

ISSN: 2349-6495(P) | 2456-1908 (O)



# International Journal of Advanced Engineering Research and Science

(IJAERS)

An Open Access Peer Reviewed International Journal



Journal DOI: 10.22161/ijaers

Issue DOI: 10.22161/ijaers.5.6

**AI PUBLICATIONS**

**Vol.- 5 | Issue - 6 | Jun, 2018**

editor@ijaers.com | <http://www.ijaers.com/>

# FOREWORD

I am pleased to put into the hands of readers Volume-5; Issue-6: 2018 (June, 2018) of “**International Journal of Advanced Engineering Research and Science (IJAERS)** (ISSN: 2349-6495(P) | 2456-1908(O)”, an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to Science, Technology, Management and Humanities. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release print issue also, but this decision the journal issue will be available in various library also in print and online version. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind. This journal has DOI (Digital Object Identifier) also, this will improve citation of research papers. Now journal has also been indexed in **Qualis (Interdisciplinary Area) (Brazilian system for the evaluation of periodicals, maintained by CAPES)**.

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

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

With warm regards.

**Dr. Swapnesh Taterh**

Editor-in-Chief

Date: June, 2018

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## Vol-5, Issue-6, June 2018

Sr No.	Detail with DOI
1	<p><u><a href="#">Distance Analysis of Multimodal Transportation Based on Traveling Salesman Problem with Particle Swarm Optimization Method</a></u>  <b>Author:</b> Omer Faruk Cansiz, Samed Göçmen   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.1">10.22161/ijaers.5.6.1</a></p> <p style="text-align: right;"><b>Page No:</b> 001-006</p>
2	<p><u><a href="#">Analysis of induced drag and vortex at the wing tip of a Blended Wing Body aircraft</a></u>  <b>Author:</b> Pedro Paulo Santos Rodrigues da Cunha, Pedro Mariani Souza, Letícia Campos Valente, Gabriel Maertens Vaz de Mello, Pedro Américo Almeida Magalhães Junior   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.2">10.22161/ijaers.5.6.2</a></p> <p style="text-align: right;"><b>Page No:</b> 007-009</p>
3	<p><u><a href="#">Polyethyleneglycol nanoparticles adsorbed to glycine as a bioengineered neomaterial for application in inflammatory processes</a></u>  <b>Author:</b> Paulo Celso Leventi Guimarães, Eduardo Luzia França, Adenilda Cristina Honório rança, Ricardo Bentes de Azevedo, Paulo Cesar Morais, Sebastião William da Silva   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.3">10.22161/ijaers.5.6.3</a></p> <p style="text-align: right;"><b>Page No:</b> 010-016</p>
4	<p><u><a href="#">Feasibility and Environmental Sustainability of a 103.5 kWp floating Photovoltaic Electrical System with a Case Study in a Hydroelectric Power Plant, Santa Clara Hpp, Located in the South of Brazil Region</a></u>  <b>Author:</b> Kleber Franke Portella, Rodrigo Paludo, Gelson Luiz Carneiro, Júlio Werner Yoshioka Bernardo, Marianne Schaefer França Sieciechowicz, Mariana D'Orey Gaivão Portella Bragança, Nicole Machuca Brassac de Arruda, Emerson Luiz Alberti, Augustus Caesar Fr   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.4">10.22161/ijaers.5.6.4</a></p> <p style="text-align: right;"><b>Page No:</b> 017-027</p>
5	<p><u><a href="#">Monitoring of water Quality in the São João River Hydrographic Basin in the Municipality of Porto Nacional - Tocantins</a></u>  <b>Author:</b> Rilben Ribeiro Sepúlveda Pereira Moraes, Angelo Ricardo Balduino, Diogo Pedreira Lima, Polyana Lopes da Silva   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.5">10.22161/ijaers.5.6.5</a></p> <p style="text-align: right;"><b>Page No:</b> 028-032</p>
6	<p><u><a href="#">Proposal of the use sodium silicate as a corrosion inhibitor in hydrostatic testing of petroleum tanks using seawater</a></u>  <b>Author:</b> Fernando B. Mainier, Anne Aparecida Mendes Figueiredo, André Armando M. de Alencar Junior, Brígida Bastos de Almeida   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.6">10.22161/ijaers.5.6.6</a></p> <p style="text-align: right;"><b>Page No:</b> 033-038</p>
7	<p><u><a href="#">Feasibility Analysis of the Solar Energy System in Civil Construction</a></u>  <b>Author:</b> Allef Facundes Cerqueira, Angelo Ricardo Balduino, Diogo Pedreira Lima   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.7">10.22161/ijaers.5.6.7</a></p> <p style="text-align: right;"><b>Page No:</b> 039-044</p>

8	<a href="#"><u>Evaluation of Groundwater Prospect in a Clay Dominated Environment of Central Kwara State, Southwestern Nigeria</u></a> <b>Author:</b> Bawallah M.A., Adebayo A, Ilugbo S.O., Olufemi B., Alagbe O.A., Olasunkanmi K.N  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.8">10.22161/ijaers.5.6.8</a>	<b>Page No:</b> 045-056
9	<a href="#"><u>Characterization of the Use and Occupation of Soil on Rural Properties Using Remotely Piloted Aircraft Systems - RPAS</u></a> <b>Author:</b> Ivan Carlos Bertoldo, Francisco Nogara Neto, Gean Lopes da Luz, Sideney Becker Onofre  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.9">10.22161/ijaers.5.6.9</a>	<b>Page No:</b> 057-063
10	<a href="#"><u>Developing Multi Linear Regression Models for Estimation of Marshall Stability</u></a> <b>Author:</b> Omer Faruk Cansiz, Dilay Duran Askar  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.10">10.22161/ijaers.5.6.10</a>	<b>Page No:</b> 064-067
11	<a href="#"><u>An analysis of rainfall based on entropy theory</u></a> <b>Author:</b> Vicente de Paulo Rodrigues da Silva, Adelgicio Farias Belo Filho, Enio Pereira de Souza, Célia Campos Braga, Romildo Morant de Holanda, Rafaela Silveira Rodrigues Almeida, Armando César Rodrigue s Braga  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.11">10.22161/ijaers.5.6.11</a>	<b>Page No:</b> 068-075
12	<a href="#"><u>Photocatalyical and Thermal Properties Consideration of nanocomposites preparation of La2Ti2O7-Zeolite-MCM-41</u></a> <b>Author:</b> Nasim Mahdian  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.12">10.22161/ijaers.5.6.12</a>	<b>Page No:</b> 076-083
13	<a href="#"><u>Removal of vegetation in the state of Mato Grosso: a perspective based on the actions of IBAMA between 1998 and 2016</u></a> <b>Author:</b> R. Miranda, M. Avila, L. Vieira, R. Ribeiro, T. Jacobson, L. G. Oliveira  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.13">10.22161/ijaers.5.6.13</a>	<b>Page No:</b> 084-090
14	<a href="#"><u>Evaluation of the Stiffness Effect of Pipe Supports in Relation to Static and Dynamic Loads in a Flexibility Analysis</u></a> <b>Author:</b> Pedro Américo Almeida Magalhães Junior, Tiago Martins Portela  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.14">10.22161/ijaers.5.6.14</a>	<b>Page No:</b> 091-094
15	<a href="#"><u>Experimental Design and Optimization of Conical Horn of Ultrasonic Amplitude</u></a> <b>Author:</b> Djo Bakadiasa Kabongo, YA Gang  DOI: <a href="https://doi.org/10.22161/ijaers.5.6.15">10.22161/ijaers.5.6.15</a>	<b>Page No:</b> 095-099
16	<a href="#"><u>Measurement of a superficial texture by applying the alpha parameter on the profile P, for measuring a manual transmission gear</u></a> <b>Author:</b> Saraiva Q. M., Magalhães Junior P.A.A.	

	<p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.16">10.22161/ijaers.5.6.16</a></p> <p style="text-align: right;"><b>Page No:</b> 100-103</p>
17	<p><b><u><a href="#">Epidemiological Profile of Precocious Neonatal Mortality in the Period 2008 to 2015 in Porto Velho, Rondonia, Brazil</a></u></b></p> <p><b>Author:</b> Marcuce Antonio Miranda Dos Santos, Dorisvalder Dias Nunes, Maria Ines Ferreira de Miranda, Luiz Carlos Cavalcanti de Albuquerque, Leonardo Severo da Luz Neto, Bianca Cristina Martins Nunes, Marta Gabriela Barbosa Sobreira Luz</p> <p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.17">10.22161/ijaers.5.6.17</a></p> <p style="text-align: right;"><b>Page No:</b> 104-110</p>
18	<p><b><u><a href="#">Simulation Mechanism with 2 Degrees of Freedom</a></u></b></p> <p><b>Author:</b> Túlio Pinheiro Duarte, Weslei Patrick Teodósio Sousa, Bruno Rodrigues Castro, Tarcísio Flávio Umbelino Rego, Fernanda Silva Machado, Pedro Américo Almeida Magalhães Junior</p> <p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.18">10.22161/ijaers.5.6.18</a></p> <p style="text-align: right;"><b>Page No:</b> 111-116</p>
19	<p><b><u><a href="#">Productiveness Evaluation of a Machine Tool Manual Setup Compared with Automated CNC Machine</a></u></b></p> <p><b>Author:</b> Santos Diego Barbosa Pratis, Magalhães Junior Pedro Américo Almeida, Martins Paulo Sérgio, Miranda Brendo Felipe da Silva, Pereira Gustavo Amaral, Batista Josiel Augusto Vieira</p> <p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.19">10.22161/ijaers.5.6.19</a></p> <p style="text-align: right;"><b>Page No:</b> 117-119</p>
20	<p><b><u><a href="#">Analysis of Elastic Recovery in The Process of Bending Sheets of Duplex Steel SAF 2205 via Experimental Method and Numerical Simulation</a></u></b></p> <p><b>Author:</b> Aderci de Freitas Filho<sup>125</sup>, Valmir Sales, Pedro Américo Almeida Magalhães Júnior, Carlos Trivellato de Carvalho Filho, Alysson Lucas Vieira</p> <p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.20">10.22161/ijaers.5.6.20</a></p> <p style="text-align: right;"><b>Page No:</b> 120-125</p>
21	<p><b><u><a href="#">Conjectures of Mathematical Logic and Educational Games for Basic Education Based on the Guidelines of NCP, NCG and NBC</a></u></b></p> <p><b>Author:</b> Antônio Lemos Régis, Raimundo Josedi Ramos Veloso, Fabrício Moraes de Almeida</p> <p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.21">10.22161/ijaers.5.6.21</a></p> <p style="text-align: right;"><b>Page No:</b> 126-130</p>
22	<p><b><u><a href="#">Practical Based Learning (PBL) for Academic, Technological and Scientific Education in Engineering Courses - Case Study</a></u></b></p> <p><b>Author:</b> João Fernando Zamberlan, Gil Eduardo Guimarães, Gustavo Corbellini Masutti, Rodrigo Fernando dos Santos Salazar</p> <p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.22">10.22161/ijaers.5.6.22</a></p> <p style="text-align: right;"><b>Page No:</b> 131-134</p>
23	<p><b><u><a href="#">Design and Development of a Magnus Hydrokinetic Rotor</a></u></b></p> <p><b>Author:</b> Rodrigo Paludo, Rodrigo C. Quadros, Gelson L. Carneiro, Paulo C. Moro, Tiago Francesconi, Paulo C. Pereira, Ricardo L. da Luz, Eduard N. Stutz, Carlo G. Filippin</p> <p><b>crossref</b> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.23">10.22161/ijaers.5.6.23</a></p> <p style="text-align: right;"><b>Page No:</b> 135-145</p>
24	<p><b><u><a href="#">Perspective of Environmental Services and Management in the Amazon Region, Pará-Brazil</a></u></b></p>

	<p><b>Author:</b> Marcelo Augusto Machado Vasconcelos, Paulo Celso Santiago Bittencourt, Cassiano Moraes Guerreiro, Paulo Alves DeMelo, Francivaldo AlvesNunes</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.24">10.22161/ijaers.5.6.24</a></p> <p style="text-align: right;"><b>Page No:</b> 143-147</p>
25	<p><b><u>Power Flow Calculations by Deterministic Methods and Artificial Intelligence Method</u></b></p> <p><b>Author:</b> Meriem Fikri, Touria Haidi, Bouchra Cheddadi, Omar Sabri, Meriem Majdoub, Abdelaziz Belfqih</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.25">10.22161/ijaers.5.6.25</a></p> <p style="text-align: right;"><b>Page No:</b> 148-152</p>
26	<p><b><u>Proximate Analysis of Seed Extracts and Methanol Content of Juice of Some Grape Varieties in Turkey</u></b></p> <p><b>Author:</b> Ozcan Baris Citil, Yener Tekeli, Aydin Akin, Fatih Sevgi, Tuba Tekeli</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.26">10.22161/ijaers.5.6.26</a></p> <p style="text-align: right;"><b>Page No:</b> 153-157</p>
27	<p><b><u>Soybean Breeding Aiming at increasing Productivity and Root-Knot Nematode Resistance</u></b></p> <p><b>Author:</b> Osvaldo Toshiyuki Hamawaki, Raphael Lemes Hamawaki, Ana Paula Oliveira Nogueira, Jacqueline Siqueira Glasenapp, Cristiane Divina Lemes Hamawaki, Makyslano Rocha Resende, Tuneo Sedyama, Marcio Pereira</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.27">10.22161/ijaers.5.6.27</a></p> <p style="text-align: right;"><b>Page No:</b> 158-165</p>
28	<p><b><u>Experimental Planning Factorial: A brief Review</u></b></p> <p><b>Author:</b> Magno de Oliveira, Valéria MM Lima, Shizue Melissa A. Yamashita, Paula Santos Alves, Augustus CaesarFranke Portella</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.28">10.22161/ijaers.5.6.28</a></p> <p style="text-align: right;"><b>Page No:</b> 166-177</p>
29	<p><b><u>Double-Display Media in Geometrical Optics Learning in Vocational High School</u></b></p> <p><b>Author:</b> Dendik Udi M., Sutarto, Imam Mudakir</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.29">10.22161/ijaers.5.6.29</a></p> <p style="text-align: right;"><b>Page No:</b> 178-181</p>
30	<p><b><u>Performance of Reference Evapotranspiration Estimation Methods at the Southern Paraná, Brazil</u></b></p> <p><b>Author:</b> Luis Miguel Schiebelbein, André Belmont Pereira</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.30">10.22161/ijaers.5.6.30</a></p> <p style="text-align: right;"><b>Page No:</b> 182-190</p>
31	<p><b><u>Appliance of Textbook Basic on Process Image of Human Respiratory System against High School Student's Critical thinking Ability</u></b></p> <p><b>Author:</b> Eva Laila Widita, Jekti Prihatin, Imam Mudakir, Sutarto, Indrawati</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.31">10.22161/ijaers.5.6.31</a></p> <p style="text-align: right;"><b>Page No:</b> 191-194</p>
32	<p><b><u>Effect of "AERBETON" on the Mechanical and Physical Properties of Concrete</u></b></p> <p><b>Author:</b> Ali I. Tayeh</p> <p> DOI: <a href="https://doi.org/10.22161/ijaers.5.6.32">10.22161/ijaers.5.6.32</a></p> <p style="text-align: right;"><b>Page No:</b> 195-199</p>

33	<p><a href="#"><u>Comparative Analysis of three Growth Medium for Arthrospira platensis Cultivation based on Lab-Scale Results</u></a>  <b>Author:</b> Fernando Caixeta, Monica Hitomi Okura, Marlei Barbosa, Lucia Helena Pelizer   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.33">10.22161/ijaers.5.6.33</a></p>	Page No: 200-207
34	<p><a href="#"><u>Network Data Security for the Detection System in the Internet of Things with Deep Learning Approach</u></a>  <b>Author:</b> Kalubi Kalubi Deiu-merci, Mayou   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.34">10.22161/ijaers.5.6.34</a></p>	Page No: 208-213
35	<p><a href="#"><u>Factorial Economic Planning Applied to Agricultural Experimentation</u></a>  <b>Author:</b> Adriana Cioato Ferrazza, Beno Nicolau Bieger, Gean Lopes da Luz, Cristiano Nunes Nesi, Cristiano Reschke Lajús, Márcio Antônio Fiori   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.35">10.22161/ijaers.5.6.35</a></p>	Page No: 214-221
36	<p><a href="#"><u>Selective and Simultaneous Removal of Ni (II) and Cu (II) Ions from Industrial Wastewater Employing a Double Ni-Cu-Ion Imprinted Polymer</u></a>  <b>Author:</b> Morlu Stevens, Bareki Batlokwa   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.36">10.22161/ijaers.5.6.36</a></p>	Page No: 222-230
37	<p><a href="#"><u>Family Health Strategy and More Doctors Program in Rural Area of Porto Velho, Brazil: A Qualitative Analysis under the Nurse's Perspective</u></a>  <b>Author:</b> MarcuceAntonio Miranda dos Santos, Leonardo Severo da Luz Neto, Luiz Carlos Cavalcanti de Albuquerque, Helio Franklin Rodrigues de Almeida, Solange Alves da Silva Costa, Daiane Regine Lira Corrêa, Daniele Lopes Aguiar   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.37">10.22161/ijaers.5.6.37</a></p>	Page No: 231-240
38	<p><a href="#"><u>Experimental Determination of the Convective Coefficient of Heat Transfer Using the Global Capacitance Method</u></a>  <b>Author:</b> Fernanda da Silva Machado, Thaís Roberta Campos, Túlio Pinheiro Duarte, Felipe Raul Ponce Arrieta, Pedro Américo Almeida Magalhães Júnior   DOI: <a href="https://doi.org/10.22161/ijaers.5.6.38">10.22161/ijaers.5.6.38</a></p>	Page No: 241-245



# Distance Analysis of Multimodal Transportation Based on Traveling Salesman Problem with Particle Swarm Optimization Method

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**Abstract**— The globalizing world and the growing economy cause the companies have to find new quests to survive in the economic competitive environment. The fact that raw materials and production costs are at almost the same level in the same sectors foreground the logistics. Because Logistics plays an active role at every stage from the supply of raw materials to the supply of products to customers. An optimization that can be done at logistics will directly affect the corporate and enterprise economies. In this study, a multimodal transport optimization experiment was carried out with particle swarm optimization (PSO) based on the traveling salesman problem (TSP). Logistic villages and commercial ports were selected which are suitable for transportation mode change for multimodal transport. With optimization, we have solved the distance parameter for Unimodal Road Transportation and Multimodal Transportation which are widely used in our country. The solution for distance's parameter was compared and evaluated separately for Unimodal Road Transport and Multimodal Transport. Multimodal transport is seen to be more advantageous for distance's parameter as a result of evaluation. Finally, the integration of the optimization into intelligent transport systems (ITS) has been investigated.

**Keywords**— *Logistics Village, Multimodal Transport, Traveling Salesman Problem, Particle Swarm Optimization, Intelligent Transportation Systems*

## I. INTRODUCTION

Transportation systems consist of transport modes such as highways, sea routes, airlines, railways, pipelines. Performance analysis of transportation systems is very important. This is because transport shifts between modes cause significant changes [12, 13, 15, 16]. A lot of work has been done for efficiency in both freight and passenger transport [4, 11]. Logistics that can be summarized as the sector that includes all of the transportation activities; the

marketing sector is in direct interaction with the economy as it starts with transportation. With the development of technology, globalization and the concept of distant day is decreasing, the development of the logistics industry in parallel with this development is of great importance for the development country's economy [2]. An optimization that can be achieved in logistics will contribute positively to the economy of the institutions and organizations directly involved with logistics, as well as to the economy of the country, in proportion to the minimization of all costs and transportation periods, and an important step will be taken in terms of sustainability in logistics [3, 14]. Logistics is carried out by means of single transportation called unimodal transportation, because the distance is relatively short when the internal transportation is considered on the basis of it. In international transport, countries with a sea connection usually prefer shipping, and after they enter the freight country they are transported to the buyer by changing the mode of transportation in the ports and in the inner stations according to the transportation infrastructure of the region to be visited. This type of transportation is made by changing the types of transportation is called multimodal transportation. Logistic villages are logistics centers where all logistics activities can be done together. Logistic villages have direct connections to at least two transportation routes, including railway and highway. Logistic villages are suitable centers for the change of transportation type as logistic activities such as handling, storage, loading-unloading can be done and direct connection to at least two transportation routes is available. The Traveling Salesman Problem is a problem that aims to find the shortest route to return a starting point to a starting point after a certain dealer has known certain points [7]. Although the Traveling Salesman Problem is an easy problem to understand, the linear solution is a rather difficult and difficult problem class, especially as the number of nodes increases, due to the increase of the total number of laps

and the elongation of the accounts. In traditional solutions of Traveling Salesman Problem, solution is made with Euclidean relation according to bird flight distances. In this study, Particle Swarm Optimization intuitive method, which is developed by inspiring birds and fish in their herd behavior, has been preferred since it can be solved according to real values and modification to the algorithm is required. In the study, an optimization experiment was conducted for multimodal transport. Minimization of distance on multimodal transportation routes is aimed with the optimization made [4]. Based on the general solution of the Traveling Salesman Problem for optimization, the solution algorithm is written with particle swarm optimization.

