2	0.224	0.141	Not Supported
SI -> IA	3	0.041	0.359	Not Supported
FC -> IA	4	0.277	0.052	Not Supported
PTS -> IA	5	0.212	0.014	Supported
IA -> IREC	6	0.431	0.000	Supported
SAT -> IREC	7	0.322	0.004	Supported

Additionally, path coefficients analysis was run under the bootstrapping method in the PLS-SEM to analyze the established relationship of a hypothesis. Therefore, the study signified three supported hypothesis out of seven hypothesis (refer to Table 6). The path coefficient on performance expectancy, effort expectancy, social influences, and facilitating conditions to behavioral intention to adopt WeChat mobile payment innovation indicates a positive path coefficient value. Moreover, the indicated p values of performance expectancy, effort expectancy, social influence, and facilitating conditions to behavioral intention to adopt WeChat mobile payment innovation were released as having insignificant value. It is because the p values of the proposed hypothesis exceed the lower limit of the specified measure of p values that is above .050. Hence, H1, H2, H3, and H4 defines a positive insignificant relationship which leads to the proposed hypothesis rejection. However, perceived technology security was found to signify a positive significant relationship to the behavioral intention to adopt WeChat mobile payment innovation. It can be seen by the p values that indicates a value above the lower limit of the specified p values measure. The path coefficients have also indicated a positive value of 0.212. Hence, H5 confirmed the proposed hypothesis developed in the study.

At last, the behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction denote to confirm the H6 and H7. The path coefficients on both behavioral intention to adopt WeChat mobile payment innovation and customer satisfaction to behavioral intention to recommend WeChat mobile payment innovation give forth a positive path coefficient value. Furthermore, its p values have pinpointed a significant value as it is indicating the result of greater value than the lower limit of the specified measure on p values. Speaking of, perceived technology security found to has indirect effects on the behavioral intention to recommend WeChat mobile payment innovation. It was defined as having an indirect effect by the evidence collected under current study that perceived technology security has a direct effect on behavioral intention to adopt WeChat mobile payment innovation. Moreover, behavioral intention to adopt WeChat mobile payment innovation provide the evidence under the study of having a direct effect on behavioral intention to recommend WeChat mobile payment innovation.

V. CONCLUSIONS AND RECOMMENDATIONS

Indonesia is a startup country in the development of a cashless society. Government and practitioners have been searching and introducing cashless society in many

ways as cash payment method has been the society payment pattern for many years back. Authors expected to provide new insight to the government and practitioners in Indonesia about the mobile payment innovation as the representative of cashless society. Moreover, authors pick WeChat payment innovation in China to be the study objective with the fact that WeChat mobile payment innovation has taken over the leading mobile payment first rank around the world. Authors believe that by choosing China as the objective study to analyze the approach in introducing and marketing the mobile payment method to the society can lead to some fresh insight into Indonesia. It is because China and Indonesia are both categorized as developing countries in Asia which is believed to have some similarities.

Moreover, the study framed out that some of the proposed hypothesis appears in the study are not in line with the prior study as it has mentioned in the aforementioned proposed hypothesis. Performance expectancy, effort expectancy, social influence, and facilitating conditions are having a positive relationship but has no significant value. However, prior studies has also indicates a not significant relationship on performance expectancy (Attuquayefio & Addo, 2014), effort expectancy (Oliveira et al., 2016; Baptista 2016; Slade et al., 2015), social influence (Attuquayefio & Addo, 2014; Baptista, 2016), and facilitating conditions (Oliveira et al., 2016); Baptista, 2016) to behavioral intention to adopt particular technology. There is a possibility for the contrary of current finding with the former UTAUT 2 Theory introduced by Venkatesh et al (2012) due to WeChat mobile payment innovation in China was found to be something new for Indonesian users. Mobile payment with the means of social media chat application used is new for Indonesian. Firstly, the Indonesian government and practitioners are still searching out for the best path taken in introducing the mobile payment innovation to the society in Indonesia. However, some practitioners have performed their good existences in promoting the mobile payment method among the society in Indonesia. Hence, even though WeChat pay is ranked one over the world which made the social chat application payment as an unbreakable payment method during the current year of the present day, it cannot lead to a proper result when it comes to Indonesian users of WeChat pay in China. It might be happened due to Indonesian users in China are still learning in catching up with the present development technology of WeChat mobile payment innovation in China. Additionally, China is a country which upholds the sense of nationalism, even the WeChat mobile payment provide English version, there still have some Chinese version provide within the social chat application

used. Hence, it can lead to a lack of understanding to Indonesian in China that actually are still searching out for their second nature of using mobile payment approach. Moreover, the future study shall explore in more detail to satisfy the issues arise in the current findings.

Additionally, the study captured behavioral intention to adopt WeChat mobile payment innovation plays a major role in the intention to recommend the utilization of WeChat mobile payment innovation. The finding is consistent with the earlier research (Oliveira et al., 2016; Zhang et al., 2015; C. Xu et al., 2015). Indonesian found to have high intention to recommend WeChat mobile payment innovation in China to others. Hence, there might be some opportunities for Indonesian government or practitioners to learn the method used by WeChat enterprise in introducing the services. Even though Indonesian were found to have no significant relationship on performance expectancy, effort expectancy, social influence, and facilitating conditions, the people are testifying to have high interest to recommend WeChat mobile payment innovation. Authors found some interesting fact here which can lead to the future study of other researchers. Additionally, Customer satisfaction found to be the second influential determinant to the behavioral intention to recommend WeChat mobile payment innovation. The finding is consistent with earlier research that issued by C. Xu et al (2015), Suchánek et al (2017), and Finn et al (2009). The finding can be interpreted as a way once the satisfaction needed on Indonesian has been achieved, the person will be more likely to recommend WeChat mobile payment based on their experience.

Moreover, perceived technology security sequentially signified the remains influential determinants of behavioral intention to adopt WeChat mobile payment. The findings are in line with the prior study written by Oliveira et al (2016) and Mohammed & Tejay (2017). The supporting fact behind it, can happened from the emerged of WeChat mobile payment innovation that spreading all over the city side in China. Even to purchase in a vegetable market or street vendor WeChat pay can be used. Furthermore, once society or WeChat Pay users have applied using the mobile payment method not only in a giant market, but also street vendor, there might seems that the user experienced a perceived technology security. Hence, future researchers are able to discuss in more detail regarding the facts behind the high intention of Indonesian to adopt WeChat mobile payment in China. Overall proposed hypothesis, it seems that all of the hypothesis directed to the behavioral intention to recommend WeChat mobile payment innovation is significantly satisfied. Hence, the findings clearly defined

that there is a big chance and lesson can be learned by the Indonesian government and practitioners from WeChat mobile payment innovation in China to the development of mobile payment in Indonesia. Additionally, future research can consider to put concern on more specific targeted respondents as the current study has wider targeted respondents and resulting in unbalance collected city from one another. It is suggested that future study are able to frame other determinant factors on behavioral intention to adopt particular technology and the behavioral intention to recommend a particular digital technology.

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Appendix A. Questionnaires Items and Sources

Constructs	Items	Sources
Performance Expectancy	PE 1 - I find WeChat mobile payment innovation useful in my daily life	Venkatesh et al., (2003,2012); Oliveira et al (2016)
	PE 2 - Using WeChat Mobile Payment innovation helps me accomplish things more quickly.	
	PE 3 - Using WeChat mobile payment innovation increases my productivity	
	PE 4 - Using WeChat mobile payment innovation helps my work to be more effective	
Effort Expectancy	EE 1 - Learning how to use WeChat mobile payment innovation is easy for me	Venkatesh et al., (2003,2012); Oliveira et al (2016)
	EE 2 - My interaction with WeChat mobile payment innovation is clear and understandable	
	EE 3 - I find WeChat mobile payment innovation easy to use	
	EE 4 - It is easy for me to become skillful at using WeChat mobile payment innovation	
Social Influences	SI 1 - People who are important to me in China think that I should use WeChat Mobile Payment Innovation	Venkatesh et al., (2003,2012); Oliveira et al (2016)
	SI 2 - People who influence my behavior in China think that I should use WeChat Mobile Payment Innovation	
	SI 3 - People whose opinions that I value the most in China prefer that I use WeChat mobile Payment Innovation	
Facilitating Conditions	FC 1 - I have the resources necessary (smartphone and bank account) to use WeChat mobile payment innovation	Venkatesh et al., (2012); Oliveira et al (2016)
	FC 2 - I have the knowledge necessary to use WeChat mobile payment innovation	
	FC 3 - WeChat mobile payment innovation is compatible with other technologies I use	
	FC 4 - I can get help from others when I have difficulties using WeChat mobile payment innovation	
Perceived Technology Security	PTS 1 - I would feel secure using mobile payment innovation like WeChat for activities relates to financial background	Oliveira et al., (2016); Z. A. Mohammed and G. P. Tejay (2017)
	PTS 2 - Mobile payment innovation like WeChat is a secure means through which to send sensitive mobile	
	PTS 3 - I would feel totally safe providing sensitive information about myself over mobile payment innovation like WeChat	

	PTS 4 - Overall mobile payment innovation like WeChat is a safe place to send sensitive information	
Behavioral Intention to Adopt WeChat Mobile Payment Innovation	IA 1 - I intend to continue using WeChat mobile payment innovation in the future IA 2 - I will always try to use WeChat mobile payment innovation in my daily life	Venkatesh et al., (2003,2012); Oliveira et al (2016)
Customer Satisfaction	IA 3 - I plan to continue to use WeChat mobile payment innovation frequently SAT 1 - I feel very satisfied with the overall experience of using mobile payment innovation like WeChat SAT 2 - I am very pleased with the overall experience of using mobile payment innovation like Wechat SAT 3 - I feel very delighted with the overall experience of using mobile payment innovation like WeChat	C. Xu, D. Peak, and V. Prybutok (2015)
Behavior Intention to recommend WeChat mobile payment innovation	IREC 1 - I intend to positive things about mobile payment innovation like WeChat IREC 2 - I would like recommend mobile payment innovation like WeChat to my friend IREC 3 - I intend to encourage other people to use mobile payment innovation like WeChat IREC 4 - It will be grateful if mobile payment innovation like WeChat release in China can also be introduce and apply in Indonesia	Oliveira et al (2016)

Economic Viability in Photovoltaic Panels: a Systematic Review in Capes Periodical Portal and Scopus Database

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Abstract — *To accomplish this work, it was necessary to perform a survey about studies on the economic viability of the use of photovoltaic panels. This investigation was carried out by a literature review, which is essential to provide theoretical support for future researches. This work aims at conducting an analysis on the subject in works that approach the economic viability and the use of solar panels, from a previous set of bibliographic references to assist the theory contribution of this work. The webibliomining was adopted to perform the mining of the bibliographic sources that compose this systematized review of literature based on search tools and access to bibliographic information on the Internet. Scopus Elsevier database was chosen, as it is the most comprehensive one concerning the other ones. The search terms applied were (“solar photovoltaic system board” OR “pv” AND “economic viability”) in the following fields: title, abstract, and keywords. This study also focuses on research relevance for companies interested in using the photovoltaic panels. Results points out that the United States is the country that publishes the most about the subject, as well as the area that publishes is Energy. It is also noticed that Brazil is among the countries of most interest in such issue. In this way, it is concluded that the analysis of the sample of articles found and analyzed here shows that solar energy has increased visibility and has been applied in domestic, rural, commercial, and industrial plants. Nonetheless, there is also a lack of incentives or tax credit to make this power source competitive and viable.*

Keywords— *Webibliomining; Economic viability; Photovoltaic solar system.*

I. INTRODUCTION

Environment preservation, sustainable development, energy grid change, increase in power demand and industrial development are some of the factors that stimulate the fossil fuel substitution by renewable and clean sources, such as the solar source (NASCIMENTO, 2017).