## II. MATERIAL AND METHODS

As a method of study, a solution algorithm is firstly written with Particle Swarm Optimization for the Euclidean Mapping of the Traveling Salesman Problem and for the bird flight linear solution. Then a modified Particle Swarm Optimization algorithm, which can make the route drawing according to the coordinates according to the input values, is designed by separating the inputs from the input coordinates so that the algorithm can be solved according to the actual values and the solution according to the actual values is done through this algorithm. In order to demonstrate the general solution of the Traveling Salesman Problem, a bird-flight linear solution was made on the points of account and then a solution was made for the unimodal road transport which is the common type of transportation in the account route and for the multimodal transportation by means of the distance parameters and the results are shown in Mathworks Matlab is compared and evaluated through a comparison function.

### Unimodal Transportation

Unimodal transport with a single transport module is a transport system with one or more transporters and a single transport module. The constructed transport system is essentially a single transport method, such as land transport only, sea transport only or air transport only. The most widely used transport mode in single mode transportation is the land route. [1]

### Multimodal Transportation

Multimodal Transport is a type of transport made by using multiple transport modes with different transport units or vehicles [3]. With the emergence of modern multi-carriage containers came to the agenda. The container in the standard container is a transport vehicle for the load; as well as packaging. In addition, the container, which is an investment in terms of bearing, is generally used as the main material of the multiple cargos. The first applications of multicast are container operators. Multimodal transport is a burden, between a seller and a buyer, with at least two

transport systems and a single cargo ship. It can be applied within the national boundaries of a country as well as by making the international carriage of multiple carriages. Today's application is predominantly international multi-transport.

### Traveling Salesman Problem

The Traveling Salesman Problem is the shortest tour problem that a traveling salesman who can travel from one point to the other by going to all the other points to return to the starting point [5]. Traveling Salesman Problem when you think of the problem as a graph, all the points to go are expressed as a linear line and the stops as a point. Traveling Salesman Problem expression is an easy problem. But solution is a difficult problem. The solution of problems with too many nodes is very difficult. The Traveling Salesman Problem is a difficult problem class.

### Particle Swarm Optimization

Particle Swarm Optimization is a heuristic method inspired by the behavior of birds and fish in the wild [6]. The behavior of birds and fish swarms trying to find food in contact with each other in search of food in the nature is the basis of Particle Swarm Optimization. Particle Swarm Optimization is also the best in the population, the best of the crawl, and the best in the global. The solution algorithm continues by selecting from these three cases in each iteration.

Herd intelligence is not a specific algorithm or a system. Herd intelligence is a form of collective behavior of natural or artificially distributed, self-organizing systems. The best known examples of algorithms based on swarm intelligence are ant colony algorithm and particle swarm optimization algorithm. Compared to other evolutionary algorithms, it is seen that in these algorithms, the herd elements affected by each other's behaviors are spread more appropriately in the solution space than the individual motions. This allows the change in dynamically changing solution spaces to be more easily followed and the adaptation to be faster. [10]

In PSO, each particle has its own velocity, which speeds up the particle towards the optimum result with the information it receives from the other particles. In each generation this speed is recalculated taking advantage of the previous best results. By this means, the individuals in the population are in an increasingly better position. The steps of the algorithm are as follows; [9]

1. Population formation; particles are created with randomly generated starting positions and velocities.
2. Calculation of eligibility values; the fitness values of all the individuals in the population are calculated.
3. Finding the best member; every individual in each generation is compared to the best (pbest) found



in the previous generation. If a better individual is displaced.

4. Finding the global best; if the best value in the future is better than the global best value.
5. Renewal of positions and speeds;

$$V_{id} = W * V_{id} + C_1 * rand_1 * (P_{id} - X_{id}) + C_2 * rand_2 * (P_{gd} - X_{id}) \quad (1)$$

$$X_{id} = X_{id} + V_{id} \quad (2)$$

Where  $X_{id}$  is the position and  $V_{id}$  is the speed value,  $rand_1$  and  $rand_2$  are randomly generated numbers between 0 and 1.  $W$  is the inertia weight value. Here  $C_1$  and  $C_2$  are constant values and are generally considered to be close to 2.

6. Repeat the steps until the stopping criterion is met. Repeat steps 2-5 until the stop criterion is met.

#### Particle Swarm Optimization's Solution for Traveling Salesman Problem Algorithm and Modifications

In Particle Swarm Optimization, every particle in the herd has its own value. Throughout the solution, the particles are both searching for the best by sharing information among themselves and comparing their previous best state with their current state. In this way, they try to reach the optimum solution from all these evaluation criteria. Particle Swarm Optimization's operating system is as follows. First, the random position and velocity of each particle is created. Then the fitness values of the particles are determined. Subsequently the values of all the particles are replaced if they are better than the previous iteration. Then the best value of the iteration is compared to the global best value and replaced if it is better than the global best value. Subsequently, the Particle Swarm Optimization speed refresh formula renews the speed of all particles and continues the cycle until the stop criterion is met. This is the general solution of Particle Swarm Optimization. This method of solution does not reach the correct solution because local minimums cannot be avoided when applied directly to the Traveling Salesman Problem, and a number of modifications are required in the algorithm. In order to avoid local minimums, after the algorithm cycle has been completed and the optimum result has been found, a mutation has been added to the algorithm, and if the crossed result is better than the optimum result, it is replaced and the closer result is reached.

For example, the optimal term in the iteration for 6 points:  
 $gbest=[2\ 4\ 3\ 1\ 5\ 6];$  (3)

Form, when we make a reversion mutation on this tour:  
 $gbest=[2\ 5\ 1\ 3\ 4\ 6];$  (4)

It has come to shape. The algorithm compares the resulting turntable distance with the optimum lap distance, and if the

mutated lap distance is better, the solution is transformed by displacement.

When solving according to the coordinates of Traveling Salesman Problem with Particle Swarm Optimization:

N number of points:

$$D=zeros(N,N); \quad (5)$$

A matrix of 0 is formed and

$$D(i,j)=100*(sqrt((x(i)-x(j))^2+(y(i)-y(j))^2)); \quad (6)$$

$$D(j,i)=D(i,j); \quad (7)$$

The D distances found by the equation form the matrix D. The algorithm draws distances D from the matrix when solving. Expressions  $x$  and  $y$  in Equation (6)  $i$  and  $j$ . Corresponds to the X and Y coordinates. Equation (7) with the formula  $i$  and  $j$ . point distance between the point and the return is defined as equal. That is, the program will place the same value in D ( $j$ ,  $i$ ) after placing the matrix D ( $i$ ,  $j$ ).

The solution for the Traveling Salesman Problem with Particle Swarm Optimization was solved according to the actual values. The formula for the D matrix was closed and the D (N, N) matrix was manually entered by the number of points prepared according to the actual values. For example, the matrix of road distances D (18,18) divides the matrix by 0 values diagonally to the left, since the distance between the two matrices is equal. The lower and upper values are equal to each other. In addition, the optimum angle is plotted on the point coordinates of the route.

While solving the Traveling Salesman Problem with Particle Swarm Optimization according to the actual values, all the transportation type options between the two points are defined in the program. For example, if we consider the Iskenderun Port - Mersin Port for distance optimization:

Iskenderun.Mersin.Road=207;

Iskenderun.Mersin.Railway=204; [8]

Iskenderun.Mersin.Sea=122;

After defining the distances in the form, a distance matrix of Iskenderun Port Mersin Port is formed as follows.

Iskenderun.Mersin.Distance= [Iskenderun.Mersin.Road  
Iskenderun.Mersin.Railway Iskenderun.Mersin.Sea]

Then  $i$ . point Iskenderun Port  $j$ . point Let's accept Mersin Port. D ( $i$ ,  $j$ ) th value of the matrix D (N, N):

$$D(i,j)=min(Iskenderun.Mersin.Distance);$$

And for the optimization solution, it again subtracted the values from the D matrix. Here the algorithm chooses the algorithm if the transport type is more advantageous because the matrix forms the minimum distance values of the alternative transportation types. Therefore multimodal transport can be preferred. Again, the optimum angle is plotted on the point coordinates of the route. The following parameters are used in the solution algorithm.

**Herd Size:** Although the size of the herd size depends on the type of problem being solved, a population size of 50 to 100 is generally preferred over the solutions made with the Particle Swarm Optimization algorithm. As the size of the herd increases the scanning speed, the resolution time increases with the convergence. In order to obtain better results in the study, the size of the herd was selected as 100 with the extension of the solution.

**Learning Coefficients:**  $C_1$ , the particle learning coefficient, and  $C_2$  learning coefficients, which are the herd learning coefficient, will slow the learning ability of the particle when values are too low, and the particle will be slow to reach the best position. When very high values are given, the particle will memorize and will accept its best in global best and stick to local minima and will not reach the correct results. In the Particle Swarm Optimization solution algorithms, values of 1 to 2 are usually preferred for the learning coefficients, while the learning of the correct particle is controlled and the values are changed. In the study,  $C_1$  and  $C_2$  learning coefficients were chosen as 0.5 to try to avoid both local minima and to obtain more close results.

**Weight Coefficient:** The weight coefficient prevents the particles from being scattered in the algorithm and allows them to converge at one point. Selecting an appropriate weighting factor creates a balance between local and global searches. In the literature, Particle Swarm Optimization shows that the best result is the variable weight coefficient between 0.5 and 1. Taking the weight coefficient value over 1 increases the speed vector, so it does not give very healthy results and the particle cannot search for values near. Global searches cannot be performed when very low values are obtained. In the study, the commonly accepted variable weighting coefficient was applied in the literature. Starting with 1, the weight coefficient is reduced by 0.001 in each iteration and decreased to 0.5 in the final iteration for the solution.

**Stopping criterion:** It is about stopping the problems such as Traveling Salesman Problem which enters the difficult problem class when the termination logic reaches the optimum result. Or the program defines an iteration number and the program stops when it reaches that iteration. When the number of iterations that need to be considered here is defined, it is absolutely possible to reach the optimum result when the termination is done. That is to say, a straight line must be reached from somewhere in the solution graph. Given the maximum number of iterations, in the number of stopping iterations, the solution is unnecessarily prolonged. The maximum number of iterations in the study was 500.

### III. RESULTS AND DISCUSSION

Solution of the Problem According to Unimodal Highway Distances

The solution according to the unimodal road distances is shown in Fig.1 in the route drawing taken from the program. Route Map of Turkey finished the state is as in Fig.2. In Fig.3, the calculation of the algorithm is given. In addition, the irregularity in the shape is caused by the solution of the program according to the actual distances. Algorithm solutions are made according to the actual distances entered into the proofer. The program draws the route according to the classical resolution of the Traveling Salesman Problem, according to the coordinates. In other words, due to the fact that the coordinate distance based bird flight distance is different from the actual distance, irregularity has occurred in the drawing of the route. But the solution is provided. This is true for both solutions based on unimodal and multimodal distances.

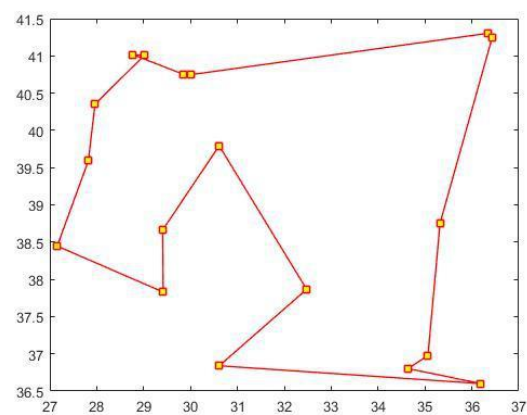


Fig. 1: Solution route drawing according to unimodal road distances

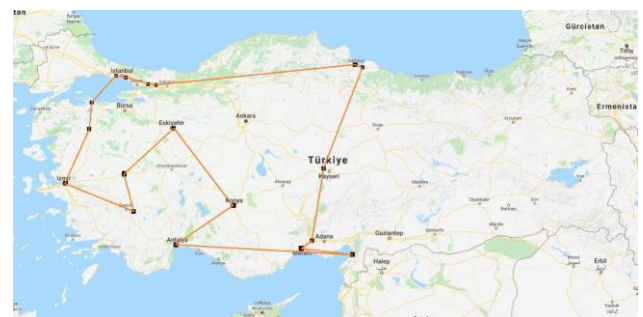


Fig. 2: Solution map display according to unimodal road distances

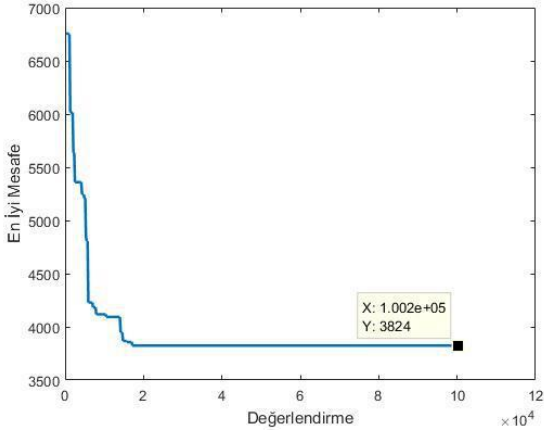


Fig. 3: Solution calculation chart according to unimodal road distances

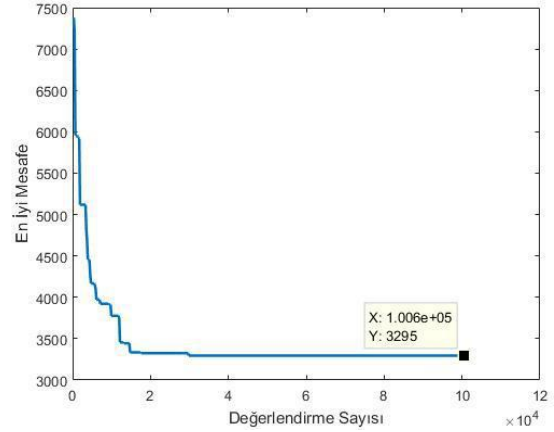


Fig. 6: Solution calculation chart according to multimodal distances

Solution of the Problem by Multimodal Distance  
 The solution made according to the multimodal distances is shown in Fig.4 of the route diagram taken from the program. Route Map of Turkey finished the state is as in Fig.5. In Fig.6, the calculation of the algorithm is given.

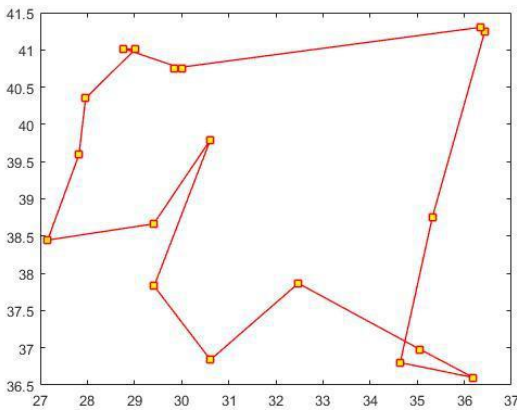


Fig. 4: Solution route drawing according to multimodal distances

#### Comparison Function

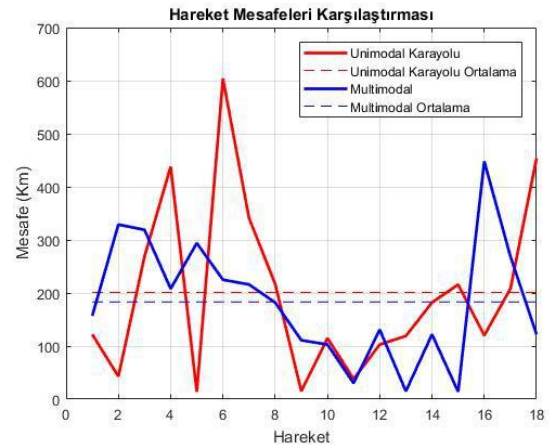


Fig. 7: Graphical distance comparison

Although multimodal transport is more advantageous in comparing movement distances during the round trip compared to optimization data, the distance reduction of multimodal transport is shown in Fig. 7, it is not too much to see. This is why; the road infrastructure is stronger and more accessible. This situation necessitates the investment in other types of transportation, especially railway transportation, in order to prefer multimodal transport in terms of distance. The most advantageous mode of transportation is maritime transportation because it provides approximately bird flight movement when considering the distance. The disadvantage of sea transport is that it cannot provide services in the interior.

#### IV. CONCLUSION

- In the solutions made, unimodal highway distance 3824 km, multimodal distance 3295 km.
- As seen in Fig.7, multimodal transport is more advantageous from the beginning to the end of the turn.
- When considered unimodal, the most advantageous type of transportation in terms of distance is maritime

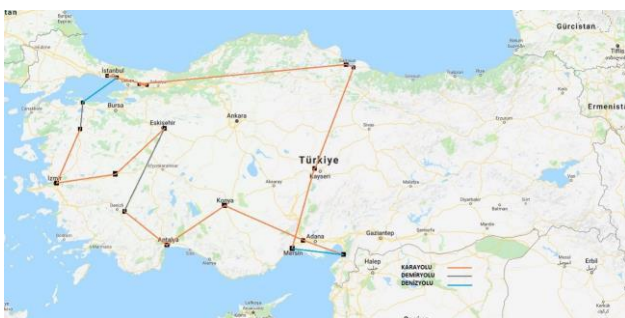


Fig. 5: Display in solution map according to multimodal distances

transport. The reason for this is the fact that the vessels move about the bird flight.

- Related to the solution algorithm: correct selection of values such as weight coefficient, learning coefficient converges the solution. However, the extreme sensitivity in the values can extend the solution.
- With optimization to be done the optimum route can be determined according to the desired criterion without the load going further.
- With optimization to be done load equipment can be installed with equipment to be installed and the load can be directed while moving.
- With optimization to be done according to the new requirements, new routes can be created and transferred to the carrier or interim logistics center while the load is in motion and the route or mode of transportation can be changed.

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# Analysis of induced drag and vortex at the wing tip of a Blended Wing Body aircraft

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**Abstract**—The authors aimed with this work to study the “vortex” on the wing tip of a “Blended Wing Body” aircraft using computational tools available that use the methods of “finite element” and “Computational Fluid Dynamics”. The purpose of it is to reduce the vortex intensity, improving stability, reducing the “induced drag” and promoting less turbulence in the aircraft. This new aircraft configuration is a little different from the ones we have today. Blend Wing Body aircrafts fuselage and wings are one body, changing a lot of flight characteristics.

**Keywords**—Blended Wing Body, Computational Fluid Dynamics, Finite Element Method, Induced Drag, Vortex.

## I. INTRODUCTION

The Blended Wing Body is a very new concept of aircraft airfoil. Great companies like Boeing and NASA have already made some studies in this field. The creation of new models are being studied more in order to create better airfoil models. The structural and fabrication study has started too, as like how to use the aircraft for commercial benefits. The Blended Wing Body aircrafts have many advantages compared with the conventional ones, such as more lift, less drag, and it can save more fuel during flights. This project consists in compare two models of BWB, aiming to reduce the vortex and the induced drag. One model has wing tip devices in the wing, called winglets, and the other one is a model without winglets.

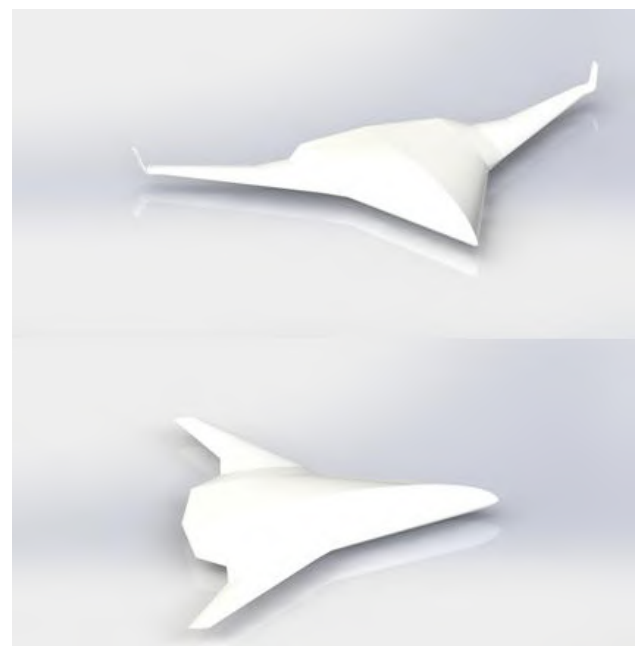


Fig.1: Blended Wing Body Models

## II. METODOLOGY

To compare the two configurations was used a CAD software to analyze the models, and two different CAE models to simulate the flight dynamics conditions. The CAD software chosen is the SolidWorks, because it is used in almost all projects nowadays. The CAE software to make the pre-processing was the HyperMesh. This one can generate one of the most confinable meshes compared to the other pre-processing softwares. To make the post-processing, the Star CCM+ software was used because of its reliability in fluid dynamics field simulations.

III. SIMULATION

3.1- Pre-Processing

To make the pre-processing was used a shell geometry, and was chosen to used r-trias elements because of the geometry of the models. The mesh was more refined at the leading edge and in the trailing edge, as like as in the wing tip.

3.2- Post-Processing

Done the final mesh, it have been imported to Star CCM+, and begin the simulation. We have made a spherical wind tunnel to simulate a flight condition, and applied some inputs, like velocity, density and turbulence. After the simulation, the obtained lift coefficient, the drag coefficient, the drag, the lift and the vortex lines of the both models, and the registers were compared the both results.

IV. MATHEMATICAL MODELING

We chose to consider the aircraft body and wing as a big wing, then we measure the span of the model in SolidWorks, and calculate the area of the aircraft as a trapezoidal wing, where S is the area, cr is the root chord, ct is the tip chord and b is the span (1).

$$(1) S = \sum \frac{(cr+ct)b}{2}$$

With the wing area, we can calculate the aspect ratio of the aircraft (2).

$$(2) AR = \frac{b^2}{S}$$

Now, it is possible to obtain the Oswald's efficiency (3), and then calculate the induced drag coefficient (4).

$$(3) e = 1.78(1 - 0.045AR^{0.68}) - 0.64$$

$$(4) C_{Di} = \frac{c_L^2}{\pi \cdot AR \cdot e}$$

Finally, we can estimate the Induced Drag (5) with the following equation, where ρ is the air density at cruise flight, and we consider the aircraft flight at 0.85 Mach:

$$(5) D_i = \frac{1}{2} \rho \cdot V^2 \cdot S \cdot C_{Di}$$

The reduce of induced drag with winglet

$$(6) 100 - \left( \frac{D_i(\text{winglet}) \cdot 100}{D_i(\text{without winglet})} \right)$$

V. RESULTS

At the simulation, we consider a cruise flight at 0.85 Mach, and obtain the result below:

Table. 1: Simulation results

	C <sub>D</sub>	C <sub>L</sub>	Lift (N)	Drag (N)
Without Winglet	0.01395	0.40070	29937	104236.
Winglet	0.01316	0.40961	31930	102592.
	0766	24	54	18

In addition, with all the calculations we obtain the following results:

Table.2: Equations results

	C <sub>Di</sub>	Induced Drag (N)
Without Winglet	0.007498	68941.8486
Winglet	0.006988	65259.17658

Table.3: Winglet efficiency at induced drag

Winglet efficiency (%)	5.341707679
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The vortex simulation demonstrate that the aircraft with winglets have a higher reduce in the vortex generation, increasing the aircraft stability and helping the controllability.

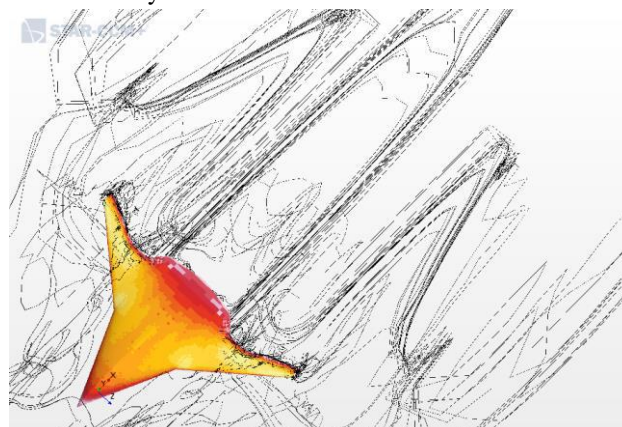


Fig. 2: Model without winglet vorticity

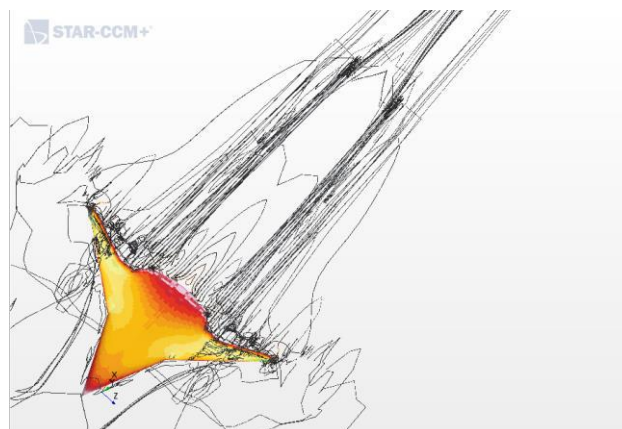


Fig. 3: Model with winglet vorticity

VI. CONCLUSION

With this results we can conclude that the winglet model have less Induced Drag, Drag coefficient, total Drag and an increase of Lift and Lift coefficient. The winglet aircraft also have the vortex reduced. Therefore, the winglet is a great choice to improve the aircraft flight conditions.

ACKNOWLEDGEMENTS

The authors have a special thanks to the Pontifícia Universidade Católica de Minas Gerais, to the National

Council for Scientific Development (CNPq), and for the Foundation for Research Support of Minas Gerais (FAPEMIG).

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# Polyethyleneglycol nanoparticles adsorbed to glycine as a bioengineered neomaterial for application in inflammatory processes

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**Abstract**— Polyethylene glycol nanoparticles (NP-PEG) have good adsorption in bioactive compounds and are considered promising vehicles. Several studies have reported the importance of the amino acid for several treatments, among them glycine that has immunomodulatory, cytoprotective and anti-inflammatory effects. The objective of this work was to evaluate the efficiency of the synthesis of polyethylene glycol (PEG) nanoparticles adsorbed with glycine (NANO-PEG/GLY) on functional activity of colostrum macrophages. Human colostrum cells were obtained from 18 clinically healthy women and used for bioassays of cell viability, phagocytosis, microbicidal activity and cytokines concentration. It was observed that the cell viability index in the presence of NANO-PEG/GLY was above 85%. Phagocytosis rates in colostrum cells treated with glycine and in the presence of EPEC, whereas the highest microbicidal index were observed in macrophages treated with PEG-NANO-GLY. IL-1 $\beta$  and TNF- $\alpha$  levels increased in GLY and NANO-PEG/GLY groups. The levels of IL-12 and IL-17 also increased in the macrophages cultures under the NANO-PEG/GLY treatment. In the supernatant cell culture IL-8 and IFN- $\gamma$  levels were similar among the treatments. The data suggest that NANO-PEG particles produced were able to adsorb the amino acid glycine, and this new bioengineered material is capable of modulating the functional activity of human colostrum macrophages and represents an alternative route for the treatment of inflammatory diseases..

**Keywords**— Colostrum, Glycine, Inflammation, Macrophages, Polyethylene glycol.

## I. INTRODUCTION

The inflammatory processes are part various pathologies which involves leukocyte infiltration, enzymes release and formation of free radicals derived from oxygen [1,2]. Macrophages are cells important in the regulation of the immune response during the inflammation [3]. Some works have reported that colostrum presents soluble immunological components and contains large amounts of viable leukocytes, especially macrophages [4]. On the other hand, other studies have revealed that many nutrients and metabolites provided by food exert an antioxidant effect, useful in protecting human health, preventing diseases [5,6]. There are some amino acids, such as glycine, which is being used in the treatment of patients suffering from enterocolitis because they have cytoprotective and anti-inflammatory action [7,8,9,10]. Glycine is a simple, non-essential amino acid known as a functional supplement used in the pharmaceutical industry, nutritional supplementation [10] and is bioactive compounds with anti-inflammatory activity present in colostrum [11,12,13]. Previous work showed that the adsorption of glycine onto Polyethylene glycol (PEG) microsphere was able to stimulate the colostrum macrophages and suggest that the controlled delivery system of glycine may be an additional mechanism of protection and treatment of patients with infections and/or inflammation gastrointestinal, as well as for the functioning of colostrum cells [7]. Considering that the PEG is a biodegradable and biocompatible component [14] and that this particles have the capacity not to be recognized by the immune system, circulate for longer periods in the body [15,16,17] ] and has the ability to adsorb organic compounds, it is possible that this carrier of biological components to be used in the treatment of



gastrointestinal inflammation [7,18,19,20]. The aim of this study was to evaluate the efficiency of the synthesis of polyethylene glycol (PEG) nanoparticles adsorbed with glycine (NANO-PEG/GLY) on functional activity of colostrum macrophages.

## II. MATERIAL AND METHODS

### 2.1 Synthesis and Preparation of PEG Nanoparticles

The nanoparticles were obtained from Polyethylene glycol 6000 (Sigma-Aldrich Brasil Ltda.) PH = 6.8 using a modification of the described method [18,19,20]. For the synthesis of polyethylene glycol (PEG) nanoparticles (NP-PEG) with glycine adsorbed for the complex formation (NANO-PEG/GLY) PEG 6000 (10g) at the concentration of 0.016 mol/L, was diluted in 100 mL of phosphate buffered saline (PBS), incubated for 45 min at 45°C. Thereafter, 100 µL of a 2% sodium sulfate solution in PBS was added by dropwise. After incubation, the PEG solution was 3: 1 in PBS under rigorous stirring by adding 100 µL of sodium sulfate (UltraTurrax IKA T25/10 min Ultrasound Probe). Shortly thereafter, heat treatment was carried out for 30 minutes at 45°C to favor sorting in size. After this period the PEG solution was centrifuged for 15 minutes at 15,000 rpm and washed (2x); Diluted 10 times (PEG + sodium sulfate 100µL 0.45mM) in PBS to thermally induce the formation of nanoparticles for 7 minutes at 97 °C. Subsequently, the pH was adjusted to 6.4 and incubated volume to volume the glycine solution (GLY - concentration of 10<sup>-3</sup> mol /L - Dynamic® - Diadema, São Paulo, Brazil) and PEG nanoparticles at 37 °C for 30 minutes. The experiments were repeated 20 times and the results were analyzed and compared for hydrodynamic diameter and surface charge by means of dynamic light scattering (DLS) and Zeta potential (ζ).

### 2.2 Dynamic light scattering (DLS)

GLY, NP-PEG and NANO-PEG/GLY systems were prepared for analysis by DLS technique. It was then possible to investigate the hydrodynamic diameter of the dispersed solid. DLS analyzes were obtained from the Zetasizer Nano Z90 equipment (Malvern Instruments, Malvern, Worcestershire, United Kingdom), with excitation at 632.8 nm.

### 2.3 Effect of GLY, NP-PEG and NANO-PEG/GLY on the functional activity of phagocytes

After obtaining written consent, about 15 ml of colostrum were collected from 18 clinically healthy women (18 to 30 years), all registered in the health system of Barra do Garças, Mato Grosso, Brazil. All mothers had given birth to healthy newborns. Colostrum samples were collected in sterile plastic tubes between 48 and 72 hours postpartum. All procedures were submitted to the ethics committee for evaluation and received approval.

### 2.4 Macrophages from Human Colostrum

After collection in sterile plastic tubes of each donor, the samples were centrifuged at (160 × g, 4 ° C) for 10 minutes, where the colostrum was separated into three distinct phases: cell pellet, an intermediate aqueous phase, and a lipid-containing supernatant as described by Honorio-França et al. [21]. Cells were separated by a Ficoll-Paque gradient [Pharmacia, Upsala, Sweden]. This procedure generated 98% pure mononuclear cell preparations as analyzed by light microscopy. Purified macrophages were resuspended independently in serum-free 199 medium at a final concentration of 2 × 10<sup>6</sup> L<sup>-1</sup> cells. After this period the cells were washed twice and used for the cell viability, phagocytosis and microbicidal assays and the culture supernatant used for quantification of cytokines by the flow cytometric assay.

### 2.5 *Escherichia coli* strain

The enteropathogenic *Escherichia coli* (EPEC) used was isolated from stools of an infant with acute diarrhea (serotype 0111: H- AL-, eae+, eaf+, bfp+). This material was prepared and adjusted to 10<sup>7</sup> bacteria/ml, as previously described Honorio-França et al. [21].

### 2.6 Cell viability determination by acridine Orange and MTT method

In order to determine the cellular viability of GLY, NP-PEG and NANO-PEG/GLY after treatments in the cultures by acridine orange the experiments were performed according to Belinatti-Pires et al. [22]. The cells were stained with 200 µl of acridine orange (Sigma, St. Louis, USA; 14.4 g L<sup>-1</sup>) for 1 min. The pellet was resuspended in cold medium, washed twice and observed under an immunofluorescence microscope at magnification of 40x and 100x. The viability index was calculated by counting the number of orange- stained [dead] and green- stained [alive] cells out of 100 [23]. All experiments were performed in triplicate.

To verify the cytotoxicity of the NANO-PEG / GLY system using the colorimetric method Tetrazolium bromide 3- [45-Dimethylthiazol-2-yl] 25- Diphenyl Tetrazolium bromide [MTT Sigma St Louis USA], colostrum macrophages (5 × 10<sup>5</sup> cells) were distributed into plate wells and incubated with their respective treatments in humidified chamber with 95% air and 5% CO<sub>2</sub> at 37° C for 2h30min. After incubation the supernatant was removed and each well was added 40 µL of 5 mg.mL<sup>-1</sup> MTT and 360 µL of complete culture medium. The plate was then incubated for 3 h in the same humidified chamber. The supernatant was then discarded and 150 µL of DMSO (Dimethylsulfoxide) was added to solubilize the Formazan crystals. Optical density was measured in a plate spectrophotometer using an interference filter at 492-630 nm.

### 2.7 Bactericidal assay

Table 1. Stability of the NANO-PEG/GLY system in different periods (days).

Samples	0		15		30		45		60	
	D <sub>h</sub> /nm	ζ/mV	D <sub>h</sub> /nm	ζ/mV	D <sub>h</sub> /nm	ζ/mV	D <sub>h</sub> /nm	ζ/mV	D <sub>h</sub> /nm	ζ/mV
PEG	191±11	-1.2	197±11	-3.7	321±20	-1.5	349±22	-1.3	549±34	-1.9
NANO-PEG/GLY (1Molar)	209±12	-1.6	214±14	-2.9	362±27	-1.8	355±28	-1.9	557±32	-1.4
NANO-PEG/GLY (2Molar)	213±14	-11.9	218±16	-14.7	340±44	-13.6	371±47	-10.1	571±37	-8.9
NANO-PEG/GLY (3Molar)	229±14	-9.5	234±16	-11.4	356±24	-10.9	391±25	-9.2	599±45	-9.7

Biocompatibility and toxicity studies of the GLY, NP-PEG and NANO-PEG/GLY complex were evaluated prior to a potential biomedical use, the cytotoxicity of each stimulus was examined by acridine orange and MTT assays. Cell viability was determined as shown in figure 1. The results indicate the high biocompatibility of GLY, NP-PEG and NANO-PEG/GLY. The cell viability index in the presence of Gly, NP-PEG and NANO-PEG/GLY was above 85% (Figure 1A and 1B ).

Phagocytosis and microbicidal activity were evaluated using the acridine orange method [22]. Equal volumes of bacteria and cell suspensions were mixed and incubated at 37°C for 30 min under continuous shaking. Phagocytosis was stopped by incubation on ice. To eliminate extracellular bacteria, the suspensions were centrifuged twice (160 x g, 10 min, 4°C). Cells were resuspended in serum-free 199 medium and centrifuged. The supernatant was discarded, and the sediment was dyed with 200 μL acridine orange (Sigma, ST Louis, USA; 14.4 g/L) for 1 min. The sediment was resuspended in cold 199 medium, washed twice and observed under immunofluorescence microscopy at 400x and 1000x magnification.

The phagocytosis index was calculated by counting the number of cells that ingested at least 3 bacteria in a pool of 100 cells. To determine the bactericidal index, we stained the slides with acridine orange and counted 100 cells with phagocytized bacteria. The bactericidal index was calculated as the ratio between orange- stained [dead] and green- stained [alive] bacteria x 100. All of the experiments were performed in duplicate.

### 2.8 Quantification of cytokines

The cellular supernatant was collected and stored at -80°C prior to analyses. The samples were thawed and cytokines (IL-1β, IL-6, IL-8, IL-10, IL-12, IL-17, TNF-α and IFN-γ) were measured by cytometric bead array [CBA BD Biosciences USA] according to the manufacturer procedures. A flow cytometer was used for these analyses [FACSCalibur BD Biosciences USA]. The data were analysed using the software FCAP Array 1.0 [CBA BD Biosciences USA].

### 2.9 Statistical analysis

Data were expressed as the mean ± standard deviation (SD). The statistically significant difference was evaluated using the Analysis of variance [ANOVA] and were

considered significant when the "p value" was lower than 0.05 (p <0.05).

## III. RESULTS

### 3.1 DLS analysis of the GLY, NP-PEG AND NANO-PEG/GLY

To evaluate the stability of the NANO-PEG/GLY system the samples were submitted to potential Zeta and Zetasize tests and the results are showed in the table 1. The tests were performed at the periods of 0, 15, 30, 45 and 60 days. It was observed that the stability of PEG and NANO-PEG/GLY up to 45 days in relation to arrangement and growth, as well as the average potential of PEG, GLY and NANO-PEG/GLY and after 60 days increased the size. Biocompatibility and toxicity studies of the GLY, NP-PEG and NANO-PEG/GLY complex were evaluated prior to a potential biomedical use, the cytotoxicity of each stimulus was examined by acridine orange and MTT assays. Cell viability was determined as shown in Fig. 1. The results indicate the high biocompatibility of GLY, NP-PEG and NANO-PEG/GLY. The cell viability index in the presence of Gly, NP-PEG and NANO-PEG/GLY was above 85% (Fig. 1A and Fig.1B ).

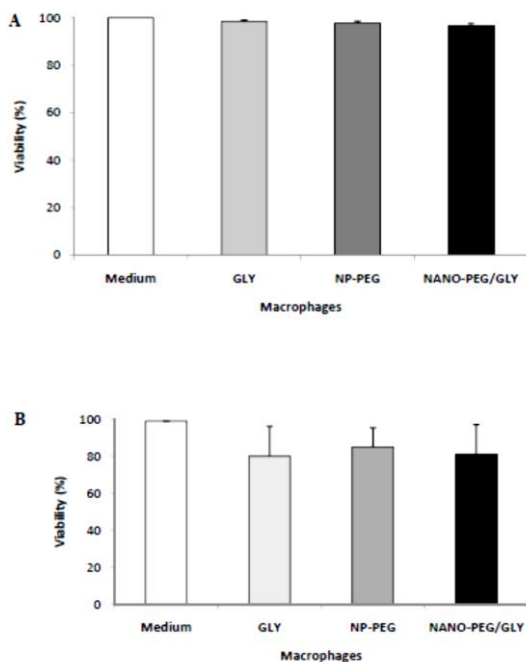


Figure 1. Viability index (mean ± sd; N=5) of colostrum macrophages treated with GLY, NP-PEG and NANO-PEG/GLY in the concentration of  $10^{-5}$  mol/L. Viability index is represented by acridine orange method (A) and MTT method (B).

### 3.2 Effects of PEG nanoparticles adsorbed to Glycine on phagocytosis and microbicidal by colostrum cells.

Phagocytosis rates in colostrum cells treated with glycine and in the presence of EPEC was higher than in cells from non-treated phagocytes (Fig. 2A). Colostrum macrophages treated with GLY and PEG-NANO-GLY showed higher microbicidal indices in the presence of EPEC than the non-treated phagocytes. The highest microbicidal index were observed in macrophages treated with PEG-NANO-GLY (Fig. 2B)

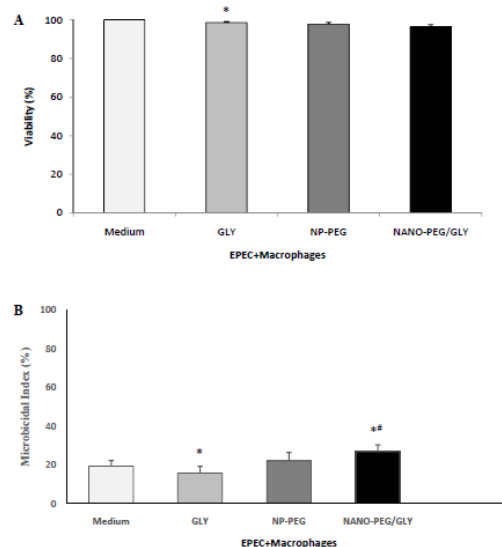


Figure 2. Phagocytosis and microbicidal activity of macrophages from the colostrum treated with glycine (GLY), PEG nanoparticles (NP-PEG) and PEG nanoparticles of glycine (NANO-PEG/GLY).