The photovoltaic solar energy is the power produced by the solar incidence that reaches the surface of the Earth in electromagnetic waves (photons), which can be diffused or directly converted into electricity (IMHOFF, 2007). Solar energy on Earth can be considered as the origin of the water cycle, of the wind, and of the photosynthesis of the plant and animal kingdoms, which also depends on the plant kingdom by means of the food chains.

In that way, this article addresses the webibliomining method proposed by Costa (2010), as it provides a selection of academic works to a researcher who has just entered an area of knowledge, and its methodology consists of six stages. This method has been applied to make it easy to find a theoretical reference about the economic viability and photovoltaic panels theme.

Jesus and Costa (2015) state that, generally speaking, direct mechanisms are used to perform this type of research. Then, the text is searched by keywords, author, or title, and there are no additional filtering on the records found.

During this work, some questions were raised, such as: Has this subject been the focus of study for a long time? What was the year of largest search? Has any author been stood out or been distinguished by the largest number of documents published about the topic? What is

the area that have most documents related to it? Which country publishes the most in the search for the keywords in this case? What has been said about this theme? Which universities have developed projects and studies?

Within this context, this paper aims at providing theoretical contribution to base and complement future works by means of a systematized review of literature, identifying works that address the economic viability of the use of photovoltaic panels, as well as presenting a view of scientific production using the Scopus Elsevier database from the Capes periodical portal.

These results highlight the graphs elaborated with the publication number on the subject, the authors who most relate the theme, besides the quantitative of works published per year, per country, and per area, so that they can help future works.

II. REVIEW OF LITERATURE

2.1 Solar power in the world

It is worth noting that, since ancient time, a need for the sun to feel its direct heat and light was already a necessity (CARVALHO; CALVETE, 2010). Da Cunha Kemerich et al. (2016) apud Hémary et al. (1993) state that the “use of solar energy to provide light for lighting functions happened in the Paleolithic period”. Moreover, Da Cunha Kemerich et al. (2016) apud Farias & Selitto (2011) address that, since the beginning, there was already a concern about “obtaining a form of artificial light”. Then during the fire production period, by using a sticky plant, the man succeeded in managing his/her first step towards his/her purpose.

Furthermore, Carvalho and Calvete (2010) point out that there has been a “two thousand-year time gap”, which goes from the Greek-Roman architecture to the series production of current thin photovoltaic panels.

In Ancient times, Romans and Greeks efficiently managed to use the architecture in a passive solar design to take advantage of the capacity to warm and light interior architectural rooms, building the most important part of the house to the South. The need arises for human skill and, in this context, the Romans were more daring when they covered the open parts of the buildings with mica or glass to keep the heat of the winter sun.

Also Carvalho and Calvete (2010) cite that, in the nineteenth century, Auguste Mouchot, the “French inventor of the first active solar engine”, who was responsible for transforming solar energy into steam power, raised some questions, which were almost predictive about the thinking that the fossil fuels used at that time, especially coal, would be never exhausted:

“Possibly, the industry will stop finding resources in Europe to meet its prodigious necessities. Coal will be extinguished unquestionably. What will the

industry do at that moment?” However, his research abruptly ended. The cuts in English exports of coal to France caused the English monarch to renegotiate a more economic deal for the French for obtaining coal, making that first technological advance of solar energy succumb right after its beginning (somewhat premonitory and actual). The French monarch did not consider that alternative as a priority, with a consequent cut of funds to continue the improvement of technology. Since then, the time frame of the research in the solar energy area has been the same for its breakthroughs and setbacks, always from the same estimates, as well as its aim.

The most promising systems for the search for sustainable and renewable sources of clean power are photovoltaic cells, as they have capacity to convert directly solar light into electrical power.

Besides, the great photovoltaic market has had a significant increase, promoted by the policies started in countries such as Japan and Germany and which took place in this century. For instance, in the decade of 2000, Japan installed 25,000 solar panels in habitations. Such growth gave rise to a decrease in production costs, creating scale economies and establishing a 30 per cent increase of the photovoltaic sector annually worldwide, although with a continuing state support in many countries (CARVALHO; CALVETE, 2010).

According to the *Agencia Internacional de Energia-AIE* (International Energy Agency), by the year 2050, the solar generation of electrical power will be of 11% of the total amount, around 5000 TWh. To obtain that generation capacity, the solar installations occupied, in total, around eight thousand Km².

It makes it possible for the generation of solar energy to become the largest source of income in North Africa, exporting power to Europe, Russia, the Middle East, and other parts of Asia (MME, 2015).

Data from 2015 show that solar power installed until that year was of 234 GW, being 229 GW of photovoltaic generation (PG) and 5 GW of Concentrating Solar Power (CSP). With a mean capacity factor of 13.9%, the total generation was 253 TWh.

Observing data from the *Nucleo de Estudos Estrategicos de Energia* of the *Ministerio de Minas e Energia-MME* (Center of Strategic Power Studies of the Ministry of Mines and Power), Italy had the highest solar generation percentage regarding its total generation of 9.3%, followed by Greece (7.8%).

Spain has the highest capacity factor of 29.3% because of more than 40% of installed power of CSP, a large part with a heat storage between 7 and 8 hours to generate in periods with no sunlight.

The first five countries in installed power respond for 68% of the world total. In 2015, China (1st) and the United States (2nd) overtook Germany in solar generation.

In 2018, Brazil should be among the 20 largest solar power-generating countries in the world, considering the operation of 2.6 GW power already contracted. Geographically, the 234 GW of 2015 represent 1,635 km² of solar panels, or 40.4 km square of side, considering 143 W/m² (efficiency of 15% solar absorption) (ANEEL 2018).

2.2 Solar Energy and Brazil

For Nascimento (2017) apud MME (2017), Brazil had 81 MWp of photovoltaic solar power installed by the end of 2016, which represented 0.05% of total installed capacity in the country. Moreover, “from a total of 81 MWp in 2016, 24MWp corresponded to centralized generation and 57 MWp, to distributed generation (NASCIMENTO, 2017 apud MME, 2017).

In accordance with Nascimento (2017) apud Empresa de Pesquisa Energetica - EPE (2012), Brazil has “large reserves of quality quartz, because of its location and territorial extension, which can generate competitive advantages for silicon production with high purity grains, solar cells and modules, products of high aggregate value”.

The Agencia Nacional de Energia Eletrica - ANEEL (National Agency for Electric Power) asserts in its report on solar energy that its largest current applications are for water heating and photovoltaic generation of electrical power, the second most found in the North and Northeast Regions in communities that do not have access to the electrical power grid (ANEEL, 2018).

The solar source application to generate electrical power provides many benefits cited by the Associação Brasileira de Energia Solar Fotovoltaica-ABSOLAR (Brazilian Association of Photovoltaic Solar Power), both from the electrical, environmental, and socioeconomic perspective (ABSOLAR, 2017).

There is legal support for ANEEL Resolution 482, of April 7, 2012, which allows access to the micro-generation distributed to the national electric grid, ensuring a legal base for the response to the socioeconomic and environmental solutions of the generation and distribution of electrical power (MME, 2015).

With regard to the environmental aspect, Imhoff (2007) stresses solar energy is one of the least pollutant primary sources of power. It is silent, with a low maintenance level, less aggressive to the plant and animal kingdom than other power sources and, as it can be generated in its own consumer unit, it does not need

transmission lines, greatly minimizing its environmental impact.

After the introduction of the net measuring regulation in 2012, Holdermann et. al. (2014) examined the viability of small-scale, grid-connected development of the photovoltaic system as an alternative to environmental and socio-economic questions. Rocha et. al. (2017), complementing those studies, indicate that there is strong pressure for change in the means of power production and that the reading is an important mechanism in the dissemination of photovoltaic systems of small scale.

As a major solution to the socioeconomic power question, Vale et. al. (2017) addressed studies in the Programa Minha Casa Minha Vida (MCMV) (A program that provides support for the acquisition of a house or apartment for low-income families) to evaluate the reduction of costs and economic impacts of the installation of small-scale photovoltaic systems connected to the grid in the households of this Program.

In the view of Mitscher et. al. (2012), who performed a study on economic competitiveness of grid-connected micro-generation of electrical power, that system has already proved to be as commercially competitive, since there are tax exemptions.

Such study is based on the work of Byrne et al. (1998), who conducted a similar investigation in Mongolia, demonstrating its economic viability. Considering some technical differences, the socioeconomic scenarios are very similar, which is worthwhile to support the research carried out by Mitscher et al. (2012).

By its location and territorial extension, Brazil has the most renewable power grid in the industrialized world, with almost half of its production coming from water resources, biomass and ethanol, in addition to wind and solar energy. Figure 1 presents the power grid in Brazil.

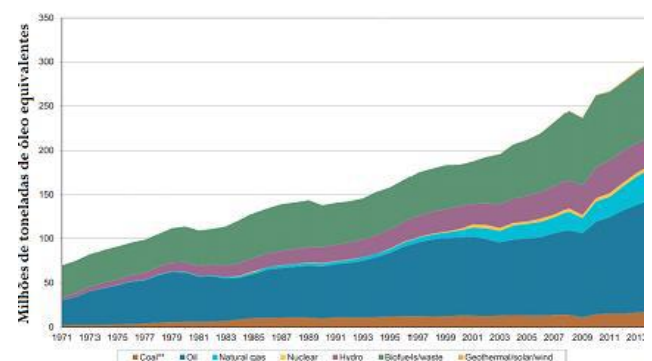


Fig.1: Total Primary Power Supply in Brazil (IEA, 2018)

Data from Figure 1 indicate the relation between million tons of oil equivalent in a period, in which it can be seen the Brazilian power grid. In green color, it is noticed that the biofuel production is increasing in the

country. In addition, Hydro, Nuclear, Geothermal, Natural Gas, and Oil sources had an increase throughout that period. Lastly, Coal was the one that kept greater linearity compared to the others.

As most of Brazilian territory lies between the Equator and the Tropic of Capricorn, there are no considerable variations in the sunlight duration. Nevertheless, to maximize the solar radiation use, it is essential to adjust the position of the collector or solar or photovoltaic panel at the local latitude and the year period when more power is required (ANEEL, 2018).