### 3.3 Cytokines concentration in supernatant of culture of macrophages in the presence of GLY, NP-PEG and NANO-PEG / GLY.

Table 2 shows cytokine levels in the culture supernatant of colostrum macrophages incubated with the different stimulus. IL-1 $\beta$  and TNF- $\alpha$  levels increased in GLY and NANO-PEG/GLY groups. The levels of IL-12 and IL-17 also increased in the macrophages cultures under the NANO-PEG/GLY treatment. In the supernatant cell culture IL-8 and IFN- $\gamma$  levels were similar among the treatments.

Table 2- Cytokines concentrations (pg/mL) in culture supernatant of human colostrum macrophages. Cells in untreated, cells treated with Glycine (GLY), PEG nanoparticles (NP-PEG) and PEG nanoparticles adsorbed with glycine (NANO-PEG/GLY). The results are expressed as mean and standard deviation of 6 replicates with human blood cells from different individuals. P>0.05.

Cytokines	Medium	GLY	NP-PEG	NANO-PEG/GLY
IL-1 $\beta$	13.4±4.4	16.9±1.8*	20.8±1.7*	19.9±2.9*
IL-6	11.8± 4.6	14.2± 2.0	18.5±1.7*	16.5±3.3
IL-8	19.1±1.0	19.3±2.8	19.5±1.7	20.6±3.6
IL-10	4.1 ± 0.2	4.8 ± 0.2	4.5±0.2	5.4±1.2*
IL-12	15.3±6.3	19.9±2.4	22.5±2.9*	21.3±2.7*
IL-17	5.0 ± 1.6	4.7 ±0.8	4.6 ± 0.6	7.1 ± 3.8*
TNF- $\alpha$	11.2 ± 3.4	17.1±1.9*	17.2 ± 2.5*	17.8 ±1.8*
IFN- $\gamma$	3.2 ± 0.1	3.3±0.1	3.4 ± 0.2	3.5±0.5

The results represent the mean and SD of five different individuals. \*p<0.05 indicates intergroup differences.

## IV. DISCUSSION

The synthesis of functional materials in nanoscale has been increasing interest in the research, due control mechanisms

on material in relation the morphology, size, functionalities and properties [24]. Functional materials such as polymers that are produced on nanometer scale as

well as PEG nanoparticles can be used in drug delivery control [25]. Nanoparticles based on polymeric substances can be used in the clinical administration of drugs and / or other bioactive substances due to their incorporation capacity [26,27]. This study it was verified that nanoparticles of PEG adsorbed glycine, and that this material acts as an immunomodulator on the functional activity of human colostrum cells. The analysis of the NANO-PEG/GLY system was performed by Dynamic Light Scattering (DLS) and Zeta Potential and showed that this material maintained stability for 45 days in relation to arrangement and growth and increased the size after 60 days. Drug delivery is controlled by two main factors: pore size and drug concentration. It is important to understand the physical and chemical properties in the synthesis of neomaterials. It is known that PEG nanoscale particle formulations can allow the control of the speed at which the drug is released from the polymer matrix [28]. In this sense the PEG nanoparticles have a high potential in the hormone transport system [19,20]. This material has biocompatible characteristics their degradation products do not present toxicity and are easily metabolized and excreted by natural physiological pathways [29]. Several classes of drugs and bioactive compounds, such as enzymes, cytokines, antibodies and glycine, are significantly improved by the pegylation effect (PEGylation) and can bind to amines [30]. Interactions between amino acids and delivery mechanisms of bioactive compounds have been reported in the literature. Glycine is known for its anti-inflammatory and immunomodulatory properties [7,31]. The effectiveness of association of bioactive substances with the polymer matrix increased the ability to obtain new formulations and activate the immune system [19]. In our experimental model we employed colostrum cells considering that glycine is present in secretion [32] and that can occur easily interactions between this amino acid and these cells reproducing a natural environment. Our results confirm that interaction of NANO-PEG/GLY with colostrum macrophages, independent of method used, did not affect the viability suggesting that this system is non-toxic and can act as immunomodulator. The mechanisms of activation of human colostrum phagocytes depend on some signals and stimuli emitted by biologically active molecules that mediate the signals that lead to the production of oxygen free radicals and to the phagocytosis process [33,34]. Phagocytosis and microbicidal activity are important defense mechanisms against several pathological agents such as: virus, bacteria, protozoa infectious and inflammatory processes [7,23, 34, 35]. In this study, the adsorbed glycine PEG nanoparticles were able to modulate the functional activity of human colostrum phagocytes. NANO-PEG/GLY complex increase the microbicidal activity by colostrum

macrophages. Studies have shown the immunomodulatory potential of glycine and its cytoprotective capacity to combat infectious and inflammatory processes in various organs and tissues [31]. The NANO-PEG / GLY complex was more efficient at potentiating bacteria death than glycine treatment alone, thus demonstrating the system's immunomodulatory capacity against inflammatory processes. Soluble components present in colostrum interact with cells and can increase the microbicidal activity [34]. Human colostrum and breast milk are rich in active biological compounds that are essential for pro-oxidative functions. Macrophages also participate in inflammatory response by releasing cytokines and factors that promote cell recruitment to the injured tissue or inflammation site or during the infection [36]. In our work we have showed that macrophages in presence of NANO-PEG/GLY complex increase both cytokines with activity pro-inflammatory such IL-1 $\beta$ , IL-6 and TNF- $\alpha$  and cytokines anti-inflammatory as IL-10 suggesting a balance between these mediators, since it is characteristic of the immunological components of colostrum act together without causing an inflammatory response [37]. Interesting that the macrophages in presence of NANO-PEG/GLY complex increase de IL-17. This cytokine is typical produced by the Th17 T cell subset, but study has demonstrate that macrophages also express Th17 cytokines [38]. In general, the effects of Th17 and the mechanism underlying its action in conditions of systemic inflammation. On the other the presence of IL-17 impairs monocyte/macrophage apoptosis and induces intense differentiation, guaranteeing efficient removal of apoptotic neutrophils and restoration of anti-inflammatory conditions and suggest an unexpected role of IL-17 in the resolution of inflammation [39], that can be important during the phagocytosis and microbicidal process by macrophages. Glycine has therapeutic properties in many models of inflammatory processes [40]. However, cytokines are mediators necessary to conduct the inflammatory response to the sites of infection. The exaggerated production of proinflammatory cytokines from the lesion may manifest systemically with hemodynamic instability or metabolic disorders. Here the microbicidal activity promoted by the presence of NANO-PEG/GLY in phagocytes associated with the balance between pro-inflammatory and anti-inflammatory cytokines may have important clinical implications during the infections.

## V. CONCLUSION

The data suggest that NANO-PEG particles produced were able to adsorb the amino acid glycine, and this new bioengineered material is capable of modulating the functional activity of human colostrum macrophages and



represents an alternative route for the treatment of inflammatory diseases.

#### ACKNOWLEDGEMENTS

This work was supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brazil, Fundação de Apoio a Pesquisa de Mato Grosso (FAPEMAT), Brazil.

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# Feasibility and Environmental Sustainability of a 103.5 kWp floating Photovoltaic Electrical System with a Case Study in a Hydroelectric Power Plant, Santa Clara Hpp, Located in the South of Brazil Region

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**Abstract**— Typical environmental problems associated with the implementation of solar photovoltaic systems for the generation of peak electrical energy, on a larger scale, such as on the order of 1 MWp, is in the occupied area, usually more than 3 km<sup>2</sup>. This can be minimized by the use of water parks or water dam's reservoir, small and large hydroelectric power plants dams. Both the terrestrial and aquatic systems can impact the site, the first one, for the need to promote earthworks, removal of extensive green areas in the surroundings, installation of new transmission line, among others; and the second, despite the fact that a flat surface is already used and that there is no need for new civil procedures for its installation and can normally take advantage of the existing power transmission line, may cause changes in the biota of the reservoir, depending on the shading areas on the surface of the lake. Due to these facts, this research was proposed to investigate, parameterize and tropicalize an electric power generation system based on floating silicon photovoltaic cell panels installed in the Santa Clara HPP reservoir, in terms of peak power, durability, aspects and environmental impacts, with the study of

possible evolutionary improvements of the project such as "tracking" or solar tracking, as well as dynamism of the structure, allowing the shadow area to be shifted over time, minimizing its effects in the local biota.

**Keywords**— floating photovoltaic plant, case study in hydroelectric plant reservoir, environment, durability.

## I. INTRODUCTION

The generation of floating photovoltaic electricity is better utilized and with its lower costs in several countries. The main issue of its implementation is focused mainly on its clean energy and its greater sustainability, since with this technology it is possible to reuse the available surface area in lakes or even water reservoirs with large surface extensions, such as those of hydroelectric plants and, in the latter, by the joint availability of transmission lines installed therein [1-8]. However, the recent technology may cause environmental impacts that have not yet been verified in its extension, due to its recent application in the hydroelectric energy park, thus requiring, research of parameterization, environmental tropicalization and joint investigation of its generation

potential with the integrated form to the physical environment and biota.

In Brazil, the implantation of this type of enterprise is incipient [1, 9-12] and the generated environmental studies are little known and diffused, therefore, its knowledge from the multidisciplinary and environmental point of view has an innovative character. Thus, the survey of possible environmental impacts and the integrated analysis of the project are fundamental for the elaboration of the best alternative in the technical and economic aspects, mainly considering the plants with capacities of generation superior to 1 MWp, considering the necessity of a surface area of the lake or reservoir, at current power standards (of the order of 250 W, per panel), exceeding 10 km<sup>2</sup>. Also, adverse climatic conditions influence the energy yield of the plant, such as the speed and direction of the winds, without even considering the other factors of a tropical country. These have direct influence on the production of an effective anchoring system in order to avoid deviations from its parallelism to the condition of the greater luminous intensity and the dynamism of the panel influenced by the waves.

## II. REVISION AND STATE OF ART

From the mid-2000s onwards, interest in Brazil began for the applications of photovoltaic energy connected to the grid, in the context of research carried out by universities and research centers. With this, dozens of small photovoltaic systems, most of them smaller than 10 kWp, were installed in several regions [13].

With the promising results and in conjunction with other specific Brazilian legislation and program initiatives, in 2011, the first large photovoltaic solar power plant with an installed capacity of 1 MWp was inaugurated and in 2012, the first of a series of stadiums with the same technology, with Brazil having an installed capacity registered at Aneel at the end of 2012, of almost 2.6 MWp [13].

In 2011, there was also a strategic demand for research projects of the National Electric Energy Agency, ANEEL, Report 13, "Technical and Commercial Arrangements for the Insertion of Solar Photovoltaic Generation in the Brazilian Energy Matrix". In this, 19 research projects were registered involving solar generation with photovoltaic power plants in concessionaires of energy of practically all the Brazilian regions, with investments of the order of US\$ 110 million for an installed power of about 25 MW, that is, to a cost approximately US\$ 4.00/W. As one of the possible results of this strategic demand of ANEEL, it was the consideration that in the country, in 2013, "cleaner" energy matrixes were used, with a participation of 41% of the global amount. By 2015, according to the Information Generation Bank (BIG),

317 photovoltaic plants with installed capacity of 15.2 MW of energy were invested in the country, corresponding to 0.01% of the generation capacity, of which 95% were included in generation of up to 100 kW, and that only 6 projects, or 5%, had installed capacity greater than 1,000 kW. Among the largest investments in the area, up to 2015, are MPX's Tauá Plant (2011), installed in Ceará, with 1.0 MW (and a maximum capacity of up to 50 MW) and the Central Mineirão Plant, with an installed power of 1.42 MWp, of Companhia Energética de Minas Gerais, CEMIG. However, in none of these investments was the use of floating [14-18]. Under the call 003/2015, the companies cooperated by the Centrais Elétricas do Norte do Brasil SA, ELETRONORTE, and the Hydroelectric Company of São Francisco, CHESF [19] launched a call for a research and development project entitled "Exploration of solar energy in lakes of hydroelectric power plants", with the objective of implementing a sustainable generation system of complementary solar power of 10 MWp of power (of these: 1 MWp of a pilot system for the evaluation of the load factor and the installation of 4 MWp in each of the lakes), using photovoltaic panels mounted on floating platforms on the lakes of the hydroelectric plants of Sobradinho (BA, Northeast of Brazil) and Balbina (AM, northern region of Brazil). In this project, at a cost around US\$ 3.00 / W, the objectives were to study the behavior of this application on the surface of the reservoirs, the resulting environmental impacts, the use of ecologically correct and technically feasible materials for replication in the other reservoirs and which do not necessarily block the passage of natural light, anchorage and studies to enable the connection of the systems to the grid, as well as other electrical parameters. However, none of the data generated was previously available to the scientific community.

In 2016, the Companhia Energética de São Paulo (CESP), in the municipality of Rosana, SP, Brazil, launched the first photovoltaic plant with flexible plates and floating systems with research project with ANEEL and resources of the order of US\$6.3 million, for a rigid 250 kW ground and 25 kW floating plate system and one with 250 kW flexible solar panels and 25 kW floating systems [9], the occupied area being estimated at, approximately 500 m<sup>2</sup>, and the reservoir had 2,250 km<sup>2</sup>, at an approximate cost of US\$ 12.00 / W. Strangueto, 2016 [1], pointed out that the generation of floating photovoltaic solar energy installed in lakes and dams, is already used in several other countries, but in none of these has it found projects in reservoirs of hydroelectric plants. These generators are focused on the pumping of water for agriculture, for the maintenance of production or the increase in the electric grid, with additional advantages being



the reduction of the evaporation rate of the water in the reservoirs and the reduction of the algae proliferation. For Brazil, Strangueto, 2016 [1], calculated the scenario obtaining an estimate of the energy potential of the reservoirs and the total energy that could be produced, with limits for a maximum average scenario of 4,519 GWp for the Brazilian potential, with average power of 753 GW average, or up to 4,443 TWh of energy per year, and for a lower limit of 10% of these values for the lower scenario, using 80% and 8%, respectively, of the reservoirs in each scenario. As suggestions for future work related, the researcher highlighted: a) to make a parallel study of economic analysis, in which, the costs of panels, the manufacture of floats, the anchoring process in the reservoirs should be contained; b) investigate the characteristics of the environments in order to reduce the impacts caused by the losses by evaporation of water; the reduction of water oxygenation and changes in the biota of the reservoirs; c) extend knowledge about social impacts, resulting from the reduction of possible fishing and aquaculture activities, loss of leisure areas; d) to investigate and carry out the survey of field parameters, in order to obtain generation values of each system; e) to promote additional studies on the possible deflections of the systems in relation to the depth of the reservoirs and their variations of level and exclusion areas.

Projects of floating photovoltaic installations are still expanding themes and research. Its motivators are, mainly, the restriction of the use of terrestrial areas for the installation of solar plants, using as alternatives, water reservoirs. In Trapani and Santafé, 2015 [2], a review of the projects of floating photovoltaic plants installed between 2007 and 2013 was presented, being these separated in projects of conventional photovoltaic plants and conceptual projects. The common benefits presented for all the projects reviewed in this work were the reduction of evaporation of water from the reservoir and the decrease in the growth of aquatic vegetation due to the lower penetration of solar energy (when there are no environmental restrictions, as in artificial reservoirs). In most cases, it was found that the efficiency of the solar installation was improved by the cooling caused by the evaporation of the water, or by the direct contact of the panels with the water as in the conceptual design [3]. Still, in Trapani and Santafé, 2015 [2], were cited the projects implemented until 2013.

The project of the Polytechnic University of Valencia, installed in 2009 on a water reservoir for irrigation in Agost, Spain was described in Santafé et al., 2015 [4], Ferrer Gisbert et al., [5] and in Ferrer and Ferrer et al., 2010 [20], the system of support and flotation of the installation, characterized by the following elements: floating platform,

support structure, metal couplings articulated between floats, flexible joints, ropes and rigid anchorage system. The floats were designed in modular formats that allowed the fitting between them by flexible joints, to absorb the relative movement between them, also considering a possible drought situation of the reservoir. The system in general numbers was constituted of 1,458 photovoltaic panels supported on 750 floats, totalizing 4,490 m<sup>2</sup> of area on the water reservoir.

In this investigation, the parameters of tropicalization, the technical and scientific viability of the installation of a floating photovoltaic plant on the 103.5 kWp small-scale photovoltaic power plant (SFPPP-StC) reservoir were analyzed and discussed. to be installed in an area of over 1.5 km<sup>2</sup>, being one of the first similar projects to be implemented in the Southern region of Brazil, in the state of Paraná. In order to do so, emphasis was placed on its influence and the environmental effects or impacts on the physical environment and biota present, since a large part of the existing energy systems are not installed in reservoirs of hydroelectric power plants.

### III. MATERIALS AND METHODS

**Photovoltaic panels, inverters and accessories.** The acquisition of the photovoltaic panels was based on the maximum electric power available within the research budget, which was 345 Wp (watt-peak), Canadian Solar brand, type 144 Cells, poly-Si, dual cell – 1,500 V. all, were considered for the purchase, approximately, 300 panels for the service of 103.5 kWp of the plant. As inverters, 2 units of the ABB trio TM equipment, 50.0-400-power module, 3MPPT-380 V, were acquired with 98% efficiency. Other accessories made up the electrical system and corresponded to cables and fastening devices for connection to a 34.5 kV power distribution network.

**Prototype float.** In order to reduce the environmental impact on the physical environment and biota of the reservoir, by reducing the total area of shading by the plant, a float module constructed in metallic system of carbon steel coated by hot galvanizing was idealized. In this, the beams, the body guard, the catwalk (in perforated expanded plate) and the galvanized carbon steel fixings, with a minimum of fixing with screws were considered. For the floats, high-density polyethylene, HDPE, was added as a base material, with the addition of anti-UV material in its constitution, using 250 L cylinders from reuse material made available after the intercontinental transport of oils. These were prewashed and disinfected for reuse.

The metal fixing profile of the panels was designed to meet a static or dynamic tracking system for SFPPP-StC, following the highest daily solar incidence. Also, the design was

worked with a linear distance of 980 mm modules to obtain panel slopes up to 25° for better geometry in relation to solar radiation. In terms of safety, a body guard was designed to meet Brazilian standard requirements (NR 12 [21]) and to cause minimal shading on panels.

For the interconnection of the modules, a system was developed with the capacity to allow the angular relative displacement between them, taking into account the oscillation of the lake water. Thus, the main idea of the lateral and longitudinal junction system was to allow its movement in the most independent way possible in relation to the others. For this fixation, we chose a design with cushion systems between them.

**Location of deployment of SFPPP-StC.** During a technical visit to the Santa Clara HPP reservoir, three sites were economically and technically considered viable for the plant's implantation, as shown in Figure 1, A, B and C.

**Hydrodynamic modeling of the reservoir for the implantation of the SFPPP-StC.** In order to parameterize the reservoir for the implantation of the plant, modeling was done with respect to the water velocity, the average height of the waves, with a parametric approach that calculates the significant height of the wave as a function of wind speed, direction and "fetch" wind track in 16 directions, with delft3d software, from the company Deltares [22, 23].

The historical series of water levels, between 2006 and 2018, was raised in order to consider the linear deviation of the plant from the margin of the reservoir and to minimize its influence on the vertical displacements and water. Also, a topobathymetric profile of the region was obtained to obtain the mean depth, which will serve to launch an anchorage system.

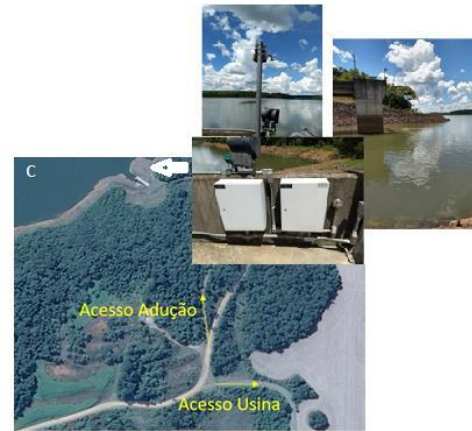


Fig.1: Illustrative images of the possible SFPPP-StC implantation sites in the Santa Clara HPP reservoir (adapted from Google Earth, 11 and 12/2017), being: A) 100 m from the left of the dam; B) 200 m from the right; and C) upstream of the adduction channel (about 150 m).

**Physical-chemical analyzes of reservoir water.** The characterization of the physical parameters and their chemical composition were performed considering the water quality index (IQA) of the reservoir, preliminary to the implementation of PCFF-StC, with the measurement of pH, dissolved oxygen, DO, temperature, turbidity, the total solids, suspended and dissolved and the main cations and anions.

Solarimetric index, local environmental data and their feasibility in terms of the use of a static or dynamic system of energy production. These local environmental parameters were considered for their measurement from the installation of a compact solar station with GPRS / GSM data telemetry, consisting of an HOBO RX 3003 datalogger, a S-THB-M002, with solar shelter, with wind speed sensor S-WSB-M003; with SR20-D2 secondary standard pyranometer and accessories.

#### IV. RESULTS AND DISCUSSIONS

**SFPPP-StC installation location.** The first two points with the possibility of installing the plant (Figure 1A and B) were discarded, because they are located next to the concrete dam at Santa Clara HPP and because in the rainy season, dragged by the stream of water from the reservoir flowing freely through the spillway that is located about 150 m from this site. The location of the SFPPP-StC was chosen based on the proximity of a 34.5 kV electric power distribution line, its easy access, the instrumental safety by video camera and the local sound system, the private area of the plant, being close to the adduction channel at 25°39'23 "S and 51°57'6" O, with elevation 750 m at sea level. Figure 1 C shows the idealized location of the photovoltaic plant.



**The float module and features.** In order to reduce the projected shading area on the surface of the reservoir, which is a function of its angular relationship with the incident radiation, this project was chosen for a higher installed power per panel. This was equivalent to 103.5 kWp, corresponding to 300 panels installed on 46 floatings modules in an area close to 1.5 km<sup>2</sup>.

The total shading area projected on the surface of the reservoir, which varies with the solar zenith, was simulated to a minimum of 5.05 m<sup>2</sup>, when the incident radiation is approximately 150° of this, and a maximum of 23.28 m<sup>2</sup>, when the angle of the radiation is 30°, that is, in the rising sun. Between these intervals, the resulting shadow per floating module is a maximum of 13.67 m<sup>2</sup>. In Figure 2, there are shown 3 schematic drawings of the float module, to reduce as much as possible the resulting shading in the reservoir and its environmental impact on the local biota. Complementing the other float modules available in the market, which mostly design a total shading on the reservoir, it was designed in order to meet different geographical positions, by changing the angle of arrangement of the solar panel in relation to the incident radiation and, also, in order to facilitate the placement of a tracking device throughout the

plant. Each module is attached to the next one by means of an articulated system, to minimize the impact of the fluvial waves on the set floating (Figure 2 C).

The prototype of the flotation module was tested for water tightness and stability over normal water and under turbulence in a controlled aquatic environment. In Figure 3, a photo of the prototype of the designed float module is shown.

**Environmental considerations of the site.** The depth profile of the reservoir is shown in Figure 4, and the SFPPP-StC installation region is indicated by arrow, with depths between 13 and 34 m.

**Weather data.** On-site historical meteorological data analyzes (number of analyzes, carried out in about 1 decade) indicated average wind speeds of up to 10 ms<sup>-1</sup>, a seasonal ambient temperature ranging from 4 to 32 °C, and a solar radiation index more than 800 W.m<sup>-2</sup>. By mathematical simulation, the maximum heights of the waves were estimated on the surface of the reservoir, which, in some way, impact on the energy yield of the plant, by altering the angle of incidence of the solar rays, having as initial variable the winds with the velocity, minimum of 1.5 m.s<sup>-1</sup>, at maximum, extrapolated to 20 m.s<sup>-1</sup>, reaching 0.1 to 0.40 m in height, as can be seen in Figure 5.

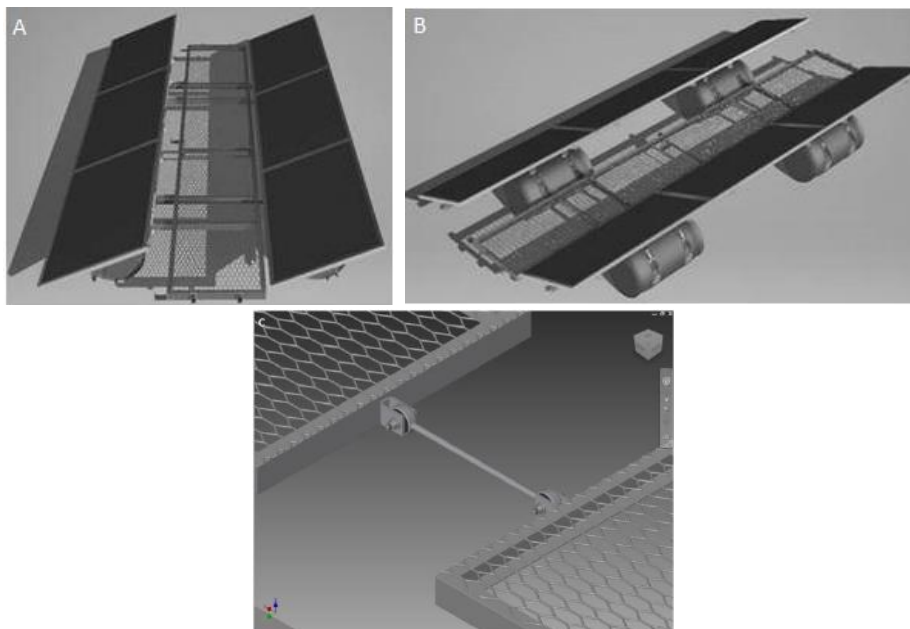


Fig.2: Illustrative schematic drawing of the SFPPP-StC float module with 6 solar cell plates with 345 Wp, each being: a) frontal view; b) cross-sectional view; and c) articulated arms for fastening between modules.



Fig.3: Illustrative picture of the prototype of the flotation module under watertight test and stability over water under conditions of greater turbulence.

By analyzing the historical data of reservoir floods, it was verified in a decade a variation of its quota in about 17 m (top / down), which makes it impossible to install the SFPPP-StC, near the reservoir margin.

*Water quality Index, WQI.* The analysis of the water of the reservoir, near the SFPPP-StC site, showed a WQI higher, on

average to 80%, being classified as optimal and not degraded, with annual average physical-chemical parameters, presented in Table 1. By the results of  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$  and  $K^+$  and  $HCO_3^-$ ,  $Cl^-$ ,  $SO_4^{2-}$  concentration, in Piper diagram showed in Figure 6, the reservoir water was classified as calcium and mixed bicarbonated.

Table.1: Analytical results of water quality in the middle portion of the Santa Clara HPP reservoir and CONAMA Standardization limit [24].

Parameters analyzed	Standardization Limit [24]	Water sample results	
Depth of sample collection (m)		0.6	16.0
Temperature (°C)		23.5	18.2
pH	6.0 to 9.0	7.5	
Electrical conductivity ( $\mu S.cm^{-1}$ )		25.0	
Turbidity (NTU)	100	14.0	
Total solid ( $mg.L^{-1}$ )		5.0	
Dissolved oxygen ( $mg.L^{-1}$ )	$\geq 5.00$	8.02	6.33
Total P ( $mg.L^{-1}$ )		0.03	0.03
Total N ( $mg.L^{-1}$ )		0.91	
Total N-NH <sub>3</sub> ( $mg.L^{-1}$ )		< 0.1	<
			0.1
Total N-nitrite ( $mg.L^{-1}$ )	1.00	<	<
		0.01	0.01
Total N-nitrate ( $mg.L^{-1}$ )	10.00	< 0.5	0.65
Inorganic total N ( $mg.L^{-1}$ )		< 0.5	0.70
BOD ( $mg.L^{-1}$ )	< 5.00	< 2.0	
DOQ ( $mg.L^{-1}$ )		< 5.0	<
			5.0
Chlorofila-a ( $\mu g.L^{-1}$ )	30.00	0.71	
Phytoplankton ( $cel.mL^{-1}$ )		1,419	15
Cyanobacteria ( $cel.mL^{-1}$ )	50,000	611	0
Potentially toxic cyanobacteria ( $cel.mL^{-1}$ )		611	0
Secchi disk (m)		1.1	1.1



At the water sampling station near the SFPPP-StC site, in the deepest portion of the reservoir, a continuous stratification pattern has been observed historically, even in colder months. However, in the months of higher temperatures, as in the summer, the stratification was more pronounced in relation to the colder ones. The temperature difference

between the surface and the bottom was 7.2 °C and the DO varied 6.8 mg/L, as shown in Figure 7. With regard to its concentration in the background region, no anoxia events were observed, however, hypoxia was recorded at a depth of 29 m, where the value of 1.21 mg.L<sup>-1</sup> occurred.

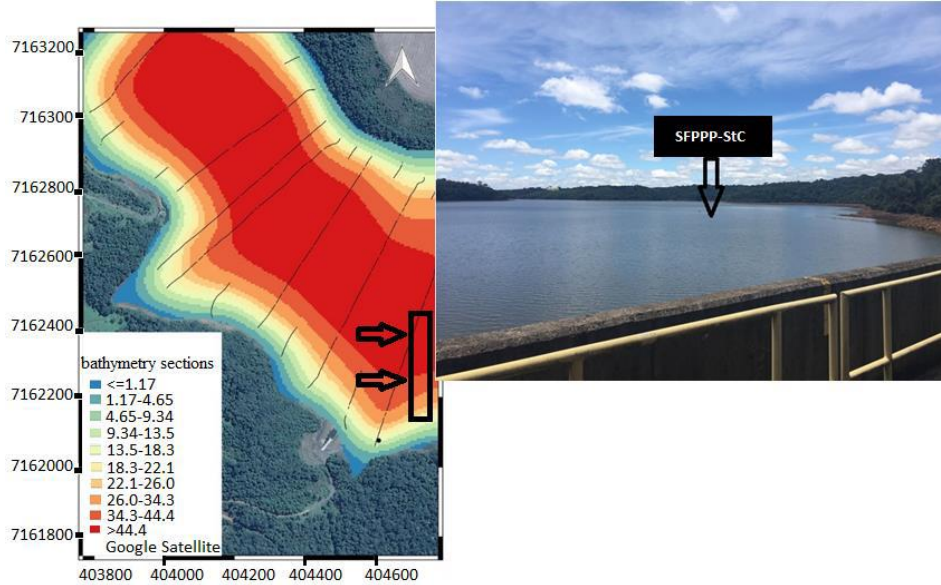


Fig.4: Graphic image of bathymetric sections, near the water outlet of the hydroelectric plant, for the installation of the SFPPP-StC.

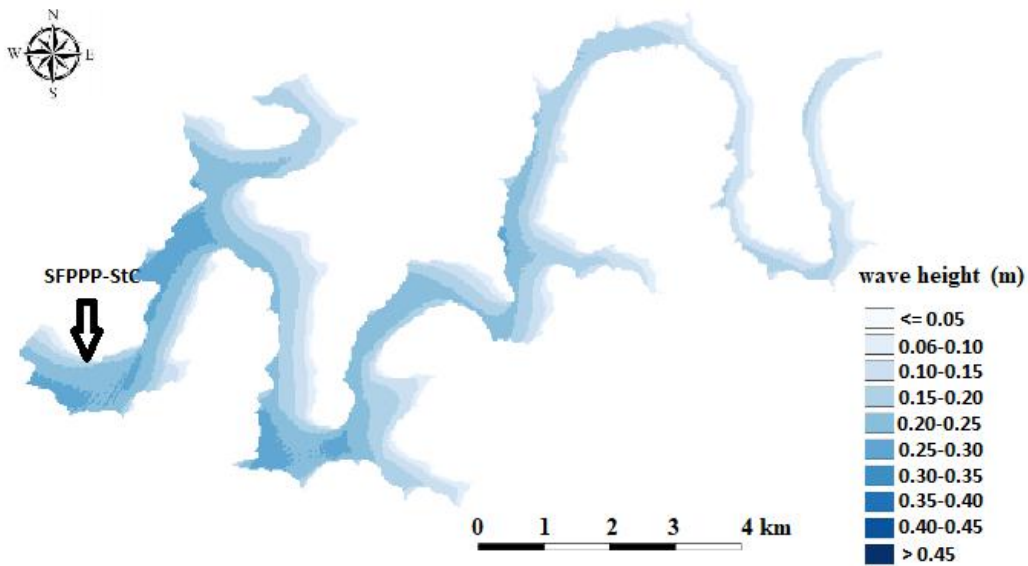


Fig.5: Georeferenced wave height map in the Santa Clara HPP reservoir, Paraná, Brazil, for a mean minimum wind of 1.5 m.s<sup>-1</sup> at 20 m.s<sup>-1</sup>, in the ENE direction.

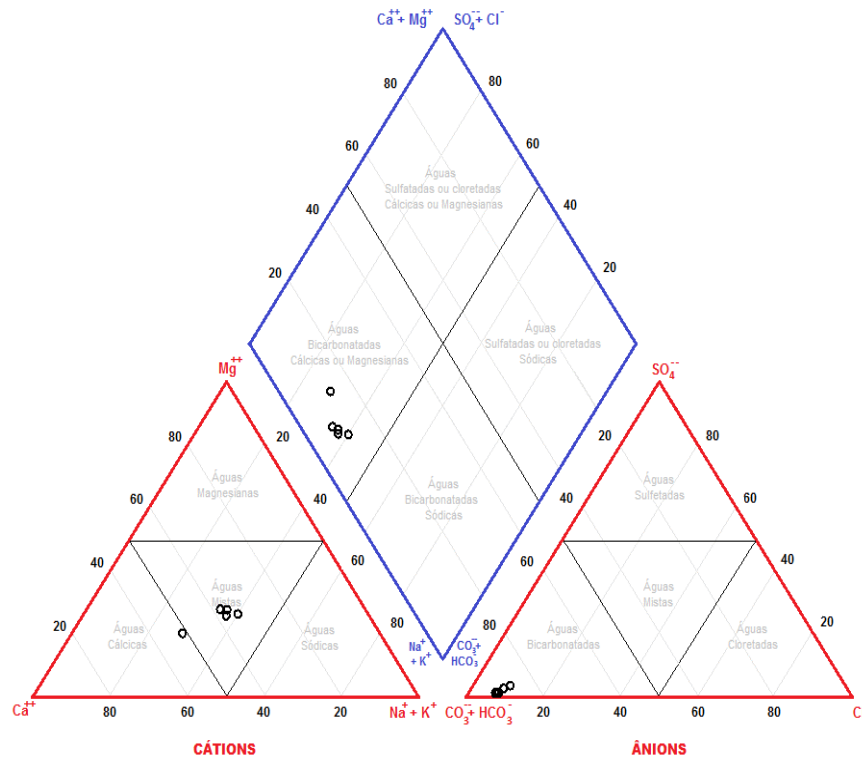


Fig.6: Piper diagram of the water samples collected in the Santa Clara HPP reservoir, at depths of 0.5 m (1); or water surface column; 3.5 m (2); 7 m (3); 14 m (4) and 28 m (5).

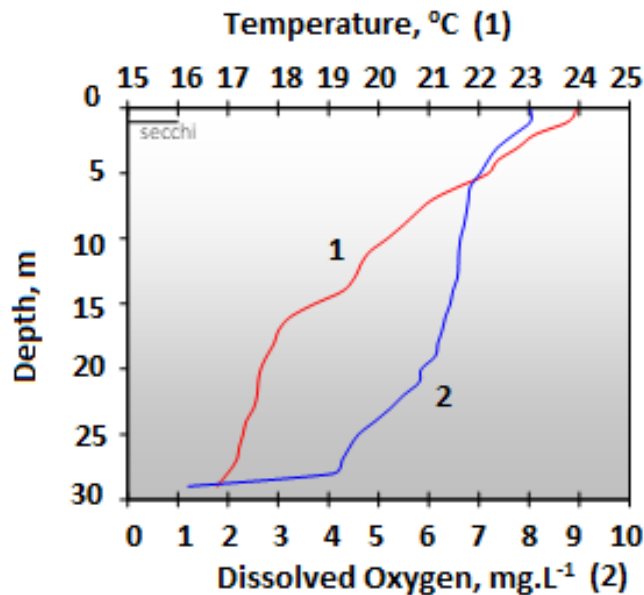


Fig.7: Graph illustrating the vertical profiles of DO and temperature, measured along the depth in the reservoir of the Santa Clara HPP, near the SFPPP-StC.

Phytoplankton. For the characterization of the phytoplankton community of the reservoir, were used data from a sample network of collection stations, one of them in the region surrounding the plant SFPPP-StC, using as indicators the cell

density, expressed in number of cells per milliliter ( $\text{cells.mL}^{-1}$ ); total richness, expressed in terms of the total number of species present; the abundant species, considering those whose occurrence exceeded the average value of the total

number of individuals of the species in a sample; the dominant species, whose density exceeded 50% of the total number of individuals counted in a sample, among others [25-30].

It can be observed that the phytoplankton community was well represented by cryptophyceae, green algae and diatoms. The environment is typically oligotrophic. Potentially toxic cyanobacteria were also recorded, but at low cell densities such as *Merismopedia tenuissima*, *Aphanocapsa delicatissima*, *Aphanocapsa sp.2* and *Cuspidothrix issatschenkoi*. Another factor of the community was the presence of the dinoflagellate *Ceratium furcoides* in two seasonal moments, winter, with a density of 8 cel.mL<sup>-1</sup> and, in the spring of 2017, with a density of 4 cel.mL<sup>-1</sup>. Although it does not present any toxicity, when flowering, it can alter the taste and odor of the water, as well as, cause the *DO*

decrease by the massive decomposition of the cells, compromising the quality of the water and increasing the costs of the treatment [29]. The presence of this dinoflagellate should be monitored because it is an exotic invasive species and its ecology is still little known.

The phytoplankton community present in the reservoir had been behaving in a seasonal manner, with some species, such as *Cryptomonas brasiliensis*, *Rhodomonas lacustris* and *Cryptomonas sp.*, As well as the green algae *Monoraphidium contortum*.

In the summer of 2017, in this season, the classes Bacillariophyceae and Chlorophyceae were the ones that presented a greater local abundance and the Cyanophyceae that presented a higher density of cells.mL<sup>-1</sup>, as can be observed Table 2.

Table.2: Occurrence of phytoplankton species in the region surrounding the SFPPP-StC, with density in cells.mL<sup>-1</sup>, in 2017.

CLASS	SPECIES	MARCH	JUNE	SEPTEMBER	DECEMBER
Bacillariophyceae	<i>Aulacoseira minuscula</i>	20	-	-	-
	<i>Aulacoseira pusilla</i>	40	-	8	3
	<i>Aulacoseira tenella</i>	-	16	-	28
	<i>Cyclotella meneghiniana</i>	-	4	-	-
	<i>Discostella stelligera</i>	147	-	4	9
	<i>Fragilaria sp. 2</i>	10	-	-	-
	<i>Nitzschia sp. 1</i>	-	25	10	-
	<i>Urosolenia obesa</i>	69	-	-	-
Chlorophyceae	<i>Closteriopsis sp.</i>	10	8	10	-
	<i>Desmodesmus sp. 42</i>	42	-	-	-
	<i>Desmodesmus sp. 25</i>	-	8	-	-
	<i>Elakatothrix gelatinosa</i>	10	-	-	-
	<i>Eutetramorus sp.</i>	39	-	-	-
	<i>Eutetramorus sp.</i>	10	-	-	-
	<i>Monoraphidium contortum</i>	20	4	27	54
	<i>Monoraphidium minutum</i>	-	8	48	32
	<i>Monoraphidium sp.1</i>	1	-	-	-
	<i>Tetranephris brasiliensis</i>	118	-	-	-
Chrysophyceae	<i>Chrysamoeba sp.</i>	-	-	76	13
	<i>Mallomonas akrokomos</i>	30	-	10	51
	<i>Mallomonas tonsurata</i>	39	8	-	-
Cryptophyceae	<i>Cryptomonas brasiliensis</i>	88	25	10	19
	<i>Cryptomonas sp.2</i>	284	90	2	2
	<i>Rhodomonas lacustris</i>	1549	385	133	318
	<i>Rhodomonas sp.1</i>	59	-	-	-
Cyanophyceae	<i>Aphanocapsa delicatissima</i>	1088	25	-	-

CLASS	SPECIES	MARCH	JUNE	SEPTEMBER	DECEMBER
	<i>Aphanocapsa sp.2</i>	1078	-	-	-
	<i>Cuspidothrix issatschenkoi</i>	392	-	-	-
	<i>Merismopedia tenuissima</i>	-	4	-	25
Dinophyceae	<i>Ceratium furcoides</i>	-	8	4	-
	<i>Peridiniopsis penardiforme</i>	10	-	-	-
Prasinophyceae	<i>Nephroselmis sp.</i>	186	16	48	13
	<i>Pedinomonas sp.</i>	412	-	48	274
	<i>Tetraselmis sp.1</i>	109	8	1	-
Zygnemaphyceae	<i>Teilingia granulata</i>	-	4	-	-

## V. CONCLUSION

The float module designed for the fixation of 6 photovoltaic panels of 345 Wp each was tested in a monitored aquatic environment, passing the tests of stability and watertightness, as well as its design showed to cause a maximum shading, in the waters of the reservoir, in zenith solar at 30° of 23.28 m<sup>2</sup>, with the rising sun, and of minimum, 5.05 m<sup>2</sup> when it is at 150° in relation to the panels in the floats. At the highest daily interval, the maximum projected shade was simulated at 13.67 m<sup>2</sup>, at 60° solar incidence.