In Pereira and Oliveira (2011), photovoltaic panels are the main components of a power generating photovoltaic system, which are composed of a voltaic cell cluster that can be electrically associated in parallel and/or in series. Their goal is to detect solar irradiation and convert it into electric power. *ptar a irradiação solar e transformá-la em energia elétrica.*

2.3 Costs of Solar Power in Brazil

As stated by Nascimento (2017), the *MME* (2009) “highlights” two basic regulatory incentive mechanisms: the price system and the quota system”. The first is related to a value paid to the provider of the solar photovoltaic power generator in a determined period equal to or higher than twenty years. The second mechanism defines power and (or) energy goals from specific sources for concessionaires, distributors, large consumers, and other agents of the electric sector (NASCIMENTO, 2017).

Moreover, *Enel Soluções* (2018) literally describes solar power as being free of charge, as for the *Enel Soluções* (2018), “we pay for the system that converts solar energy into electrical power”, as shown below:

For example, a photovoltaic solar power system of 3.3 KWp worth R\$ 25 thousand, plus R\$ 6 thousand of maintenance in the 25-year period, is equal to a total investment of R\$ 31 thousand. In 25 years, the power generated will be of approximately 94 thousand KWh. If we divide the investment value by the power generated, we will reach the price of R\$ 0,31/kWh. A value 57.6% cheaper than the current electric power tariff in Rio de Janeiro State, which is R\$ 0,73.

The environmental costs of solar power generation, in terms of environmental impact, which were not specified herein, are lowest when compared to other energy sources, such as hydroelectric generation, where deviations in rivers and the construction of large reservoirs are necessary. In this case, there is a cost of vast areas, whether they are native forest or productive or inhabited land.

2.4 Types of Solar Power in Brazil

The most frequent type of solar energy conversion to electricity in Brazil is the Photovoltaic panels (Pp). According to Brasil (2015), in the 1950s, “solar panels converted only 4.5% of solar energy into electricity”, equal to 13Wp/m² at a cost of US\$ 1,785/Wp. In addition, he says the worldwide efficiency tripled to 15% (143Wp/m²), costing 1,370 times less, of US\$ 1.30/Wp.

Most of the photovoltaic panels (Pp) used nowadays, with a 95% market share, are manufactured in pure crystalline silicon (c – SI), and have power production between 13% and 17% (MME, 2015).

There is also a cheaper variant of Pp, with lower power efficiency, called thin layer cells, composed of thin layers of photovoltaic semiconductor materials (amorphous silicon – a-Si, cadmium telluride – CdTe, and copper-indium-gallium diselenide – CIGS) on a base made of glass, stainless steel or plastic.

Concerning the photovoltaic conversion into electrical power, its use attends to small systems and autonomous microsystems, in general Distributed Generation (DG) or in large plants, which use solar energy in a centralized way. On the other hand, the CSP process is suitable for large plants. Distributed Generation (DG) is the type of generation that is close to or in the consumer unit.

ANEEL approved in 2012 its Regulatory Resolutions 482 and 517, which regulate the microgeneration of electrical power, besides establishing the compensation system of electrical power (net metering), being currently used in many countries (ANEEL, 2018).

Therefore, in the DG system, the excess energy is distributed to the grid and, subsequently, balanced with consumption of that unit or another one, stating that it should have the same ownership. The power credits generated will be valid for 60 months. The process involves only the kWh exchange between consumer – generator and the power distributor.

The use of solar energy by concentration is also registered in Brazil, in a system called Concentrating Solar Power (CSP), to produce electrical power or heat. In the CSP process, the solar energy is concentrated in a receiver, which collects and transfers the energy to a heat transfer fluid that can provide heat for final applications, or activate thermal engines, or conventional steam turbines to generate electrical power (MME, 2015). There are heat stores in large CSP plants to supply heat and electricity at night or in cloudy sky conditions.

There are four types of CSP technologies: Parabolic Troughs (PT); Fresnel Reflector (FR); Solar Tower (ST); and Solar Disk (SD). In PC and FR, the solar energy is concentrated in a focal line, reaching operating temperatures between 300° C and 550° C. In ST and SD plants, the solar light is concentrated in just one spot,

which enables achieving operational temperatures higher than the PC and FR plants.

The reflecting mirror can be fixed or adjustable, together or not with the focal plan (MME, 2015).

The PT technology is currently the most developed and most employed in the market.

Synthetic oil or molten salt is applied in the heat transfer to a steam generator.

2.5 Brazilian Legislation on Solar Energy

For Portal Solar LTDA. – ME (2018), the Normative Resolution no. 482/2012 of ANEEL establishes “the general conditions for connection of the photovoltaic solar power systems in the electrical power grid”. The same way, the Portal Solar LTDA. - ME (2018) stresses that this is a “resolution that allows us to make the ‘exchange’ of energy with the electric grid”.

The Conselho Nacional da Política Fazendária - Ministério da Fazenda (CONFAZ, 2015), by means of the Ajuste SINIEF 2 (it provides for procedures relating to electric energy circulation operations, subjected to billing), repealed the agreement that "guided the taxation of the generated energy in the grid". The decision as to whether or not to tax the solar energy that is injected into the distributor's grid was made by each state.

Moreover, some states, such as Amazonas, Parana, and Santa Catarina, have still not exempted the solar energy production from the Imposto sobre Circulação de Mercadorias e Serviços - ICMS (tax on circulation of goods and services).

Lastly, the Federal Government, by the Law no. 13.169, exempted the PIS and COFINS to the solar energy injected into the grid (PORTAL SOLAR LTDA. - ME, 2018).

III. MATERIALS AND METHODS

In this step it is explained how the search was carried out, in a detailed way, in the Scopus Elsevier database, which was chosen because it is the most comprehensive in front of the other options

3.1 Regarding the purposes

Relating to the technical procedures, this is a theoretical-conceptual work of an exploratory nature and qualitative research approach, inspired by the webibliomining method introduced by Costa (2010), to perform the systematized review of literature.

3.2 Quanto aos meios

Inspired by the models of Freitas and Costa (2017), Jesus and Costa (2015), and Neves et al. (2015), the paper will cover six stages, as described in Chart 1.

Stages	
Stage 1	Definition of the research sample;
Stage 2	Research on the sample with keywords;
Stage 3	Identification of journals with the highest number of articles published on the theme;
Stage 4	Identification of authors with the highest number of publications;
Stage 5	Verification of Production chronology, identifying the highest production cycles;
Stage 6	Selection of the articles to compose the “starting point” for the bibliographic research.

Chart 1: Development model to carry out a bibliometry (Costa, 2010).

For the first stage, a literature review was made at Scopus Elsevier database, accessed in January 2018, by the Portal de Periodicos da Capes, once it includes, besides academic articles, other types of publications, like free- access publications, commercial publications, among others (ELSEVIER B.V., 2016). The exclusion filters were not used so that the range of documents in the found area would be larger.

The fields: title, keyword and summary were listed as a research field. This study embraced all areas of knowledge in the data bank. The operator "AND" guarantees that the publications found have all the words searched, while the use of the operator "OR" allows one or another term.

After the selection of the database, the search criteria were set. With the goal of making a broad coverage of the publications on the subject of economic viability of the use of photovoltaic panels, the area was researched as a whole, to compile all the possible studies developed.

For the second stage, the set of keywords ("solar photovoltaic system board" OR "pv" AND "economic viability") were defined in the search field in accordance with "title, keywords, abstract", reaching 187 results. These terms were chosen in a way that they could be located in the title of the article, in the abstract, or in the keywords of it.

There has been a limitation of research on the time period, including only the years covered by at least two publications, until January 2018, and on other topics, only the ten main topics returned by the database have been addressed. This methodology was used to make the data more meaningful and recent.

The third and fourth stages made it possible to identify the authors, journal largest number of publications. This study was conducted on the basis of the two main data delivered by the base, i.e., in each category, the first ten data supplied by the base were considered.

The fifth stage enabled the display of the productions and authors with more citations. Lastly, the sixth stage of the methodology suggested by Costa (2010) aims at a chronological survey of academic productions produced with the aim of presenting the scientific evolution on the subject.

IV. RESULTS AND DISCUSSIONS

At this stage, the 187 resulting articles were analyzed and, from this evaluation, a group of ten articles was composed, which approached more accurately with the subject of this study.

In this way, using this group, graphics containing these publications are shown here, which are associated with the amount of publications per year, which authors published on the subject, the origins of the articles, as well as their affiliations. The number of publications per country and per area is also shown, displaying those that are of interest.

4.1 Number of publications per Year

The data given in Figure 2 illustrate the number of publications in a temporal cut. They were considered only the years that presented no less than two publications on the subject.

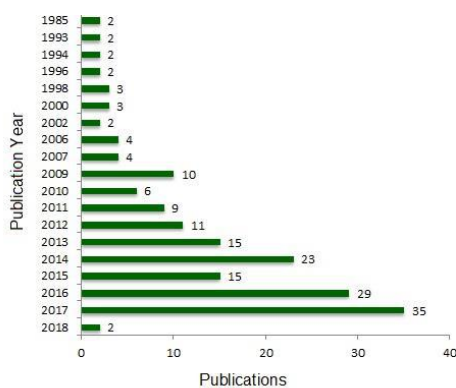


Fig.2: Graph of Frequency of publications per year from 1985 to 2018 (Scopus, 2018).

It can be seen that, from 2013 onwards, the published volume was higher. The year 2017 was the one that resulted in a larger number with 35 publications. This year of 2018 has already presented two publications.

4.1 Authors that published on the subject and number of citations

The data given in the Figure below show the graph of the authors who published the most about the subject and the number of citations.

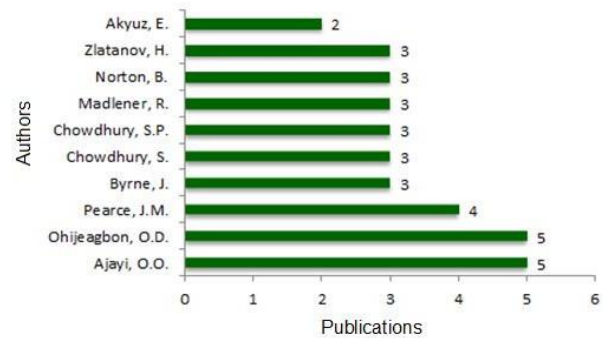


Fig.3: Graph of authors with higher Frequency of Publication (Scopus, 2018)

It can be noted that the authors Ohijeagbon, O.D. and Ajayi, O.O. were those who had the largest number of publications with respect to the theme studied in this work.

4.2 Source of publication

In Table 1, the source data of the publications are displayed, together with how many documents each one has. Furthermore, the impact factors of the Scientific Journal Rankings (SJR) and the impact of citations per documents are also shown.

Table.1: Number of published documents per publication source

Publication Source	Number of Documents	Impact Factor	
		SJR	Citation per doc.
Renewable and Sustainable Energy Reviews	14	3.0	8.78
Renewable Energy	12	1.7	4.8
Energy Policy	11	2.2	4.4
Conference Record of the IEE Photovoltaic	1	0.2	3
Applied Energy	8	3.0	7.58
Energy Procedia	6	0.4	7
Energy	5	2	4.95
Journal of Renewable and Sustainable Energy	5	0.4	2
International Journal of Hydrogen Energy	4	1.1	4
Energy Conversion and Management	3	2.2	9

Source: Scopus, 2018.