The calculated WQI showed that the waters in the Santa Clara reservoir presented excellent quality, being classified between calcium and mixed bicarbonated, and its results based on about a decade of the collected samples showed to be a poorly degraded environment.

As for the chemical and thermal stratification of the reservoir, in the region of plant implantation, the reservoir showed strong stratification, reaching the bottom hypoxia at depth of 29 m with an average value of 1.21 mg.L<sup>-1</sup>. No anoxia was recorded by the evaluation of the dissolved oxygen profile.

The general analysis of the phytoplankton showed the possibility of having them as indicators of any occurrences of a possible environmental degradation of the water of the reservoir due to the installation of the floating photovoltaic plant.

## VI. ACKNOWLEDGMENTS

The authors are grateful for the support provided by Instituto de Tecnologia para o Desenvolvimento, LACTEC; Agência Nacional de Energia Elétrica, ANEEL; Centrais Elétricas do rio Jordão S. A., ELEJOR; Universidade Federal do Paraná, UFPR; Universidade Federal do Tocantins, Campus Gurupi; and the Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq/PIBITI/

Scholarship DT 1D, process 302672/2016-8; CNPq Law 8010/90, entities that enabled the development of this work.

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# Monitoring of water Quality in the São João River Hydrographic Basin in the Municipality of Porto Nacional – Tocantins

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**Abstract**— *The world today faces a major problem that is the pollution of water resources, occurring a huge loss of water quality. The quality monitoring is of utmost importance for obtaining physical, chemical, biological and ecological information of water resources through sampling. However, this research will cover a study of the waters of São João river, an important water resource for the municipality of Porto Nacional-TO, to meet the demands of the city in relation to supply, fishing, leisure, among others. This project will be directed in three stages: study and demarcation of three points of the hydrographic basin, field methodology and then laboratory methodology. The parameters to be analyzed are: temperature, oxygen, pH, total nitrogen, total phosphorus, electrical conductivity, total of coliforms, total of solids and turbidity. The project will examine the quality of the water, verifying if the basin has the necessary parameters determined by Resolutions 274/2000 and 357/2005 of the National Environmental Council (CONAMA).*

**Keywords**— *São João river, Water Quality. CONAMA.*

## I. INTRODUCTION

One of the main natural resources for the existence of the human being is water. It would be difficult to imagine any kind of life in the absence of this vital resource. Water is a natural resource that encompasses all aspects of human civilization, from agricultural and industrial development to cultural and religious values rooted in the society.

This resource covers a series of important factors, such as ecosystem conservation, human consumption, recreational use, among others. Speaking of human survival, it is important to note that water is essential for living beings,

and as a way of life for vegetal and animal species. A large part of the world's territory is occupied by water, with 97% of them salted and only 3% fresh, and among it only 0.01% comes from lakes and rivers that are the main sources of supply for the population (CETESB, 2007).

Philippi Junior and Martins (2005) affirm that one third of the Earth's population is currently estimated to live in areas with water scarcity because of degradation. These conditions are related to the precarious nature of water systems and sanitary and industrial sewage, the abusive use of pesticides, inadequacy of the solutions used for waste disposal, the absence or insufficiency of measures to protection against flooding, erosion and depletion of water sources, pollution levels and water, atmospheric, soil, subsoil and food contamination.

Several indices were developed based on physical-chemical characteristics of the water or from biological indicators, with adjustments in weights and parameters to suit regional realities. These water quality indexes are usually based on a few variables (Gergel et al., 2002), whose definition must reflect the potential or actual natural or anthropogenic changes that occur with the water (Toledo & Nicolella, 2000).

The monitoring of water quality, through a sampling process, seeks to obtain qualitative and quantitative information, reaching purposes such as knowledge of biological, chemical and physical conditions, framing a body of water in classes or for inspection purposes. São João river is located in the state of Tocantins, which is the newest one of the federation and so has a low development level, being created in 1988, with vast water availability, thus providing good agricultural activity, irrigable areas,

and great hydroelectric potential in the municipality of National Harbor.

The water basin area of São João river is the only source of water supply in the city, and it is suffering from several aggressions, such as agricultural activities, where it is clear the necessity to use the water with rationality to improve the quality of life of the population and sustainability. In view of the above, the present work has the objective of evaluating the water quality of São João river in Porto Nacional, through the determination of a water quality index - IQA NSF, through the indicative parameters.

Currently, a huge problem is faced in relation to water quality, mainly due to the anthropic actions. The water basin area of São João river, which is located in the municipality of Porto Nacional-TO, is a major source of distribution that has undergone changes in water quality in its water body.

São João river presents a variation in the quality of the water that is used to supply the municipality. With this, it is necessary to evaluate the quality of the basin water, to correct it, looking for its necessary parameters.

With water being a resource of great necessity for life, it is indispensable to be provided with good quality. Due to the changes in water quality, it was interesting to analyze the water resource addressed to identify whether it meets the conditions of public supply, with this resource being the only source of supply of the municipality.

## II. MATERIAL AND METHODS

### Study area

The São João river Basin has an area of approximately 82 km<sup>2</sup>, which is located in the State of Tocantins, between parallels 10° 46'43 "and 20° 41'20" of south latitude and between meridians 48° 14'16 "and 48° 24'51" of west longitude, southeast of the municipality of Porto Nacional-TO (Fig. 1), with its river mouth in the urban area, being a direct contributor of the Tocantins River.

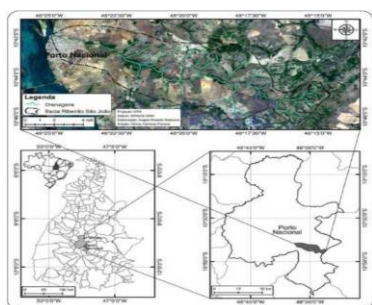


Fig. 1 – Location map of the Water Basin

Source: BALDUINO, 2018.

São João river has its source in the rural area, in Pilões Farm (coordinates S 10°46'08 "and W 48°15'57"), with direction for the municipality of Porto Nacional, crossing several rural properties and some representative neighborhoods, such as: Jardim Querido, Jardim

Umarama, Santa Helena and Vila Nova, with its river mouth (coordinates S 10°42'10 "and W 48°23'47") in the Tocantins river lake (BALDUINO, 2016).

### Diagnosis of the river basin

The diagnosis of the river basin was made through field visits, where the conditions of preservation in its extremities were observed, such as the ciliary forests that run from the source, analyzing if they will be in agreement with the new forest code, Law 12651/2012, that affirms that the Permanent Preservation Area (APP) for source and water eyes is of the order of 50m radius in the surroundings. The basin under study, related to the new forest code, is classified as a natural perennial watercourse and, in this case, its APP covers a minimum width of 30 meters, so it is a watercourse of less than 10 meters wide.

### Field methodology

The field methodology for sample collection was performed according to NBR 9897 for the demarcation of points and for sample collection. To begin the study, three (3) collection points were defined for analysis. The location of the points is shown in Table 1.

Table 1. Coordinates of water collection points for analysis of São João river in Porto Nacional, Tocantins.

Collection Points	Latitude (S)	Longitude (W)	Place of reference
PI	10° 46'08''	48°15'57''	Near the source (Pilão Farm)
PII	10°43'02''	48°22'21''	Saneatins Dam
PIII	10°42'10''	48°23'47''	Near the river mouth

It was also used satellite images for better understanding (GPS map 60CSx Garmin) and visualization of the collection points of the São João river basin (Fig. 2).

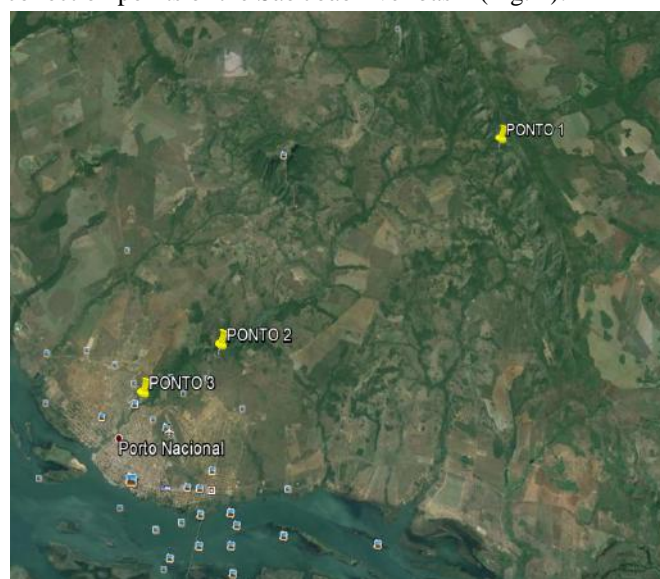


Fig. 2 - Collection Points

Source: Google Earth (2018)

For the determination of the IQA NSF (Water Quality Index), the parameters that were analyzed are:

- Water temperature (°C);
- Dissolved Oxygen (OD)
- Biochemical Oxygen Demand (BOD);
- Hydrogen Ionic Potential (pH);
- Turbidity;
- Electric Conductivity;
- Total of Dissolved Solids (SDT);
- Total Nitrogen;
- Total Phosphorus;
- Fecal Coliforms

**Collection of water samples**

The water samples for the analyzes were collected in a weekly basis in the period of six weeks at three different points, from November 2017 to April 2018, using 100 ml containers for microbiological and 2000 ml for the physicochemical ones, being then labeled and packaged in iceboxes and taken to be processed in the laboratory of the Federal Institute of Education, Science and Technology of Tocantins, in Porto Nacional and LAPEQ - Research Laboratory in Environmental Chemistry, Federal University of Tocantins (UFT) - Palmas Campus - TO In total, 18 water samples (microbiological and physicochemical) were collected at the three analyzed points.

**Laboratory Methodology**

Fecal coliforms (CF) were analyzed according to the filter membrane technique, in according to the methodology described by Standard Methods; Total Nitrogen: was analyzed by the micro Kjeldahl method; Total Phosphorus: through the ascorbic acid method after digestion with ammonium persulfate; Total of Solids: were analyzed by the porcelain capsule method; Turbidity: determined by the nephelometric method; Biochemical Oxygen Demand (BDO): was determined by the A standard method. (APHA, 2005).

**Calculation of the NSF Water Quality Index (IQA)**

The IQA was calculated by the multiplicative weighted mathematical formula of the water quality corresponding to the following parameters: sample temperature, pH, dissolved oxygen saturation percentage, biochemical oxygen demand (5 days, 20° C), fecal coliforms, total nitrogen, total of phosphorous, total of solids and turbidity. Being exposed by the equation:

Equation (1):

$$IQA = \prod_{i=1}^n q_i^{w_i}$$

Where:

- IQA:** Water Quality Index, a number between 0 and 100;
- qi:** quality of the i-th parameter, a number between 0 and 100, obtained from the respective average curve of quality

variation for each parameter, depending on its concentration or measure;

**wi:** weight corresponding to the i-th parameter or sub-level, a number between 0 and 1 (Table 2), attributed according to its importance for the global conformation of quality, where:

Equation (2):

$$\sum_{i=1}^n w_i = 1$$

Where:

**n:** number of parameters in the IQA calculation

Table 2. Parameters and weights for the calculation of IQA – NSF

PARAMETERS	UNIT	WEIGHT (wi)
CF	NMP/100ml	0,15
pH	-	0,12
DBO	Mg/L	0,10
Total of nitrogen	Mgn/L	0,10
Total of phosphate	MgPO <sub>4</sub> /L	0,10
Temperature	°C	0,10
Turbidity	NTU	0,08
Total of solids	Mg/L	0,08
OD	%saturation	0,17

Source: Yisa et al. (2012):.

The water quality classification of the river stream was performed according to the levels specified in Table 3.

Table 3 - Quality level or water classification according to the IQA-NSF result

Quality level	Rate
Excellent	90 < IQA ≤ 100
Good	70 < IQA ≤ 90
Average	50 < IQA ≤ 70
Bad	25 < IQA ≤ 50
Very Bad	00 < IQA ≤ 25

Source: Yisa et al. (2012).

**III. RESULTS AND DISCUSSIONS**

**Water Quality Index (IQA)**

The results of the physical, chemical and bacteriological parameters of the surface waters of the São João River were used to calculate the IQA in the period corresponding from November 2017 to April 2018. The classification of the waters quality of São João River was performed according to the values recommended by the NSF. The data collection took place during the rainy season and at the beginning of the dry season. In the rainy season the



water presented a dark coloration that is a result of the solids carried to the river bed, and in the period of drought the water presented a transparent coloring. It is important to note that the darker color of the water does not indicate contamination, since the colorless water may also be contaminated. With the results obtained, it was observed that the São João River Basin presented a variation of the IQA from 51.98 to 63.07. The study showed that according to the IQA values, water quality can be classified as "medium". With the results presented, it is possible to affirm that the area where a low water quality is presented is also where urban activities are predominant, in every season (dry and rainy). Similar studies such as those of GAZZAZ et al. (2015), Liu et al. (2015), OCAMPO-DUQUE et al. (2015) and RUBIO-ARIAS (2015) associated the variations in IQA values with contributions from industry, domestic activities, and drainage of the basin, which in turn affect water bodies.

According to Carvalho et al. (2016), it was observed that the behavior of the IQA in the same three points presented a variation of 49.74 to 80.72, during a different period of collection. In the Carvalho study, it was shown that according to the values obtained for the IQA, water quality can be classified as "good" for most of the period.

Of the nine parameters, three (dissolved oxygen, total of phosphorus and total of coliforms) were in disagreement with the values established by the NSF resolutions. However, the variations presented showed that they were not significant to reflect the final results, demonstrating that such variations were absorbed by other parameters.

Table 3. Water Quality Index (IQA NSF) in the three collection points.

Points	PI	PII	PIII
<b>Dates</b>			
November/2017	<b>63,07</b>	<b>59,67</b>	<b>57,70</b>
December/2017	<b>61,8723</b>	<b>60,16</b>	<b>56,89</b>
January/2018	<b>54,35</b>	<b>57,70</b>	<b>56,71</b>
February/2018	<b>56,65</b>	<b>57,54</b>	<b>54,55</b>
March/2018	<b>51,98</b>	<b>61,16</b>	<b>54,40</b>
April/2018	<b>55,27</b>	<b>60,67</b>	<b>56,16</b>

#### IV. CONCLUSIONS

The results obtained in the period under study regarding the degradation level allow us to conclude that the waters of São João River did not meet all of the quality parameters determined by the CONAMA Resolution 357/2005 for class two waters. In the NSF IQA calculation, of the nine parameters (dissolved oxygen, biochemical oxygen demand, pH, total nitrogen, total of phosphorus, turbidity, total of coliforms and total of dissolved solids), three (dissolved oxygen, total of phosphorus and total of coliforms) were in disagreement. The bathing conditions, Resolution CONAMA 274/2000, specifically in point three (PIII), presented values above the recommended ones, making it improper for recreation of primary contact.

As a result of these continuous processes of degradation affecting the hydrographic basin under study, and of its social, economic and ecological importance for the municipality of Porto Nacional, high investments should be made in the management of water resources for the prevention, recovery and preservation of this great environmental patrimony, São João River, to increase the IQA (Water Quality Index), which currently classified as "average".

The use of IQA is therefore essential for the monitoring of water resources, due to its low costs, as well as the importance for the decision-making process. In the case of São João River, it is observed that the IQA proposed by the NSF does not satisfactorily describe the quality in some specific uses, such as water bathing. Specifically, this index presents limitations in Point III, since the coliform parameter is absorbed by the other parameters, diluting its effect, which may lead to an overestimation of the quality of this water.

Therefore, preventive measures are necessary and must be taken to ensure safety, restore and preserve the quality of the waters of this valuable resource for present and future generations. This can be done through an environmental education program for the communities living in the surroundings of this water resource and revitalization of the ciliary forest, among others.

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# Proposal of the use sodium silicate as a corrosion inhibitor in hydrostatic testing of petroleum tanks using seawater

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**Abstract** —Hydrostatic tests with water are used to evaluate leaks in welds and possible cracks and failures that may have occurred during construction in petroleum storage tanks and derivatives. Defects and cracks in the concrete foundations that support the tank on the ground are also observed in these tests. The use of seawater as a fluid for hydrostatic testing of petroleum storage tanks and derivatives can be a good option in areas lacking fresh water, especially when these tanks are near the sea. The use of seawater is economically attractive; on the other hand, corrosion by seawater is much more aggressive toward carbon steel than corrosion by treated fresh water. The potential advantages of the use of a mixture of silicates and zinc sulphate as a corrosion inhibitor are the effective protection of carbon steel, especially in saline fluids, low cost, and non-aggressive behaviour toward the environment. Gravimetric and electrochemical laboratory tests were carried out using synthetic seawater with the addition of a mixture of sodium silicate ( $\text{Na}_2\text{SiO}_3$ ) and zinc sulphate ( $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ). Gravimetric testing with an immersion time of 40 days using 1000 and 2000 mg/L of  $\text{Na}_2\text{SiO}_3$  and 150 mg/L of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  gave a good performance and can be used for hydrostatic testing with seawater.

**Keywords** — corrosion, hydrostatic testing, silicate, corrosion inhibitor, petroleum tanks, failures.

## I. INTRODUCTION

It is always good to remember the important critical reflections of Michel Llory [1] and Moacyr Duarte [2] on industrial accidents considering human factors, projects, industrial assemblies, mechanical emergency repairs, and specific and localized environmental conditions, which may consequently result in spills, explosions, evacuations of communities, environmental contamination, poisoning, associated diseases, and loss of life.

According to Mainier [3] all of the above mentioned facts are intended to show those responsible for large industrial

complexes the need to respect the integrity of equipment standards and directives regarding environment preservation. In addition, it is essential to develop clean and secure technologies to avoid environmental disasters with the goal of increasing safety and reducing pollution of the planet. Therefore, it is very important to articulate the integration of environmental agencies, public health, safety and industrialization with a society organized to establish standards and procedures in order to ensure real quality of life.

Research conducted by Chang and Lin [4] based on 242 accidents with storage tanks showed that 74% of accidents occurred in petroleum refineries and petroleum storage terminals, with fires and explosions accounting for 85% of accidents. In addition, it was reported that other causes were identified such as equipment failure, sabotage, cracks and ruptures, leakage and rupture lines, static electricity, fire, and so on, with the conclusion that most of these accidents could have been avoided if the principles of good engineering, project, installation, inspection, maintenance, and monitoring had been practiced.

Some authors found that hydrostatic testing on oil storage tanks is relatively effective in the detection of possible defects that can cause failures during routine operations [5–7]. Hydrostatic testing is universally known and accepted as a means to demonstrate the fitness of a pressurized component for service.

According to the Brazilian standard NBR 7821 NB 89 [8], after industrial assembly of large tanks for oil storage, hydrostatic testing must be carried out in order to check the tightness of the welds, possible cracks or fissures, defects of construction, and the state of the foundations (reinforced concrete) that hold the tank on the ground, as shown in Figure 1.



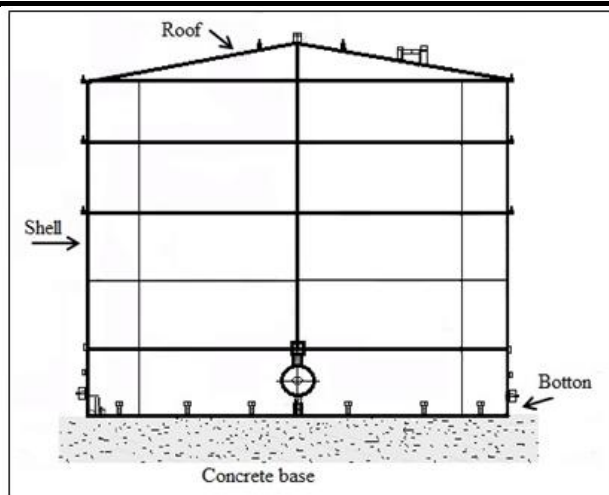
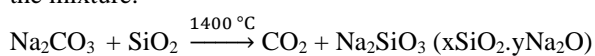


Fig. 1: Schematic of oil storage tank

Hydrostatic testing consists of a sequence of filling with water, first halfway, then up to three quarters of the total volume, and finally up to two inches above the top of the mounting bracket. Generally, fresh water is used, but due to the difficulties of obtaining a freshwater supply when the cost of treated water is prohibitive, or when the facilities are located in sea areas, it is possible to use seawater. The test time depends on the criteria of inspection, disposal of the large volume of water from the test and the environmental standards.