The data of the two main publication sources are listed in Table 1, along with how many documents each one

has. The Renewable and Sustainable Energy Review, with 14 publications in the area, followed by Renewable Energy, with 12, and Energy Policycom 11 were noteworthy.

In relation to the SJR, the source that is highlighted is Applied Energy, with 3.06, and Renewable and Sustainable Energy Reviews, with 3.05 value.

On the other hand, in the citations, it is noted that, in the first place, there is Renewable and Sustainable Energy Reviews, with a value of 8.78 per citation, followed by Applied Energy, with 7.58, and Energy Conversion and Management, with 6.06.

4.3 Affiliation

According to the information given in Figure 5, the two more relevant Universities or Organizations, also known as affiliations, are presented, as well as how many articles each one of them produces.



Fig.4: Graph of Affiliations with Higher Frequency of Publication. (Scopus, 2018).

It is worth noting, in Figure 4, Covenant University and the University of Lagos with five publications each.

4.4 Number of publications per country

The data in Figure 5 indicate the quantity of publications per country.

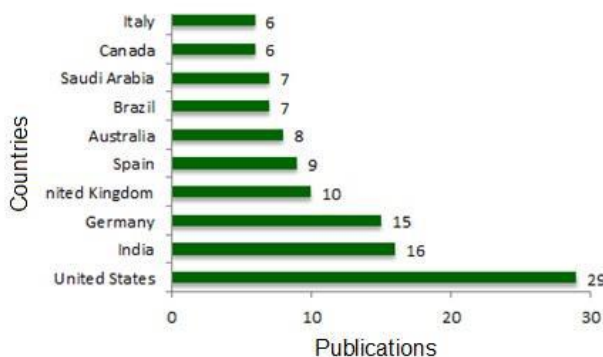


Fig.5: Graph of Countries with Higher Frequency of Publication (Scopus, 2018).

From data in Figure 5, the United States is the country that most research on the theme with 29 publications,

almost twice the following country. Then, India stands out with 16 publications and Germany, with 15. Brazil is among the ten most important countries, with seven publications, surpassing Italy and Canada.

4.5 Number of publications per area

The data contained in Figure 6 illustrate, in graph form, the knowledge areas with the highest frequency of publication.

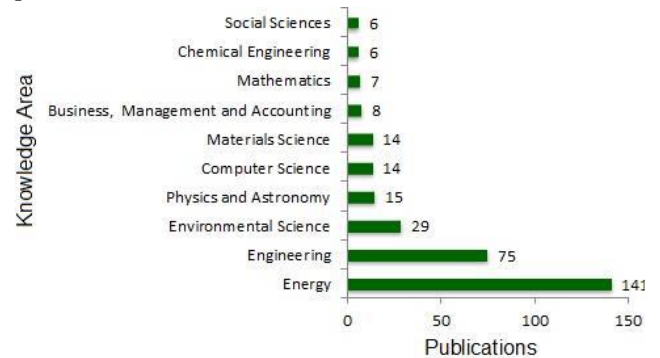


Fig.6: Graph of the knowledge areas with the highest frequency of publication (Scopus, 2018).

Among the various knowledge areas existing, the publications have been classified in ten areas: Energy; Engineering; Environmental Science; Physics and Astronomy; Computer Science; Materials Science; Business, Management, and Accounting; Mathematics; Chemical Engineering; and Social Sciences, as seen in Figure 7. The area of Energy is highlighted, with 141 publications, which is almost double of the second knowledge area, Engineering, with 75 publications.

4.6 Analysis of the article sample that forms the basis of the theme

In this phase, the 187 documents were examined and, according to the analysis of their scientific abstracts, ten articles were chosen from among the others. Available at Chart 2, they are those regarded by the author as the most relevant for the intended topic, as they will best correlate the economic viability and the photovoltaic solar system panels at a global level, in addition to focusing on the analysis of the articles produced in Brazil with the aim at identifying the results found with respect to the Brazilian authors.

Title	Author	Citations		Title	Author	Citations	
		Year	Count			Year	Count
THE ECONOMICS OF SUSTAINABLE ENERGY FOR RURAL DEVELOPMENT: A STUDY OF RENEWABLE ENERGY IN RURAL CHINA.	Byrne, J. , Shen, B. , Wallace, W.	1998	95	PRODUCTION IN BRAZIL: STOCHASTIC ECONOMIC VIABILITY ANALYSIS FOR SMALL SYSTEMS IN THE FACE OF NET METERING AND TAX INCENTIVES	Aquila, G. , Pamplona, E.D.O. , Chierigatti, B.G. , Lima, J.D.S.B.		
THE POTENTIAL AND ECONOMIC VIABILITY OF SOLAR PHOTOVOLTAIC POWER IN GHANA	Asumadu-Sarkodie, S. , Owusu, P.A.	2016	23	ANALYSIS OF THE ECONOMIC VIABILITY OF A PHOTOVOLTAIC GENERATION PROJECT APPLIED TO THE BRAZILIAN HOUSING PROGRAM “MINHA CASA MINHA VIDA”	Vale, A.M. , Felix, D.G. , Fortes, M.Z.Dias. , B.H. , Santelli, B.S.	2017	0
ECONOMIC VIABILITY OF SOLAR HOME SYSTEMS: CASE STUDY OF BANGLADESH	Asumadu-Sarkodie, S. , Owusu, P.A.	2010	43	IMPACT OF RURAL GRID-CONNECTED PHOTOVOLTAIC GENERATION SYSTEMS ON POWER QUALITY	Pinto, R. , Mariano, S. , Calado, M.D.R. , De Souza, J.F.	2016	7
DOMESTIC APPLICATION OF SOLAR PV SYSTEMS IN IRELAND: THE REALITY OF THEIR ECONOMIC VIABILITY	Li, Z. , Boyle, F. , Reynolds, A.	2011	37				
STUDY OF ECONOMIC VIABILITY OF PHOTOVOLTAIC ELECTRIC POWER FOR QUETTA – PAKISTAN	Khalid, A. , Junaidi, H.	2013	22				
DISTRIBUTED PHOTOVOLTAIC GENERATION IN BRAZIL: AN ECONOMIC VIABILITY ANALYSIS OF SMALL-SCALE PHOTOVOLTAIC SYSTEMS IN THE RESIDENTIAL AND COMMERCIAL SECTORS	Holdermann, C. , Kissel, J. , Beigel, J.	2014	15				
ECONOMIC PERFORMANCE AND POLICIES FOR GRID-CONNECTED RESIDENTIAL SOLAR PHOTOVOLTAIC SYSTEMS IN BRAZIL	Mitscher, M. , Rüther, R.	2012	33				
PHOTOVOLTAIC ELECTRICITY	Rocha, L.C.S.	2017	0				

Chart 2: Articles selected

Byrne et al. (1998) discussed the most recent case studies and modeling efforts that assessed the economic viability of photovoltaic and off-grid power technologies for rural applications in developing countries. They carried out case studies in 41 families of the Autonomous Region of Mongolia, located in the interior of China. It was seen in the analyses carried out that the leveled costs of the photovoltaic and off-grid systems on a domestic scale are competitive, in terms of costs, with conventional diesel sets, and the hybrid solar-wind systems seem to be an economic means of supplying electrical services throughout the year, in addition to meeting the energy demands of families that are most distant inland in Mongolia.

Asumadu-Sarkodie et al. (2016) assessed the potential and economic viability of photovoltaic solar power in Ghana, using the RETScreen software. A 5-megawatt solar power system is connected to the grid using a SunPower SPR-320E-WHT-D solar module, which can be used in the next localities: Navrongo, Bawku, Wa, Tema, Bolgatanga, Axim, Salaga, Kintampo, Kete Krachi, Tamale, Hohoe, Koforidua, Ejura, Takoradi, Bole, Sunyani, Bibiani, Cape coast, Prestea and Akuse. For this purpose, an investment of 17,752,179 dollars and 25,313 square meters of land were needed to install the system. As the potential of 5-megawatts is limited for

Accra, Kumasi, Wenchi and Tafo, there are photovoltaic solar energy potentials for low capacity photovoltaic modules, like these localities. To develop solar technology in a developing country, like Ghana, it is necessary to make government investments, like subsidies and the development of favorable economic environments for the investment in the private sector, which will promote the possibilities of investment in renewable energy in Ghana, in addition to reducing the power loss and leakage of energy, and increasing productivity and economic resilience.

Hossain Mondal (2010) argues that the city of Bangladesh is rich in solar incidence, thus, the photovoltaic solar system seems to be a good renewable energy investment. The most advantageous use for the domestic solar system (SHS) in Bangladesh is the generation of light. In rural areas, the most commonly used lamps are based on kerosene. The dry cell phone batteries have been utilized in radios and the car batteries have been slowly available in television sets where the battery charging systems are available. The cost of kerosene and battery charging is high and the solar system can compete with them. Six cases were examined with the aim of discovering the viability and economic sustainability of solar systems implemented in selected villages of the Gazipur district in Bangladesh, during the period from October 2004 to December 2004, and the data collection method used was based on questionnaires. Consequently, the solar system is financially attractive for small-scale rural businesses and for domestic lighting. Nevertheless, for domestic lighting needs the system is not financially and economically viable, without considering the social benefits.

Li et al. (2011) argue that, in years to come, renewable energy sources will be playing an important role in the production of electricity in Ireland. Electricity is mainly derived from imported gas and coal, given that Ireland has a lack of fossil fuels. As solar energy is widely available, freely accessible and environmentally friendly, it is becoming attractive to everyone, but has not been very widespread on both a large and domestic level in Ireland. The biggest challenge for the growth of this technology is the lack of clarity in the economy. Thus, the authors aimed at presenting a methodology to evaluate precisely the economic viability of a domestic solar system. To this end, they employed HOMER and Microsoft Excel software 2007 to perform energy and economic analyses. They carried out a realistic analysis of eight examples of domestic photovoltaic systems available in Ireland and concluded that these systems still do not seem promising even if they were given better financial support.

Khalid et al. (2013) intended to assess the viability of a photovoltaic power plant. For this purpose, they analyzed which would be the most adequate location by comparing the average monthly solar radiation data from eight Pakistani cities, and the city they selected for the 10-megawatt plant was Quetta. The software applied was the RETScreen, which proved that the plant could reach 23,206 GWh of energy per year. At a total cost of US\$ 50 million, a 50% debt rate, a 9% discount rate, the suggested photovoltaic plant generates electricity at a rate of US\$ 0.1557/kWh. In addition, the electricity produced is 30.8% more costly than the electricity delivered by the grid. The analysis of emissions revealed that the proposed photovoltaic power plant avoided the production of carbon dioxide in 17,938 tons / year. It was found that currently the suggested photovoltaic power plant is not viable if only economic factors are taken into account. If the total cost installed by the factory is approximately US\$ 35 million, the energy cost of the photovoltaic power plant will be equivalent to the electric power provided by the grid with no subsidy.

Holdermann et al. (2014) investigated the economic viability of the small-scale photovoltaic system and grid-connected in the Brazilian commercial and residential sectors after the introduction of the net metering regulation in April 2012. They applied the discounted cash flow method to calculate the necessary specific investment costs so that the photovoltaic systems are economically viable in each of the 63 distribution grids in Brazil. In its calculation, they included levies and taxes, taken from telephone interviews and published information. Another parameter was the application of the program PV*Sol to conduct local simulations of the head office of the distribution company. In the current situation scenario, photovoltaic power is not financially viable in any of the distribution grids in the commercial or residential sectors. As such, being the environment for grid-connected photovoltaic power, the commercial or residential sectors take on the lowest-cost photovoltaic system and a lower discount rate to establish the viability of the photovoltaic system.

Mitscher et al. (2012) assessed the economic competitiveness of photovoltaic solar generation connected to the grid and distributed by means of small-scale roof installations in five Brazilian cities. The locations represent a whole set of two essential parameters for the economic viability of photovoltaic solar irradiation and local electricity rates. The authors showed the leveled electricity costs for the photovoltaic production and the present net values for a specific photovoltaic system. The analysis includes three different scenarios of interest rates, which correspond to different conditions for the financing of the generators: subsidized

market, mature and adjusted by the country's specific risk. In analyzing net current values, the revenue flow is determined by the sale of photovoltaic electricity at current residential rates based on the net metering. By using subsidized interest rates, the analysis found that solar photovoltaic electricity is already competitive in Brazil, while in a country-specific risk-adjusted rate, the decreasing but still high capital costs of photovoltaics make its use economically unviable. In the tax rate of the mature market, the competitiveness of photovoltaics is largely dependent on the residential tariff. The economic competitiveness in this area is provided for places with high residential rates. The study showed the high generation potential distributed by photovoltaic installations in Brazil and proved that, in some conditions, the photovoltaic system connected to the grid can be economically competitive in a developing country.

Rocha et al. (2017) believe that there is growing pressure for a change in consumption and the production of energy standards in Brazil. Within this context, grid measurement is an important mechanism that stimulates the spread of small solar voltaic systems. As a complement to the net metering, a tax exemption is currently being offered in a number of Brazilian states. The purpose of the study was to evaluate the effect of the taxation exemption on the circulation of goods and services and the returns and risks of a photovoltaic micro-generation project in four cities in different regions of Brazil: Belem, Petrolina, Uberaba, and Uruguaiana. The simulation method employed was Monte Carlo (MCS), which takes into account uncertainties regarding financial and environmental variables. The results of the stochastic analysis of the economic viability allowed concluding that the taxation exemption on the circulation of goods and services (*ICMS*) is essential to make photovoltaic microgeneration viable in Brazil. In the cities analyzed, the photovoltaic microgeneration gave the investor economic unviability when the *ICMS* is charged. By considering the *ICMS* exemption policy, the cities of Petrolina and Belém had a high probability of viability. In relation to the risk analysis, the photovoltaic microgeneration achieved the best performance in Petrolina, both in terms of collection conditions and *ICMS* exemption. There is a high potential for solar use in the whole Brazilian territory, however, in the current state of evolution and because of the production chain of the Brazilian photovoltaic industry, high costs limit the growth of this technology. The study assists policy makers in evaluating incentive programs, highlighting that the tax exemption directly addresses one of the goals for which *ICMS* was developed, which is to stimulate the evolution of productive sectors, like the photovoltaic industry.

Vale et al. (2017) note that photovoltaic solar power grid-connected in Brazil is playing an increasingly significant role as a result of advances in photovoltaic technology, together with the reduction of capital and subsidy costs. In this way, the authors conducted an economic study of two projects in the government program "*Minha Casa Minha Vida*" (*MCMV*), in Sao Paulo State and elsewhere in Piaui State, by using the generation of distributed photovoltaic energy. The *MCMV* is the Brazilian Government's housing program that gives access to home ownership for low-income Brazilians in urban and rural areas. The analysis resulted from the evaluation of the present net value and the internal return rate, considering an attractive minimum return rate and varying the annual growth of the energy rates in 25 years of operation, which is the expected lifetime of the solar panels. These two cities were selected, since their federal states have different actions in relation to tax issues. The results demonstrated that, despite the fact that Piaui had a higher average solar incidence than Sao Paulo, the effect of the tax exemption on the circulation of goods and services is an advantage for investing in São Paulo.

Pinto et al. (2016) believe that photovoltaic (PV) generation systems have been applied more and more to produce electricity from renewable sources, taking a growing interest. The PV micro-generation installations connected in grids in private homes have increased because of government policies, and the greater attention on the part of the industry. As low voltage distribution systems (Low Voltage-LV) were built to provide the power flow in a single direction, the feed-in from the PV generation in rural low voltage grids can influence power quality (PQ-Photovoltaic Quality), and the operation and reliability of the installations. The authors intended to report the results of the PQ analysis of a real PV generation installation connected to a rural low voltage grid. Voltage fluctuations and harmonic voltage contents were noted. The statistical analysis showed a negative impact on the PQ produced by this photovoltaic installation and a small fraction of the energy in the sunny day is converted, resulting in revenue losses and forcing the converter to operate in an undesirable operating mode. The authors addressed the grid disturbances and their results with regard to the technical and economic viability of the photovoltaic system, and possible solutions. A strengthening of the low voltage grid was proposed and implemented. After this change, a new assessment of PQ resulted in a better impact on PQ, which made it economically viable.

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Method AHP to Flood Risk Map Approach

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Abstract— The phenomenon of flooding is a natural event, given by the extravasation of water to the river bed. The main objective of this study was the analysis of susceptibility to flooding of the basin of Uraim River in the municipality of Paragominas Pará state based on the physical characteristics and morphometric basin. It used the Analysis method Hierarchical method for generating a order susceptibility map of the basin. The AHP technique used to determine map algebra contributed to the analysis of the susceptibility to floods and was effective because it reduces and simplifies the proposed problem, which minimizes the errors of judgment during the process.

Keywords— Mapping, Water Resources, Floodplains.

I. INTRODUCTION

The Uraim River, located in the municipality of Paragominas, northeast of the state of Pará, Brazil, is essential for the development of sanitation services in the municipality, since it facilitates the abstraction of water for public supply, as well as the release of domestic effluents treated at stations. In this way, preventive actions and care with this water body represent, besides a sustainable and conscious attitude with the environment, a fundamental act for the development of the Paragominas society, with quality of life and well-being (SANEPAR, 2014)

In view of the above, there is a need to map the areas that are most susceptible to floods, in order to prevent losses

and avoid adversities. According to MENDES & CIRILO (2001), systematized information is essential to subsidize, for example, the prediction and control of natural or man-induced processes in the basins. In order to characterize the areas vulnerable to flooding, especially in the urban area, the present work aims at the morphometric characterization to evaluate its geological susceptibility to flooding and the mapping of these areas, using the methodology Analysis Hierarchical Process (AHP) to identify levels of susceptibility to flooding to which the river basin is subject, taking into account physiographic characteristics and soil sealing, which directly influence these occurrences. The methodological tool chosen has been used in several studies of flood maps analysis, such as by LEMOS & BISPO (2015) in the mapping of vulnerability to floods in the State of Para.

II. METHODOLOGY

To prepare the diagnosis of the areas most susceptible to flooding in the river basin, a methodological flowchart was conceived, contemplating 3 stages (Figure 01). In order to obtain the degree of relevance and weights of each criterion analyzed, the methodology proposed by SAATY (1990) was used, according to the structure of the decision hierarchy, construction of the paired comparison matrix, prioritization of alternatives and definition of the classes of susceptibility.

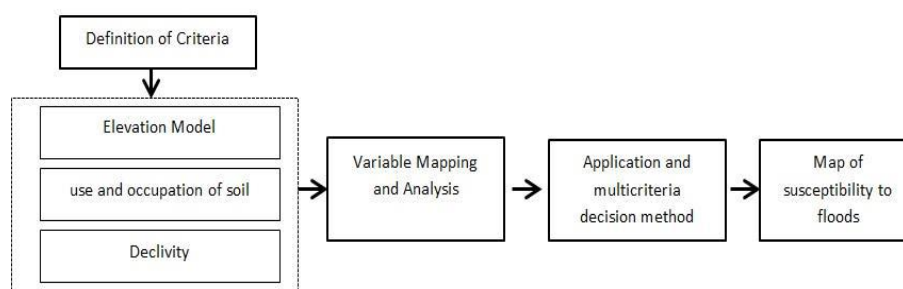


Fig. 1: Flowchart of applied methodology.

SANTOS (2010) cites that the factors determined as important and that directly influence the level of water reached by a flood, regardless of the precipitation incident are.

2.1. Mapping and analysis of variables

The methodology used to map the variables that contribute to the occurrence of floods, as well as their division into classes. Therefore, thematic maps were prepared for the proposed variables based on the methodologies described below. Also, weights were assigned for each class of selected variables on a scale of 1 to 10, where 10 is the value with the greatest influence on floods and 1, the lowest value.ude, slope, land use.

2.2. Application of the multicriteria decision method

The flood susceptibility map will be the product of the spatial crossover of the three variables represented in the above methodology and will involve two distinct phases of work, the theoretical phase, in which the criteria for crossing will be defined, and the operational phase, where the crossing will be carried out of the thematic maps from the ArcGIS map algebra tool.

To set the relative importance of the criteria with regard to susceptibility to flooding, there was the comparison of criteria, using a value of 1 is equivalent to the minimum and maximum 9 importance of one factor over another. SANTOS (2010) mentions that the phase of allocation of values, based on the comparator scale, is considered one of the most important moments during the process of preparation of flood maps, since the importance of values of a interfered factor directly in income obtained. After the judgment of the elements, we have the comparison matrix table 1.

Table.1: Matched comparison matrix.

Criteria	Elevation	Declivity	Use and Occupation
Declivity	4	1	3
Use and Occupation	2	1/3	1
Elevation	1	1/4	1/2

The matrix is interpreted in such a way as to take the example of the comparison of the slope variable with land use and occupation. These comparisons in pairs provide weights for each alternative, within each criterion, after reciprocal comparisons. These weights are obtained by calculating the main vector auto of each square matrix, and are represented in Table 2. As for the order of importance of the variables, the slope was obtained first (56%), followed by Elevation (26 %), land use and occupation (18%).

Table.2: Weights for mapping the susceptibility map.

Variables	class weight	Variables
Elevation	0,26	X1
Declivity	0,56	X2
Use and Occupation	0,18	X3

With the choices of the weights of the criteria for drawing up the susceptibility to flooding map the AHP provides a ratio of consistency, which must be less than 0.10 (PROCHMANN, 2014). The consistency ratio obtained was 0.07, attesting to the consistency in the hierarchy of the Operational phase.

2.3. Operational phase

After the definition of the weights, maps were algebra for the generation of the map of susceptibility to floods through the process presented in Figure 14. To do so, we used the Raster Calculator tool of ArcGIS software.

The first step consists in capturing the values of the cells contained in the raster file referring to the classes of thematic maps. In the second step, these values are processed algebraically based on the equation below, where x1, x2 and x3 will be the previously obtained statistical weights.

$$SI = x1 \text{ Use occupation} + x2 \text{ Declivity} + x3 \text{ Elevation}$$

Where: SI is the Susceptibility to floods.