When the tanks are near to seawater, it is valid to say that the low cost is attractive; however, due to the severe corrosivity of seawater toward carbon steel (the material from which tanks are manufactured), it is obligatory to use corrosion inhibitors. Corrosion inhibitors can be defined as substances added to the corrosive medium to slow down or inhibit the corrosive process [9, 10].

Sodium silicate is advertised as a corrosion inhibitor, is widely used in industrial applications intended for protection of metals and alloys, and is known as a "green inhibitor" because it does not have an environmental impact. Other compelling factors are the low cost and industrial availability of this inhibitor. Sodium silicate can be prepared by melting sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) with silica sand ( $\text{SiO}_2$ ) in an electric oven at a temperature of  $1400^\circ\text{C}$ , as shown by the following reaction. The product is dissolved in hot water under pressure and filtered to remove insoluble materials. The proportions of the constituents ( $x\text{SiO}_2$  and  $y\text{Na}_2\text{O}$ ) in the final product depend on the initial dosages used in the preparation of the mixture.



Based on these assumptions, laboratory tests of mass loss and electrochemical tests with specimens of carbon steel and additions of sodium silicate and zinc sulphate were

performed to allow the use of synthetic seawater in hydrostatic tests.

## II. MATERIALS AND METHODS

### 2.1 Gravimetric test

The material evaluated in this work was AISI 1020 carbon steel (0.20% carbon, 0.34% Mn, 0.35% Si, 0.011% S, and 0.009% P) used in the confection of the coupons. The coupons used in the gravimetric tests (weight loss) had the following dimensions: an outside diameter of 2.17 cm, an internal diameter of 0.80 cm, and a thickness of 0.19 cm.

The metal surface was prepared with sandpaper of grades 100 to 500. The test coupons were cleaned with acetone and ethanol and dried with hot air. They were then weighed with precision of up to four decimal places using a digital electronic balance.

Gravimetric assays (weight loss) were performed in glass containers with a capacity of 100 mL. The coupons were completely immersed in 80 mL of synthetic seawater containing 3.5% (mass %) NaCl, 800 mg/L of  $\text{MgCl}_2$  and 600 mg/L of  $\text{CaCl}_2$ .

Sodium silicate ( $\text{Na}_2\text{SiO}_3$ ) containing 50.90%  $\text{SiO}_2$  (mass %) and 25.30%  $\text{Na}_2\text{O}$  (mass %) with a  $\text{SiO}_2/\text{Na}_2\text{O}$  ratio of 1.95 was used as the anodic corrosion inhibitor. Concentrations of 250, 1000, and 2000 mg/L were used and were referred to as silicate ions ( $\text{SiO}_3^{2-}$ ). A cathodic corrosion inhibitor (zinc sulphate –  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ) was also added to the saline solution at a concentration of 150 mg/L, respectively, referenced as 33 mg/L of zinc ions ( $\text{Zn}^{2+}$ ). The exposure times of the coupons were 2, 15 and 40 days of immersion and the temperature was held at  $25^\circ\text{C}$ . The pH in the laboratory tests ranged from 7.2 to 8.5 as a function of the addition of sodium silicate and zinc sulfate.

The final mass of each coupon was obtained after the exposure time stated. Each coupon was washed with water, pickled with Clark solution for 40 seconds according to ASTM G 31-72 [12], cleaned with anhydrous ethanol, and dried with hot air. Three coupons were used to check the reproducibility of the results. From the average weight loss results, the corrosion rate (CR) and the percentage corrosion inhibition efficiency (IE %) were calculated using the following equations.

$$\text{Corrosion rate} = \text{CR} = \frac{K (W_o - W_i)}{\rho \cdot S \cdot t} \text{ (mm/year);}$$

$$\text{Inhibition efficiency} = \text{IE}\% = \left[ \frac{(W_o - W_i)}{W_o} \right] \times 100;$$

where:

K is a constant of  $8.76 \times 10^4$  (value to mm/year);

$W_o$  and  $W_i$  are the mass losses in the absence and presence of the inhibitor;

S = area of the coupon (cm<sup>2</sup>);  
 ρ = density (g/cm<sup>3</sup>); ρ = 7.8 g/cm<sup>3</sup> for carbon steel;  
 t = exposure time (h).

The evaluation of average corrosion rates of carbon steel coupons was based on NACE-RP-07-75 [13], as shown in Table 1.

Table 1: Average corrosion rate [13]

Average corrosion rate, mm/y	Corrosiveness
<0.025	Low
0.025-0.12	Moderate
0.13-0.25	High
0.25	Severe

### 2.2 Electrochemical tests

Samples of AISI 1020 carbon steel for the polarization measurements were cut so as to obtain an electrode surface of 0.20 cm<sup>2</sup>. The metal was then embedded in a polyester resin and polished with no. 600 emery paper. Next, the samples were degreased with acetone and washed in distilled water before being inserted in a conventional polarization cell as shown in Figure 2. The polarization curves were recorded using a Type III Autolab potentiostat by varying the potentials at a rate of 60 mV/min. All measurements were carried out at a constant temperature of 25 °C under aerated conditions and without agitation.

The inhibition efficiency (IE %) was calculated as follows:

$$IE\% = (I_{corr} - I'_{corr}/I_{corr}) \times 100,$$

where I<sub>corr</sub> and I'<sub>corr</sub>/I<sub>corr</sub> are the uninhibited and inhibited corrosion current densities, respectively.

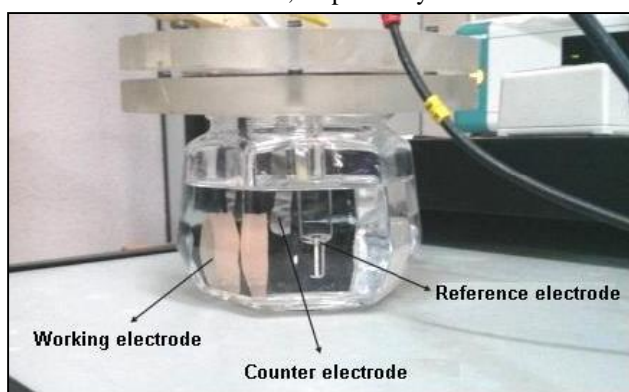


Fig. 2: Conventional polarization cell

## III. RESULTS AND DISCUSSION

### 3.1 Gravimetric test

Figure 3 shows the corrosion rate of carbon steel coupons in synthetic seawater with and without corrosion inhibitor. The exposure times were 2, 15, and 40 days of

immersion and the temperature was kept at 25 °C. Table 2, below, shows the addition of sodium silicate and zinc sulphate as corrosion inhibitor in synthetic seawater in which carbon steel coupons were immersed for an exposure time of 40 days. The results refer to the average of three carbon steel coupons, and pitting and crevices were not observed on the metallic surface. Based on Table 1 [12], the average corrosion rates can be considered to be low.

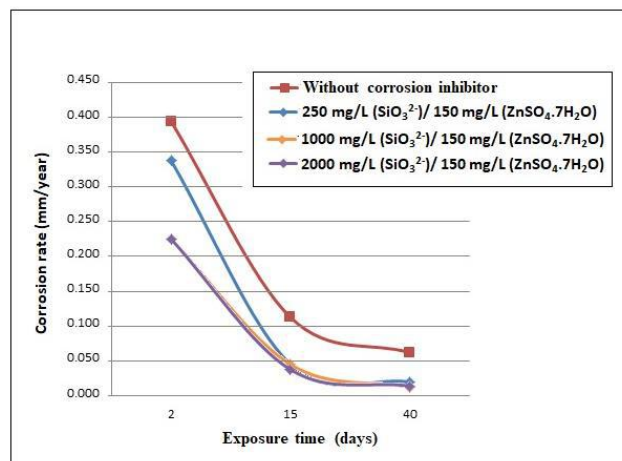


Fig. 3: Corrosion rate of carbon steel coupons in synthetic seawater with the addition of a mixture of sodium silicate and zinc sulphate as corrosion inhibitor

Table 2 – Yield of addition of sodium silicate and zinc sulphate as corrosion inhibitor in synthetic seawater in which carbon steel coupons were immersed for an exposure time of 40 days.

Silicate, SiO <sub>3</sub> <sup>2-</sup> , mg/L	ZnSO <sub>4</sub> .7H <sub>2</sub> O mg/L	Corrosion rate, mm/y	Yield, %
250	150	0.020	68.00
1000	150	0.013	79.55
2000	150	0.014	77.27

From the results obtained through the assay, it was possible to verify that during the immersion time, the corrosion rate of carbon steel decreased until it reached a constant value. It is important to note that during the gravimetric assays (mass loss), precipitation and the formation of colloidal mixtures of calcium silicates and magnesium hydroxide (considering the presence of concentrations of Ca<sup>2+</sup> and Mg<sup>2+</sup> ions in the saline solution) occurred.

When the process is static and there is no bubbling of air, the absence or low concentration of oxygen dissolved in the saline solution makes the metal corrosion process slower because of its polarizing action. In saline solution that is not aerated, the hydrogen (H<sub>2</sub>) can be adsorbed on the surface of the cathode, polarizing the reaction formed,

with consequent reduction of the corrosive process [14, 15].

### 3.2 Polarization measurements

The polarization curves for carbon steel in synthetic seawater solutions in the absence and presence of different concentrations of corrosion inhibitor constituted of a mixture of sodium silicate and zinc sulphate are shown in Figure 4. These polarization curves demonstrate, at first view, that in the presence of a mixture of silicate and zinc sulphate the cathodic and anodic branches of the polarization curves are shifted towards lower currents to a similar extent, possibly as a consequence of the blocking effect of the adsorbed inhibitor substance. The polarization curves show that there is a clear reduction of both the anodic and the cathodic current in the presence of corrosion inhibitor compared with those without inhibitor (blank solution). The addition of 250 mg/L of sodium silicate and 150 mg/L of zinc sulphate did not have a good yield, while the yield increased with the addition of 1000 or 2000 mg/L of silicate.

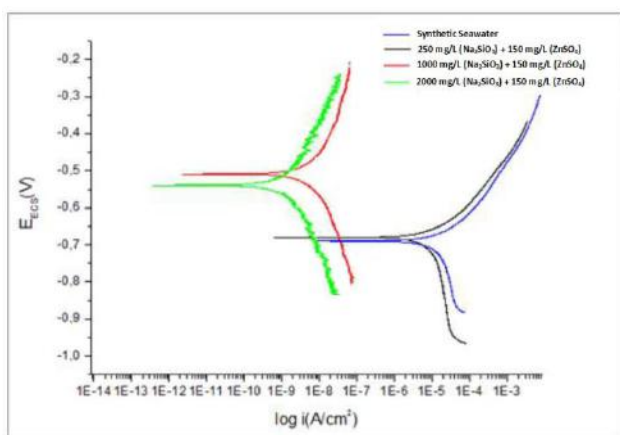


Fig.4 –Anodic and cathodic polarization curves in the absence and presence of corrosion inhibitor

Table 3, below, shows the electrochemical kinetic obtained by the Tafel polarization technique for carbon steel in synthetic seawater in the absence (blank) and presence of additions of mixtures of Na<sub>2</sub>SiO<sub>3</sub> and ZnSO<sub>4</sub>.7H<sub>2</sub>O. The parameters were E<sub>corr</sub> (mV), I<sub>corr</sub> (A/cm<sup>2</sup>), and IE%.

Table.3: Polarization parameters for the carbon steel in synthetic seawater in the absence and presence of corrosion inhibitor

Corrosion Inhibitor, mg/L		-E <sub>corr</sub> (mV),	I <sub>corr</sub> (A/cm <sup>2</sup> )	IE %
SiO <sub>3</sub> <sup>2-</sup>	ZnSO <sub>4</sub> .7H <sub>2</sub> O			
0	0	-690	2.0x10 <sup>-5</sup>	----
250	150	-680	1.0x10 <sup>-5</sup>	50.0
1000	150	-539	8.0x10 <sup>-9</sup>	99.9
2000	150	-509	2.0x10 <sup>-9</sup>	99.9

Figure 5 shows the micrographs of the carbon steel coupons that were electrochemically tested with synthetic seawater, revealing the possibility of pitting that may occur on the surface of the steel. Rare pitting occurred at concentrations of 1000 mg/L of silicate and 150 mg of zinc sulphate, while no incidence of pitting was observed at concentrations of 2000 mg/L and 150 mg, respectively

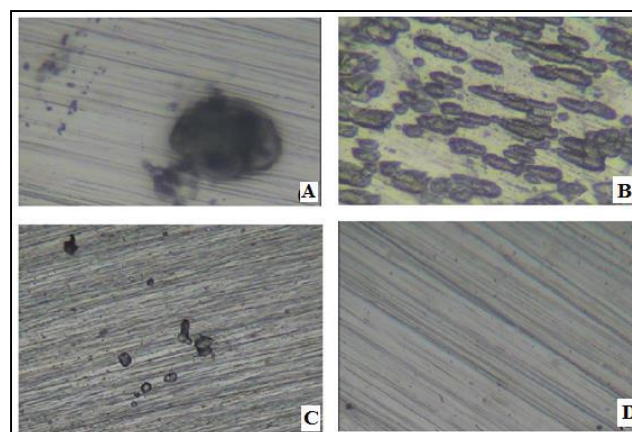


Fig. 5: Surface micrographs of samples obtained by optical microscopy to investigate the formation of pitting in synthetic seawater: (A) without corrosion inhibitor; (B) with the addition of 250 mg/L of Na<sub>2</sub>SiO<sub>3</sub> and 150 mg/L of ZnSO<sub>4</sub>; (C) with the addition of 1000 mg/L of Na<sub>2</sub>SiO<sub>3</sub> and 150 mg/L of ZnSO<sub>4</sub>; (D) with the addition of 2000 mg/L of Na<sub>2</sub>SiO<sub>3</sub> and 150 mg/L of ZnSO<sub>4</sub>; Magnification: 40x.

### 3.3 Proposed mechanism of barrier

Many authors referenced have discussed the mechanism of formation and the nature of the protective film formed on a metal surface in solutions of sodium silicate. The differences in the proposals regarding the mechanism of protection and the conclusions may be due to the variation in the concentration of the sodium silicate solution, temperature, ratio of Na<sub>2</sub>O to SiO<sub>2</sub>, experimental conditions, pH, contamination of certain ions in the saline solution that can form precipitates and colloids, presence or absence of dissolved oxygen, and addition of zinc sulphate, considering that Zn<sup>2+</sup> ions act as a cathodic inhibitor [16–19].

Sodium silicate has anodic inhibition capacity in alkaline medium, meaning that the SiO<sub>3</sub><sup>2-</sup> ions migrate to the anode region of the metal surface where they react with Fe<sup>2+</sup> ions, forming a protective film of iron silicate (FeSiO<sub>3</sub>). The Zn<sup>2+</sup> ions that are present as a type of cathodic inhibitor migrate to the cathodic region, forming a protective film of zinc hydroxide, as can be seen in Figure 6.



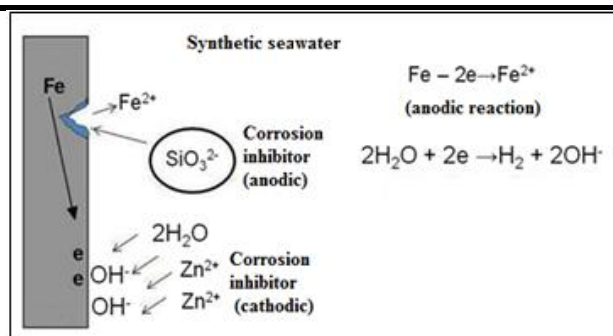


Fig. 6: Silicate formation on a metal surface in synthetic seawater with additions of corrosion inhibitor

The proposals regarding the mechanisms of the formation of the protective film are based on research by the previously referenced authors and are presented as models in Figure 7. The  $Mg^{2+}$  and  $Ca^{2+}$  ions present in the synthetic seawater may migrate to the cathodic area, find the  $OH^-$  ions, and form a protective film of  $Mg(OH)_2$  and  $Ca(OH)_2$ . Over time, it is possible to obtain a uniform protective film on the metal surface by adsorption in an alkaline medium by inhibiting the anodic and cathodic reactions, providing excellent protection of carbon steel against corrosion in a saline solution.

This film is made up of iron silicate ( $FeSiO_3$ ), calcium silicate ( $CaSiO_3$ ), magnesium silicate ( $MgSiO_3$ ), and silica ( $SiO_2$ ), which are associated with calcium hydroxide and magnesium hydroxide as well as the zinc hydroxide from the additions of  $Zn^{2+}$ . Over time it is possible to obtain a uniform protective film on the metal surface by adsorption in alkaline medium by inhibiting the anodic and cathodic reactions, providing excellent protection of carbon steel against corrosion in seawater.

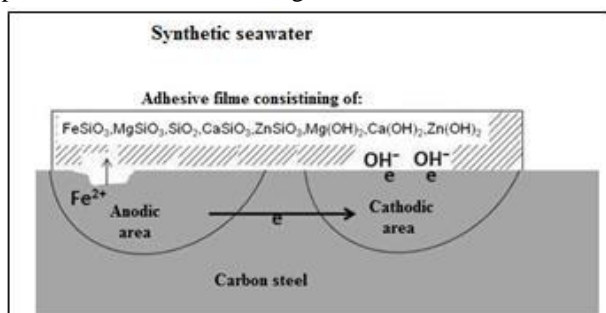


Fig. 7: Proposed barrier mechanisms provided by silicate in the synthetic seawater

#### IV. CONCLUSIONS

Based on tests conducted with synthetic seawater without air bubbles, the following conclusions can be drawn:

- Through gravimetric static testing without air bubbles, it was observed that the addition of sodium silicate and zinc sulphate resulted in the formation of a protective film (barrier) on the surface of the carbon

steel coupons, which provided a reduction in the corrosion rate;

- The concentrations of inhibitor that showed better performance in gravimetric static testing were 1000 mg/L of  $Na_2SiO_3$  and 150 mg/L of  $ZnSO_4 \cdot 7H_2O$ , which led to a corrosion rate of 0.013 mm/year and inhibition efficiency of 79.55% for an immersion time of 40 days;
- The electrochemical tests showed that at concentrations of 1000 and 2000 mg/L of  $Na_2SiO_3$  together with 150 mg/L of  $ZnSO_4 \cdot 7H_2O$ , the efficiency of corrosion inhibition was almost 100%;
- The mechanism proposed for the corrosion protection of carbon steel is based on the formation of a uniform and transparent film with a gelatinous aspect on the steel surface, constituted of iron silicate, calcium silicate, magnesium silicate, and silica, which are associated with calcium hydroxide, magnesium hydroxide, and zinc hydroxide;
- Considering the good results of carbon steel corrosion protection obtained with the addition of sodium silicate and zinc sulphate in synthetic seawater, it is valid to propose its use in hydrostatic testing.

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# Feasibility Analysis of the Solar Energy System in Civil Construction

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**Abstract**— *The use of clean energy from renewable natural resources, replacing what is commonly used is seen as a solution to environment preservation and cost savings with energy generation and distribution. Therefore, the use of solar irradiation for the generation of electric energy is a viable option for regions that present climatic conditions favorable to this technology, as the state of Tocantins does. It is analyzed the feasibility of the energy generation system capable of supplying a building of up to 50m<sup>2</sup> with monthly consumption of 800kWh using the solar potential of the region. Following the norm that regulates the micro generation of energy in the country, according to the regulatory agency (ANEEL), presenting the components of the system and punctuating the advantages of its implementation. With a survey of energy costs based on the value determined by the concessionaire and the feasibility of deploying solar energy according to the monthly solar irradiation in conjunction with the equipment costs of the system. According to the results obtained from the method of implantation of the system, which is compact and flexible and capable of suiting any existing building structure, which allows a lifespan of close to 25 years, presenting a return on investment in 60 months of operation and providing a 75% reduction in the monthly energy bill, disregarding that this percentage may increase according to possible tariff readjustments. Being a clean energy that causes very low environmental impact in relation to the other methods commonly.*

**Keywords**— *Solar Energy, Renewable Sources, Economy, Energy Generation.*

## I. INTRODUCTION

Currently, Brazil is still very dependent on two sources of energy: hydro and thermal (natural gas and coal), but after the rationing of electric energy occurred in 2001, there was a need for a bigger diversification of the Brazilian energy matrix. With this, it has become increasingly constant the

implementation of constructive methods that allow greater efficiency of a building, with respect to its daily consumption of energy. The adequacy of construction to these clean technologies provide higher performance and lower monthly consumption costs, using alternative sources for the generation of renewable energy present in nature.