Finally, in the third step the value is stored in a new raster file, which will give rise to the map of susceptibility to floods. The new cells contain values ranging from 0 to 10, where the values closest to 0 are related to areas with less susceptibility to flooding and the values closer to 10, with greater susceptibility to flooding. At the end of the execution of this routine, the map will be reclassified into five hierarchical categories, such as high elevation area, low susceptibility, medium susceptibility, high susceptibility and no susceptibility to flooding, as shown in Table 3.

Table.3: Reordering of susceptibility classes.

Values	Class
0 a 2	Too Low
2 a 4	Low
4 a 6	Avarage
6 a 8	High
8 a 10	Very high

III. CONCLUSION

By analyzing the obtained data, the study area presents for the most part (82%) between low and no susceptibility to floods. Areas with medium flood susceptibility cover 10% of the area, while areas with high susceptibility correspond to 8%.

According to the map of susceptibility to floods, the areas with greater susceptibility are more extensive in the areas with accentuated differences. The very high susceptibility class has a predominance of altitude varying from 0 to 50 meters (99%), and areas with low population density and with soil waterproofed by roads, sidewalks and alteration of ciliary vegetation are more susceptible to flooding.

The declivity was a determining factor for the separation of the high and medium susceptibility classes, where different relief types predominate and the other classes remain regular.

The average susceptibility was found predominantly in areas of agriculture and pasture where soil use influences the surface runoff and can alter the topography from the mechanization of soils, more in places with higher slopes the susceptibility is greater

The low susceptibility was found in areas predominantly of forests and successions where the soil is structured and the forest dorseil protects the soil avoiding erosion and reducing the impact of direct raindrops on the soil.

Based on the geolocation analysis and historical information of the city of Paragominas, it was verified that the neighborhoods most susceptible to flooding are the neighborhoods of Promissão, Uraim, Cidelândia, Angelim and Cidade Nova, in these neighborhoods are at lower levels what with high rainfall water and very intense and allied to the waterproofing of the soils can generate floods and disturbances to the residents.

The AHP technique used to determine the weights of classes contributing to the susceptibility to flooding was effective because it reduces and simplifies the proposed problem, which minimizes errors of judgment during the process.

The methodology applied in this research is usually used in mapping with a lower level of detail, and thus, the research carried out demonstrates the need to improve techniques and methodological proposals for the elaboration of flood susceptibility maps from the inclusion of variables not used here rainfall, river flow and soil classes, which can improve the estimates of areas susceptible to flooding.

The use of the soil in the basin is very diversified, showing that Paragominas continues being a great producer of grains and meat, it can be perceived that with the progress of the inspections the Permanent Preservation areas in rural areas are recovering or they are showy. The urban area needs recomposition of the PPAs and environmental education so that the water bodies are not compromised thus avoiding future floods.

For future work, it is also recommended to collect primary data such as drainage systems, sewage and rainfall in the region of flooded areas in occurrences so as to correlate with the areas most susceptible to the floods raised in the mapping.

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Validation of TerraClass mapping for the Municipality of Paragominas state of Pará

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Abstract - This work aims to evaluate the TerraClass mapping for the year 2014, in the municipality of Paragominas, State of Pará. The validation was made by comparing the mapping with the observations found in the field. Images of the Satellite Landsat-8, OLI sensor of the year 2014, path/row 222/062, 222/063, 223/062 and 223/063 were used to aid in the field. Using this data it was possible to analyze the main representative classes in the area, including agriculture, urban area, forest, clean pasture, dirty pasture, reforestation, regeneration with pasture and secondary vegetation. The secondary vegetation presented 2,198.16 km², clean pasture with 3,332.29 km², agriculture with 896.75 km² and the forest occupying 54.21% of the total area of Paragominas. The overall concordance index was 86%, corroborating the reliability of the mapping performed. The average error was 6% and the total value of discordance was of 14%. Concerning the secondary vegetation, pasture, agriculture, urban area and forest classes, they presented concordance higher to 50%, while regeneration with pasture and reforestation presented greater intensity of omission with 40,57% and 76,31% respectively. Inclusion errors were less than 40% for the secondary vegetation, pasture regeneration, clean pasture and dirty pasture classes. The field work was essential to validate and analyze the accuracy of the 2014 TerraClass Project for the studied region, which becomes important for the understanding of the dynamics of land use.

Keywords – *image processing, land use, remote sensing, validation*

I. INTRODUCTION

The spatial occupation and the consequent landscape modification have been occurring for decades, together with conflicts of interest in various scales. The economic development and the expansion of land activities have been pointed as one of the main actors in the amazon's deforestation (Fearnside, 2006). However, it is important to point out that the deforestation does not occur as a specific event, but more likely as a process. It means that it is not homogeneous in space and time once it involves different actors and many productive activities as livestock, logging, mining and small and large agriculture. Of course, the deforestation is mostly detected in the states of Brazil found in the "deforestation arch" an area situated in the east and south of the Brazilian Legal Amazon (BLA) (Becker, 2005).

The remote sensing is an indispensable tool in landscape or territory scale analysis, once it allows the understanding of the degradation processes of a determined region (Ferreira et al., 2012). It is used for monitoring land use and cover, therefore, it plays a crucial role in extracting information from the least accessible areas and supporting territory management, due to the subsidies that this type of mapping can offer, especially in what concern to actions that seek the establishment of sustainable practices and the implementation of biodiversity conservation policies (Abreu & Coutinho, 2014).

The advancement of geotechnologies and remote sensing techniques have strongly contributed to society with the identification and monitoring of the deforestation

(Macedo et al., 2013). State that this set of computational techniques has been strongly cooperating for a construction of knowledge about spatial and socioeconomic patterns. In addition, there are benefits from remote sensing application in studies based on the integration of field data with land use dynamics and vegetation cover (Almeida & Vieira, 2008).

Studies such as the one realized by Almeida et al. (2016) show that with the use of remote sensing, it is possible to understand the spatial patterns of land use and cover and it contributes to the studies of biodiversity, environmental modeling and climate change, essential for the creation and monitoring of land use policies. Forest formations are monitored by remote sensors in a time-scale that ranges from almost daily to annual (Diniz et al., 2015).

The conversion of natural landscapes to anthropic use or modification of management practices is known as land-use change (Foley et al., 2005). Which includes selective cutting, commercial planting of trees such as eucalyptus and paricá, conversion of forest to pastures, agricultural production areas, cut-crop agriculture and urbanization (Gardner et al., 2009). Which has expanded in the last decades, resulting in a fragmented landscape with different types of forest cover (Laurance et al., 2014).

The TerraClass Project, executed by the National Institute of Space Research (INPE), in a partnership between the Amazon Regional Center, Embrapa Oriental Amazon and Embrapa Livestock and Agriculture Informatics has as main objective qualifying the deforestation of the Legal Amazon, based on the deforestation areas mapped and published by PRODES Project and satellite images (Inpe, 2016), playing an important role in determining which land uses are replacing the Amazon forest (Almeida et al., 2016). In addition, this project is motivated by the concern of the scientific world and society in general with the threats to the greater biodiversity area of the planet, considering the role of Amazon forest in the context of global climate change (Inpe, 2016).

The interest in monitoring forest resources has been increasing by the past decades and so the demand for mapping plant cover at regional and global scales (Shimabukuro, 2000). Thus, validating orbital remote sensing data through the verification of truth land points (Congalton e Green, 1999), has become difficult and sometimes impractical in some parts of the (Hess et al., 2002).

The Pará State has the largest deforested area of the BLA, with 262.088 km², equivalent to 33.72% of the Amazon's total deforested area until 2016 (Inpe, 2017). This scenario is due to the installation of agromineral project in its territory, as the "Grande Carajás" Project for

iron ore exploitation, the implementation of transport and energy infrastructures and the advancement of the agricultural frontier (Kohlhepp, 2002).

The accuracy assessment of the land use and cover maps has been well studied by researchers in remote sensing, however, the field measurements of large territorial mappings present obstacles because of the difficulty of access, operational and logistic costs, as well as the high planning and execution demanding time (Adami et al., 2012).

According to Almeida et al. (2016), the first TerraClass mapping had a global accuracy of 76%, when tested to the states of Pará and Mato Grosso, attending the accuracy's need of the mapping and allowing statistic inferences (McRoberts, 2011).

In this sense, this paper has the objective of assessing the TerraClass mapping for the year of 2014, in a local scale, which will be applied to the municipality of Paragominas, in the state of Pará.

II. WORK METHODOLOGY

The study was realized in the municipality of Paragominas, situated at the margins of the Belém-Brasília Highway (BR-010), with connections with the PA-125 e PA-256 state highways. The population is estimated in 97.819 inhabitants, distributed in an area of 19.342.254 km² (IBGE, 2010). The municipality is part of the southeast region of Pará State and the Paragominas micro region. It presents limits with the municipalities of Ipixuna do Pará e Ulianópolis and its municipal seat is limited by the following geographic coordinates: 03°00'00" S e 47°21'30" W (Fig.1).

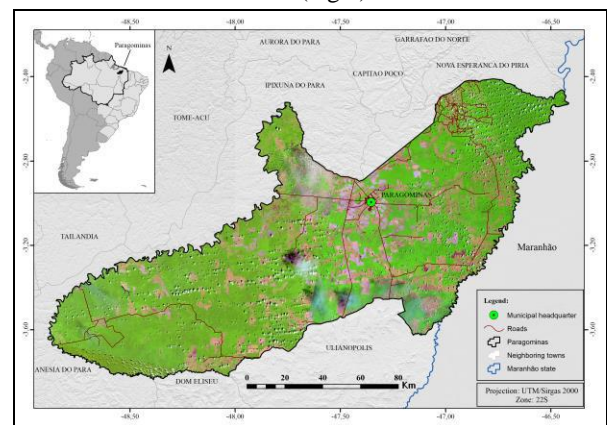


Fig.1: Study Area Location Map

The utilized images are from the Landsat-8 OLI (Operational Land Imager) satellite, which are available free of charge from the USGS (United States Geological Survey), with spatial resolution of 30 m. The images were from 2014, of the points 223 and 222 and orbits 62 and 63, dated from June, October and November.

The images were selected based on the lower presence of clouds and then submitted to geo referencing

and contrast enhancement treatment. At last, it was realized the procedures of equalization, to obtain better identification, and grouping of the land use and cover features (Fig. 2).

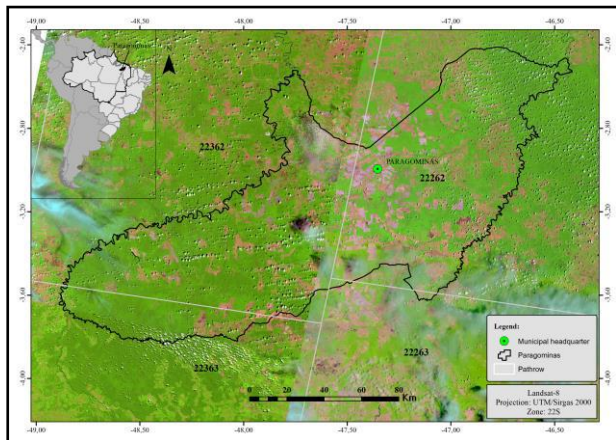


Fig.2: Path/row of the 2014's Landsat-8 images

The municipality of Paragominas was chosen due to the fieldwork that was executed in 2014, through Sustainable Landscapes Project, which involved a land route and an overflight to register images of georeferenced points, generating pictures that based the mapping validation.

The validation of the land use and coverage map for the year 2014 was based on field data, collected with GPS navigation device for land and air. In total, 321 points were collected in the field, which were used to calculate global accuracy (Fig. 3).

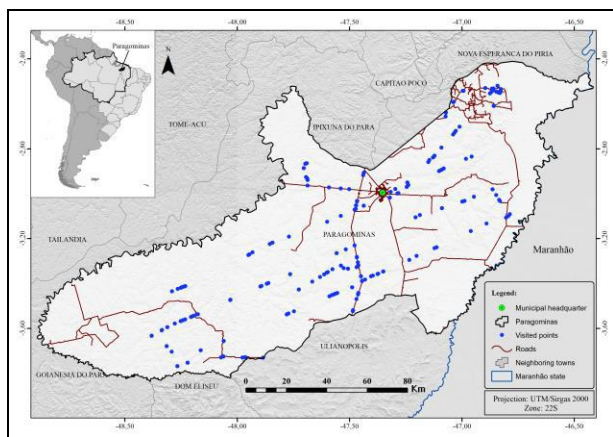


Fig.3: Fieldwork visited points in the municipality of Paragominas, PA

The accuracy assessment is an important process in the remote sensing data analysis because it results in statistic inferences to the reliability of the generated data (McRoberts, 2011).

The overall accuracy is one of the simplest measures, calculated by the total sum of correctly classified pixels divided by the total number of pixels in the confusion matrix. In addition, individual category

accuracy is calculated through the accuracy of the producer, indicating the likelihood of a reference pixel be correctly classified, and the user's accuracy, which computes the probability of a mapped pixel be compatible with the field class (Congalton, 1991).

To calculate the Global Accuracy or Global Precision (GA), User Accuracy (UA) and Producer Accuracy (PA), the georeferenced pictures taken in the fieldwork were analyzed together with the TerraClass 2014's mapping for the study area. For the calculation of accuracy, a contingency table was built (Pontius & SantaCruz, 2014) (Table 1).

Table.1: Example of a contingency table containing the functions for calculating the GA, UA e PA.

		Reference Classes			Total	Producer's Accuracy
		Class ₁	Class ₂	Class _c		
Mapping Classes	Class ₁	P ₁₁	P ₁₂	P _{1c}	P ₁₊	PA ₁ =P ₁₁ /P ₁₊
	Class ₂	P ₂₁	P ₂₂	P _{2c}		
	Class _c	P _{c1}	P _{c2}	P _{cc}		
	Total	P ₊₁	P ₊₂	P _{+c}		
User's Accuracy		UA ₁ =P ₁₁ /P ₊₁	UA ₂ =P ₂₂ /P ₊₂	UA _c =P _{cc} /P _{+c}	GA = $\sum \frac{n_{ij}}{n}$	

The values allocated on the main diagonal of Table 1 represent the correctly classified elements, whereas the elements outside the main diagonal represent errors of omission and inclusion (Stehman and Foody 2009).

III. RESULTS AND DISCUSSIONS

The technique of visual interpretation of the spectral targets of a given satellite image is part of data generated through Remote Sensing. In this sense, the acquisition of points of terrestrial truth has become an important tool for validating the data generated by interpreters through orbital images (Espírito-Santo, 2005).

The TerraClass Project maps the following thematic classes: Annual agriculture, Mosaic occupations, Clean pasture, Dirty grass, Regeneration with pasture, Pasture with exposed soil, Secondary vegetation, Reforestation, Urban area, Others, Mining and Area not observed (Adami et al., 2015). With the exception of the annual Agriculture class, all other classes are mapped through photointerpretation. The annual Agriculture class is mapped from an automatic method based on the spectral-temporal behavior of the Normalized Difference Vegetation Index (NDVI), obtained by the MODIS sensor (Roerink et al., 2000).

The validation for the municipality of Paragominas was carried out with the following thematic classes of mapping of the TerraClass Project, year of 2014: agriculture, urban area, forest, clean pasture, dirty pasture, reforestation, pasture regeneration and secondary vegetation. representative in the municipality.

Based on the TerraClass 2014 mapping, the forest occupies 54.21% of the municipality, with 10,483.37 km². The secondary vegetation presented 2,198.16 km², the clean pasture with 3,332.39 km², the annual agriculture with 896.75 km² (Fig. 4).

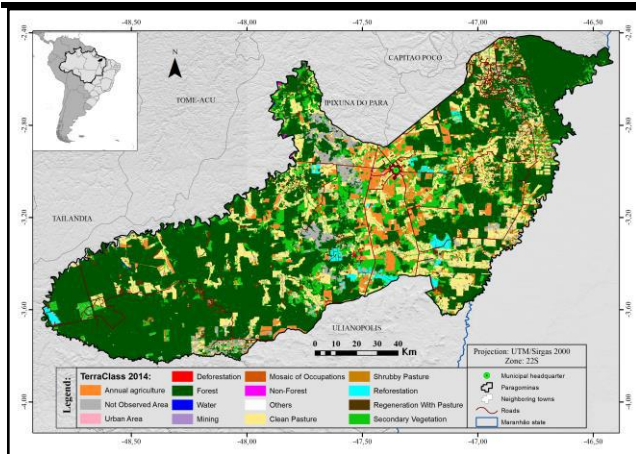


Fig. 4: Use and land cover map year 2014 of the municipality of Paragominas, PA.

In all, these three classes correspond to approximately 85% of the area of the municipality. Another interesting factor to be observed is that the predominance of forest is inversely associated with the distance of the roads that cut the municipality.

From the satellite image and photographs, it was possible to represent some validation points that can also be used for training in photointerpretation.

In point 1 it was possible to observe and validate in the field the class of urban area, with characteristics of streets, squares, houses positioned in a very closely and with regular spatial distribution (Fig. 5).

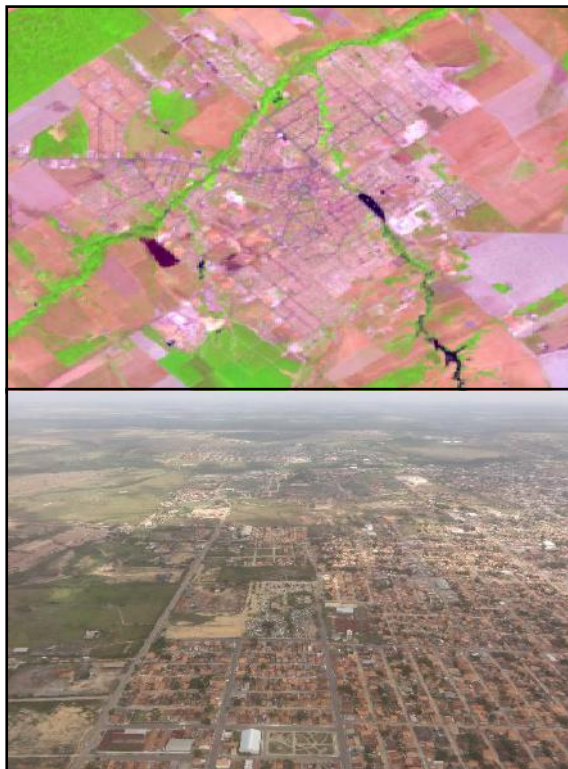


Fig. 5: Class of Urban area.

In section 2 the validation was verified by the observation in the field of the annual agriculture class

represented with soybean planting, in the magenta color, smooth texture and regular polygons characterize the feature (Fig. 6).

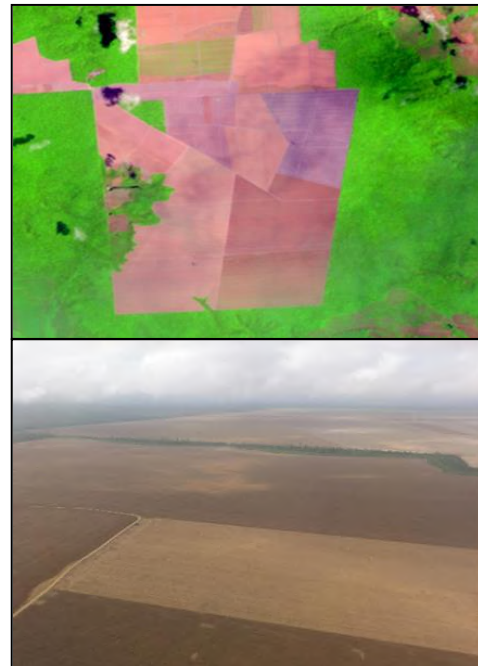


Fig. 6: Class of Annual agriculture.

It was observed in section 3 the class clean pasture validated in the field according to the representation of well managed pasture area, with low infestation of herbaceous and shrubby weeds (Fig. 7).

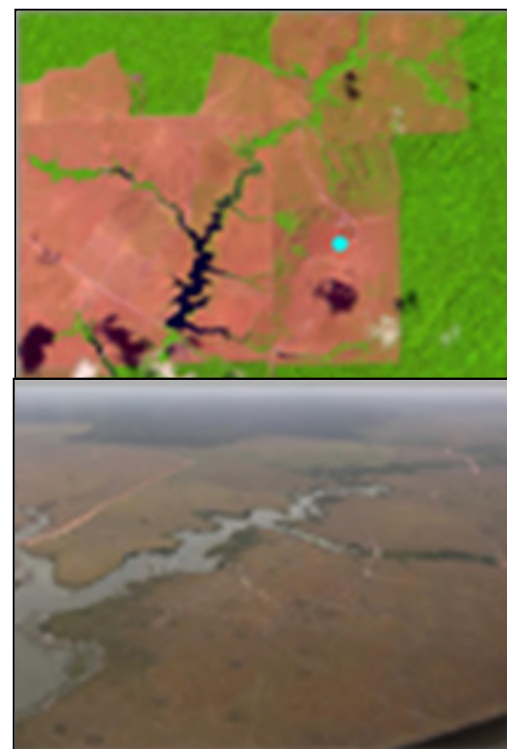


Fig. 7: Pasture clean class

For point 4, the regenerative pasture class was confirmed with the field truth by the presence of invasive species at various levels of development (Fig. 8).

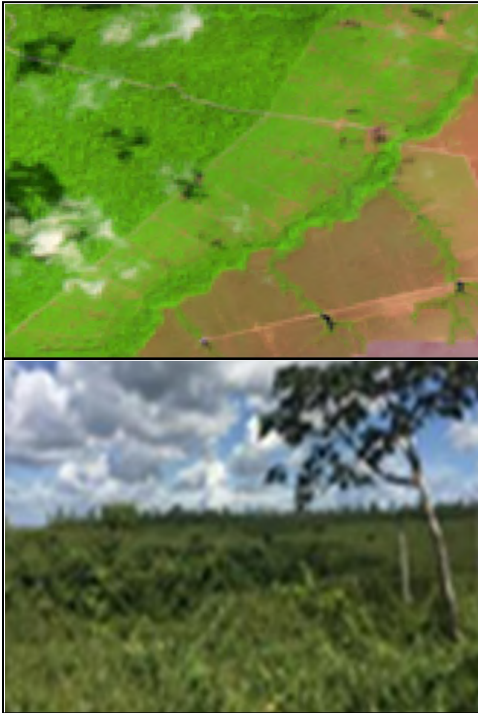


Fig. 8: Regeneration pasture class.

For point 5 the validation of the Reforestation class, represented by areas with regular polygons, division of plots and homogeneous texture (Fig. 9).

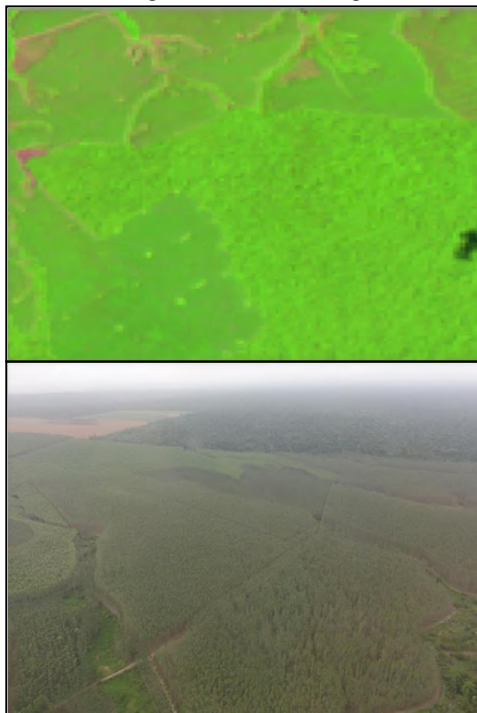


Fig. 9: Reforestation class.

At point 6 the field truth was verified by the Forest class represented by the forest management reserve

area, in the satellite image with rough texture and dark green color characteristics (Fig. 10).

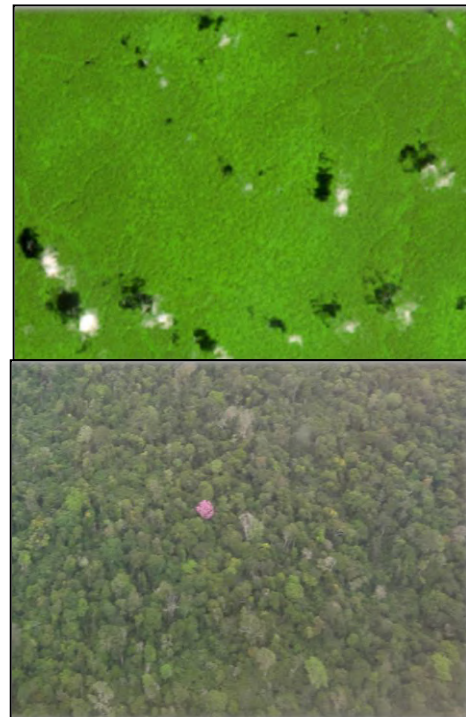


Fig. 10: Forest class.

Point 7 represents the dirty pasture class with presence of many herbaceous and some shrub species (Fig. 11).

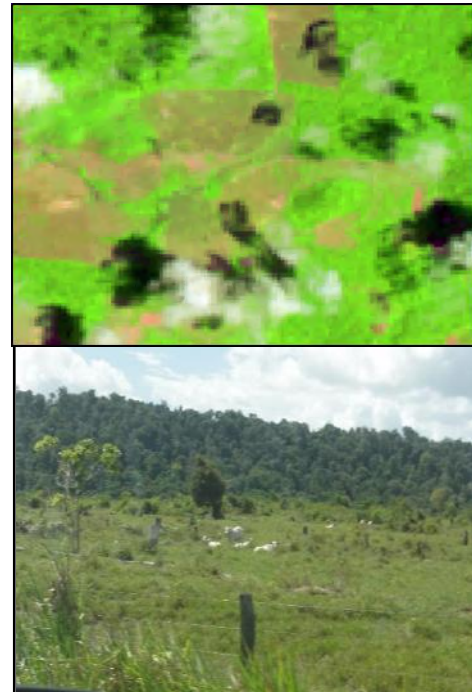


Fig.11: Shrubby pasture class.

For the representation of point 8 the secondary vegetation class was validated proving the aspect of natural regeneration of native shrub and tree vegetation (Fig. 12).

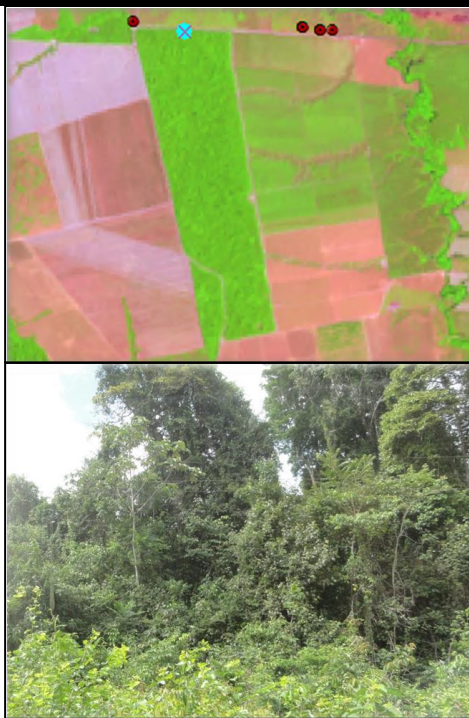


Fig. 12: Secondary vegetation class.

The classification accuracy is expressed using the error matrix also called the confusion or contingency matrix, derived from the classification and reference data set as the starting point of the precision measurements (Story and Congalton, 1986), which shows the cross

tabulation of the mapped land use and cover versus the actual one assessed in the field (Foody, 2002). The contingency matrix lists land use and cover reference values in the columns and the classified data in the rows, being the main diagonal of the matrix the correctly classified data (Banko, 1998).

Based on the contingency matrix, global accuracies, omission and inclusion errors per class and indices of disagreement (displacement, quantity and change) were calculated (Pontius and Santa Cruz, 2014). Studies performed in Cerrado areas show high reliability with a general agreement index of 80.2% (Maurano and Adami, 2017).

The validation process is a necessary step in a research that aims to analyze in a statistical way the accuracy of the classified images. Thus, table 2 shows the results of the contingency matrix of the classification for the municipality of Paragominas.

Table.2: Comparative Results between mapped data and field data

TerraClass mapping class	Agriculture	Urban area	Forest	Clean pasture	Shrubby pasture	Reforestation	Regeneration with pasture	Secondary vegetation	Total
Agriculture	50			1		3			54
Urban area		7							7
Forest			110	3			1	3	117
Clean pasture	9			49	2	12	3		75
Shrubby pasture				1	7	1	2	1	12
Reforestation						7			7
Regeneration with pasture							7	6	13
Secondary vegetation			4	3		4		25	36
Total	59	7	114	57	9	27	13	35	321

The general agreement index between mapping and the validation was 86%, demonstrating high reliability of the mapping performed by TerraClass, based on the result of the contingency matrix.

According to Pontius & Santa Cruz (2014), the mean values of agreement and disagreement are divided

into quantity, displacement, and change. The quantity errors refer to the absolute difference between omission and inclusion errors, presenting an indicative of the mean error of the mapped area. The displacement refers to the unpaired allocation difference between the analyzed classes in the contingency matrix and, at last, the change

refers to the error caused by paired exchanges between classes in the contingency matrix (Foody, 2009).

Thus, the mean error presented for the area was 6%, displacement of 7% and the change of 1%. When these disagreements are summed, a total error of 14% is obtained, which is considered low due to the complexity of the mapped classes and size of the study area (Fig. 13).

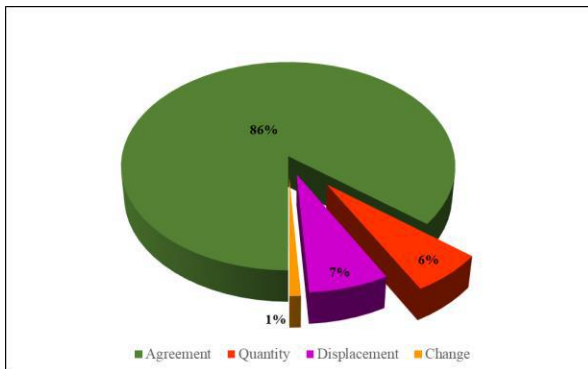


Fig. 13: Global Accuracy Results for the TerraClass 2014 in the municipality of Paragominas

When analyzing the results by thematic class, it was observed that the classes of secondary vegetation, clean pasture, agriculture, urban area and forest presented agreement superior to 50%. The classes that presented the greatest intensity of omission were grass regeneration and reforestation, with 40.57% and 76.31%, respectively. Regarding the inclusion, secondary vegetation, regeneration with pasture, clean pasture and shrubby pasture presented errors in the order of 24.39%, 27.43%, 29.87% and 35.44% respectively (Fig. 14).

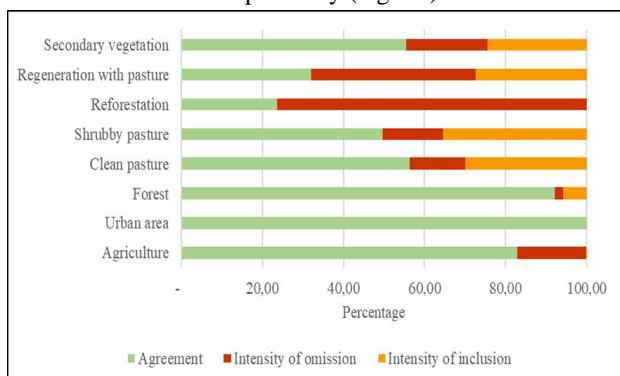


Fig. 14: Global Accuracy Results of the TerraClass mapping for the municipality of Paragominas per class

Possibly, the errors in the regeneration class with pasture are associated with the very characteristic of this class, which corresponds to a transition process from pasture to secondary vegetation or vice versa. In what concerns to the confusion between reforestation and pasture classes, it may be associated with the beginning of reforestation planting, when there is great soil and grassland exposure, making it possible to confuse with pasture classes.

IV. CONCLUSION

The presentation of the contingency matrix is fundamental, since it is possible to visualize the confusions that occurred between classes.

The global accuracy may be sufficient, depending on the purpose of the map. However, if there are specific classes of interest or more than others, individual classes' accuracy may be relevant.

The global accuracy of the TerraClass mapping for the municipality of Paragominas was 86%. Therefore, future research on this project should consider improvements for the mapping of regeneration with pasture and reforestation classes.

The validation, as part of the mapping process, estimates the data accuracy of the land cover use dynamics, giving support to the information consolidation.

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