With the regularization in the Ministry of Mines and Energy through the ANEEL (National Agency of Electric Energy), for the micro and mini generation distributed to the electric power distribution systems and the electric energy compensation system, the investment in this segment became even more profitable. This would allow a change in the current scenario where the majority of Brazilian electricity comes from hydroelectric plants, representing 61.1% (ANEEL, 2017) of the installed capacity, which even being considered low pollutants they still cause considerable environmental impacts.

Normative Resolution No. 482, of April 17, 2017, establishes the general conditions for the access of micro generation and mini-generation distributed to the distribution systems of electric energy, the system of compensation of electric energy, and gives other measures from the following articles:

Article 1 Establish the general conditions for the access of micro generation and mini-generation distributed to the electric energy distribution systems and the electric energy compensation system. (Redaction given by REN ANEEL 687, 11.24.2015).

Article 2 establishes micro-generation distributed to the power generating central, with installed power less than or equal to 75 kW and that uses qualified cogeneration. And mini distributed generation is a powerhouse of electric energy with an installed power above 75 kW and less than or equal to 3 MW for water sources or less than or equal to 5 MW for qualified cogeneration, according to ANEEL regulations, or for other renewable sources of electricity,

connected in the distribution network through facilities of consumer units. (Redaction given by REN ANEEL 687, 11.11.2015.)

The geographic location of the state of Tocantins makes it to be in the Brazilian solar belt, and the aggravating of the intensity of the solar rays of the region with the increase of the temperature every year, it propitiates the installation of photovoltaic systems of generation of energy. This phenomenon was observed by the conversion of solar radiation into electricity by means of semiconductor materials obtaining solar photovoltaic energy, that in 1839 by the scientist Alexandre Edmond Becquerel, where the physicist verified that plates of metal, of platinum or silver, dipped in an electrolyte, produced a small potential difference when exposed to light. And later in 1877 the American inventors W. G. Adams and R. E. Day used the photo-conductive properties of selenium to develop the first solid device of producing electricity by exposure to light. It was a film of selenium deposited on an iron substrate and with a second semitransparent gold film that served as a frontal contact. It presented conversion yield in the range of 0.5%, but, even with the low efficiency presented, However, even with the low efficiency presented, Werner Siemens, a German engineer, marketed selenium cells as photometers for cameras (VALLÊRA et al., 2006).

Due to the energy crisis that settled in the world in 1973, the price of oil quadrupled and this aggravating added to the climatic changes occurred in the same period caused an environmental concern, taking the great world powers to invest heavily in the photovoltaic technology, seeking a reduction of the costs of generation from the sun. These investments provided a reduction of about 80% in the cost of electricity from this form of generation in less than a decade. The threat of lack of energy and climate disasters led to the creation of the first photovoltaic generation park in 1982 in the USA and solar roofs in 1990 in Germany and in 1993 in Japan. Researchs have shown that reducing installation costs of photovoltaic cells is not only due to technological development, but also to increased production and improvements in manufacturing techniques. With this cost reduction it is believed that solar panels would be a generation alternative with competitive costs to that of conventional energy (GUIMARÃES, 2012).

By means of Technical Note 05/2017, published by the Ministry of Mines and Energy in July of the same year, the Federal Government announced the privatization of the Eletrobrás System hydroelectric generator park, which could lead to a increase of 7% in energy bills of the Brazilian population, which has been growing since 1995. The growth of the world's environmental discourse related to climate change, which is discussed at the United

Nations Conference on the Environment, has made the government in agreement with the credit lines ( banks) to provide a high percentage of resources for the implementation of "green systems", which aim at preserving the environment.

Due to these factors, the present work had the objective of analyzing the economic viability for the implementation of an energy generation system for the supply of a 50 m<sup>2</sup> residence in the state of Tocantins.

## II. METODOLOGY

The study was developed based on solar radiation data from CRESERB - Reference Center for Solar and Wind Energy Sérgio de S. Brito in the last 12 months, through the meteorological station of Porto Nacional (Latitude: 10.5 ° S, 48.417206 ° O) with an altitude of 239.2 meters at sea level, which is part of the network of stations of the INMET-National Institute of Meteorology and is 60 km from Palmas the capital of Tocantins.

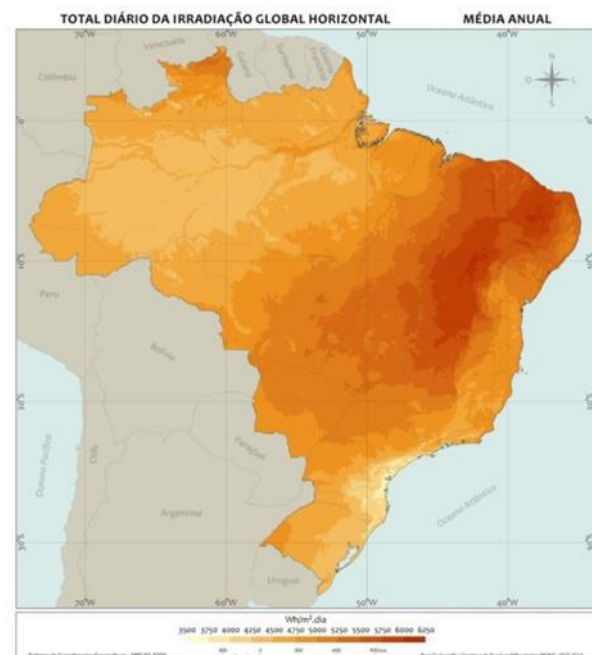


Fig. 1: Global Average Irradiation in Brazil

Source: Geographic Coordinate System

The survey of the system's installation costs was based on a project executed in Porto Nacional at the beginning of the year 2018 in a residence located in the center of the city, taking into account that the project was dimensioned for a construction model bigger than the one proposed in the pre-project. There was a need to resize and evaluate the final cost for the execution of the solar energy generation system in a 50 m<sup>2</sup> residential project.

The electricity costs of the residence are based on the tariffs defined by the (ENERGISA) concessionaire of electric power of the state of Tocantins. This unit value is determined by ANEEL and is used to calculate the

monthly billing of the electricity distribution system users for the use of the system and energy consumption.

Since the year 2015, energy bills have started to join the Tariff Flags System, which presents the following modalities: green, yellow and red. They indicate whether there will be an increase in the amount of energy to be passed on to the final consumer, according to the characteristics of each modality:

Green flag: favorable conditions of power generation. The fare does not suffer any increase;

Yellow flag: less favorable generation conditions. The tariff is increased by the amount of R\$ 0,010 for each kilowatt-hour kWh consumed;

Red flag - Level 1: more costly generation conditions. The tariff is increased by the amount of R\$ 0,030 for each kilowatt-hour kWh consumed.

Red Flag - Level 2: even more costly conditions of generation. The tariff is increased by the amount of R\$ 0,050 for each kilowatt-hour kWh consumed.

This division happens according to the time of year when the power plants have a decrease in their production because of the water level of the reservoir.

The system is installed in parallel with the grid, thus allowing its power supply both by the photovoltaic system and the grid, which ensures the power supply of the charges during periods of high and low light intensity. This activity is only possible by using electronic components of modulated power output.

The photovoltaic systems connected to the grid (SFCRs) are basically composed of: PV panels and frequency inverters that convert alternating voltage to an output normally given in 120/127 or 220V, and a frequency rate of 50 or 60 Hz (GUIMARÃES, 2012), discarding the use of elements to store the electricity produced. The production is interconnected to the electricity grid of the concessionaire, working as the storage element, because all generated energy is placed in parallel with the energy of the network. (URBANETZ, 2010).

The meter must be bi-directional with double operation. It must at least differentiate the active electrical energy consumed from the active electric energy injected into the network. (ANEEL, NT 0129/2012).



Fig. 2: Residential SFCR  
Source: Solar Portal

Spreadsheet 1- List of materials used in the SFCR installation.

BLACK SOLAR CABLE WITH 4.0MM <sup>2</sup> UV PROTECTION
RED SOLAR CABLE WITH 4.0MM <sup>2</sup> UV PROTECTION
VD/AM SOLAR CABLE WITH UV PROTECTION 6.0MM <sup>2</sup>
CONNECTOR MC4 FEMALE 4-6MM <sup>2</sup> (12-10AWG)
CONNECTOR MC4 MALE 4-6MM <sup>2</sup> (12-10AWG)
INTER KLAMP 40MM KIT (INTERMEDIATE CLAMP)
END KLAMP 40MM KIT (TERMINATOR CLAMP)
STEEL HOOK KIT
ALUMINUM PROFILE CLUTTER GS
GROUND CLAMP
WIRE CLAMP
GROUND JUMPER
GROUND CLIP
ANODIZED ALUMINUM PROFILE FOR PV MODULES (4,20M) GS
STB02-1000V / 01, STRING BOX DC + AC
PHB5000D-NS, PHOTOVOLTAIC INVERTER – wifi
325WP PHOTOVOLTAIC MODULE; (JKM325PP-72-V) JINKO (brand)

With the definition of the monthly average consumption and the production achieved with the implementation of the system during the whole year, in the most favorable periods of irradiation and in rain periods, it was performed a comparison and an analysis of the investment for the implantation of the new technology of energy production from these tabulated data.

For the tabulation and analysis of the found data, the Microsoft Office Excel tool was used. The project parameters are in accordance with RN N ° 482 of April 17, 2012 (ANEEL), which regulates all mini and micro generation of solar energy, ABNT NBR 11704 -

Photovoltaic Systems-Classification: this standard classifies the systems photovoltaic conversion from solar to electric.

### III. RESULTS

For the presentation of the results, a case study was performed in a residence that installed a Grid Tie photovoltaic generator system of 10.40 kWp, with an average generation estimate of 1600 kWh per month. The article presents a model capable of supplying the energy demand for a residence of 50 m<sup>2</sup> where a traditional Brazilian family of four people resides.

The sizing of the electric energy consumption is based on the quantity of electric appliances and their power (Table 1).

Table.1: Household appliances in a 50 m<sup>2</sup> house, where a typical Brazilian family of four middle class people lives.

Appliance Quantity	Power (W)	Usage Time (h)	Daily Consumption (E = P * Δt)
Lamps – 6	60*6= 360	6	2160
Electric Shower – 1	4500	0,5	2250
Air Conditioning – 1	1800	6	10800
Television – 1	200	8	1600
Radio 1	50	4	200
Refrigerator – 1	200	24	4800
Iron – 1	500	0,5	250
Receptor TV – 1	20-55 = 31,66	24	759,84

Computer – 1	250	4	1000
Washing Machine – 1	1500	0,5	750
Microwave – 1	1300	0,5	650
<b>TOTAL</b>			<b>25.219,84</b>

In 30 days the consumption will be,

$$25.219,84 * 30 = 756,595 \text{ Wh or } 756,595 \text{ kWh}$$

Therefore, the monthly consumption of the residence is 756,595 kWh;

The system introduced to generate 1600 kWh in the analyzed residence is composed of:

- 32 Photovoltaic Modules 325 WP; (JKM325PP-72-V) Jinko;

- 02 Photovoltaic Inverters PHB5000D-NS -Wi-fi;

Table.2: Generation of Electric Energy by the photovoltaic generator system Grid Tie 10.4 kWp installed in the last 4 months.

Month	Generation (kWh)	Qty. Active Days (d)	Daily Average (kwh / d)
February	981,5	23	42,67 kWh
March	1.119,5	27	41,46 kWh
April	1179,3	30	39,31 kWh
May	601,5	15	40,1 kWh

The system has been working from February until now in a rainy season that did not provide its maximum generation capacity due to climatic conditions, not allowing high solar irradiance rates that are directly linked to SFCR energy production (Table 3).

Table.3: Solar Irradiation in the Horizontal Plan of the last 12 months

Latitude: 10,5° S  
Longitude: 48,417206° O

#	Estação	Município	UF	País	Irradiação solar diária média [kWh/m <sup>2</sup> .dia]												Média	Delta				
					Latitude [°]	Longitude [°]	Distância [km]	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set			Out	Nov	Dez	
✓	Porto Nacional	Porto Nacional	TO	BRASIL	10,501° S	48,449° O		3,5	5,20	5,23	4,91	5,05	5,10	4,95	5,05	5,82	5,76	5,43	5,13	5,14	5,23	,91
✓	Porto Nacional	Porto Nacional	TO	BRASIL	10,501° S	48,349° O		7,5	5,20	5,25	4,88	5,01	5,03	5,01	5,18	5,85	5,73	5,45	5,22	5,18	5,25	,97
✓	Porto Nacional	Porto Nacional	TO	BRASIL	10,4° S	48,449° O		11,7	5,16	5,21	4,91	5,05	5,08	4,91	5,04	5,74	5,76	5,44	5,15	5,11	5,21	,86

Irradiação Solar no Plano Horizontal para Localidades próximas





It is possible to verify that in these last months in the raining season the solar irradiation presented lower values due to the climatic conditions of this time of the year, affecting the generation of energy. Even though the system was able to supply the demand for the building and also generate credits in the concessionaire. These credits can be used for the next 5 years (60 months).

The cost-benefit of the SFCR implementation is made by analyzing the last 12 months of consumption and the value of the energy bill of the building analyzed to understand the economy achieved immediately (Table 4).

Table 4 – Energy bill history of the Consumer Unit analyzed in the last 12 months.

Year	Month	Reading Date	Consumption	Value (R\$)
2018	April	04/24/2018	100	238,51
2018	March	03/23/2018	100	231,06
2018	February	02/22/2018	191	290,45
2018	January	01/23/2018	1066	900,83
2017	December	12/22/2017	861	808,04
2017	November	11/23/2017	894	886,27
2017	October	10/25/2017	1129	1.056,79
2017	September	09/25/2017	1212	1.094,10
2017	August	08/24/2017	1001	937,24
2017	July	07/25/2017	842	743,02
2017	June	06/26/2017	1199	1024,85
2017	May	05/24/2017	1150	1.038,65

The last 03 months already presented much smaller values than the previous ones, thus showing the economy achieved with the implantation of the system, but to measure the true gain with this implantation it is necessary to take into account the initial installation cost of this system that fits the design, material and manpower. The SFCR of 10.40 kWp installed in the residence had a cost of R\$ 42,000.00 with freight included.

Using the invoice values between May 2017 and January 2018 we have an energy cost average value of R\$ 943.31, considering the values of March and April/2018. With the system in operation, this average decreases to R\$ 234.78,

with a total decrease value of R\$ 708.53. This difference is almost equivalent to the value of the system’s financing parcel that revolves around R\$ 740.00, divided in 60 months.

The installed system of 10.4 kWp, with a power generation estimative of 1600 kWh, has a cost of R\$ 42,000.00 according to the project of the MVC projects and solutions. For a residence of 50 m<sup>2</sup>, a system is expected to generate 800 kWp, thus supplying the energy demand of the residence (Table 5).

Table 5 - Estimated value of SFCR implantation for a 50m<sup>2</sup> building in Tocantins according to the equipment capacity.

System	Estimate d Generation	Converter	Photovoltaic Molde	Value
GT 10,4 kWp	1600 kWh	2 un - PHB 5000	32 Plates Jinko	R\$ 42.000,00
GT 5,2 kWp	800 kWh	1 un - PHB 5000	16 Plates Jinko	R\$ 21.000,00 *

\* in the presented values are included: design, installation, material and freight.

Calculation of Return on Investment:

System implementation value: R\$ 42,000.00;

Average amount of energy bill (without the system): R\$ 943.31;

Average amount of energy bill (with the system): R\$ 234.78;

$$234,78x + 42000 = 943,31x$$

$$943,31x - 234,78x = 42000$$

$$708,53x = 42000$$

$$X = 42000/708,53$$

$$X = 59,27 > X = 60 \text{ months to return - 05 years;}$$

The tropical climate with the high incidence of solar rays is constant during the most part of the year in the North region of the country where Tocantins is located. The localization of the state is right inside the Brazilian solar belt, and the intensity of solar irradiation in the state of Tocantins tends to remain high between the months of June and January, promoting high rates of ES generation and even with the presence of rain from February to May the generation of energy continues to occur even on a smaller scale, but still the necessary amount for the demand of the building.

#### IV. CONCLUSION

The implementation of this efficient method of energy generation that is still little used by society means that the building can generate the necessary energy charge for its operation. The system presents a low weight and does not



require reinforcement of the roof structure and for being compact it is suitable on the roof of any residence.

The initial investment of the ES system is diluted in its financing installments. This option is feasible, as the banks offer credit lines to initiatives aimed at the sustainable development of the planet for the next generations, and this type of energy, which is considered clean, does not produce elements that attack the environment other than thermoelectric and nuclear, and do not promote sudden changes in a natural space such as hydroelectric. This type of energy is produced from the absorption of the natural element, in this case being solar irradiation, without harming the environment.

The photovoltaic power system is interconnected to the distribution network, launching energy production directly into the grid and calculating this consumption and production through the bidirectional meter, so that surplus storage stored by the utility can be used by the owner for the next 60 months, thus allowing that even when energy production is lower than consumption because of unfavorable climatic conditions the value remains the minimum at the end of the month.

The results presented the initial investment for the execution of the project and simulated the return of this invested capital in almost 60 months, which means that in 5 years of operation the economy generated in the energy bill is equivalent to the amount applied in the system, and since the SFCR has a useful life of 25 years, the remaining 20 years have a savings of about 75% per month in the invoice amount.

The use of the SFCR as an option for direct generation brings several points that indicate the positivity of its implementation, because the power output is close to where it will be built, thus promoting the global reduction of losses and possible reduction of the need for new transmission lines and distribution. The flexibility of implementation in a short time is another positive point, in addition to providing a modular approach to problems addressing particular demands with specific solutions. The independence of the system installation allows the reduction of the grid load, greater operational flexibility and better voltage profile that allows the application of different demand management techniques.

And so we conclude that after the analysis of the parameters of the Tocantins state for a family residing in a house of 50sqm, that in the short term the implantation of the system generates a relatively high cost, but that can be attenuated with the installment of this investment. In the medium term, considering its 25 year lifespan, the return by the mark of 5 years is considered fast. In the long term we have a satisfactory result, with 20 years of energy savings, being only willing to pay taxes like street lighting and taxes embedded in the invoice.

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# Evaluation of Groundwater Prospect in a Clay Dominated Environment of Central Kwara State, Southwestern Nigeria

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**Abstract**— In this research, groundwater prospect of Central Kwara have been investigated using electrical resistivity method for both domestic and industrial application in the face of scarce water resources, occasioned by incessant borehole failure/low yield, has prompted researches for viable source of water. The central Kwara state falls within the basement complex region of Nigeria known as the hard rock terrain, where availability of groundwater is dependent mainly on structural features. The general curve types obtained from the study area were H, HA, KH and HKH types with the H curve type more prominent in the study area. Three geoelectric sections generated with resistivity parameters ranging between 350 to 1900 ohm-meters, 7.7 to 99.1 ohm-meter and above 3000 ohm-meter; making up the topsoil, weathered layer and bedrock respectively. The topsoil is interpreted as laterite/hard pan within thickness range of 0.4 and 2.2 m while the weathered layer zone ranged between 0.9 to 36.1 m thickness respectively; making the overburden of the area with thickness range of 1.4 to 42.7 m. The bedrock resistivity ranges from 400 ohm-meter to 8192 ohm-meter, indicative of weathered/fractured and fresh basement respectively. The results of the vertical electrical sounding were used to generate clay horizon resistivity map, clay horizon thickness map, aquifer resistivity map and overburden thickness map. This study reveals that the study area is dominated by clay which lead to borehole failure and dry up of hand pump well because most of the hand pump well were terminated within the clayey formation.

**Keywords**— clay horizon resistivity, clay horizon thickness, aquifer resistivity, overburden thickness.

## I. INTRODUCTION

The importance of water to the existence of life deserves attention, because health and growth are closely associated

with it. Water plays a very crucial role in the survival of both plant and animal hence the common saying “water is life”. Generally groundwater sources are generally accepted as the best quality sources of water for both domestic and industrial purposes around the world (Hoque *et al.*, 2009). The rapid pace of urban development and rise in the demand for private, public and industrial water supply occasioned by growth in population (Adul *et al.*, 2001). Demand for groundwater as source of water for drinking, irrigation and industrial uses has caused tremendous rise in various domain of groundwater related studies. Different factors have been used as indices of groundwater resources occurrence in different study areas. Some of which includes, subsurface layers, and structural features on fractures that cause ‘stratigraphical disturbances’ (Tizro *et al.*, 2010) among other factors also includes geoelectric and geological parameters (such as aquifer resistivity, aquifer thickness, overburden resistivity and overburden thickness) derived from derived from 2D resistivity imaging. Recharge rate is another important factor that can determine the occurrence of groundwater resource in an area. An aquifer can be recharge by the infiltration of river and lateral subsurface inflow that usually occur through subsurface water zones. Such as fracture, joints, cracks, rock contacts, etc. In a typical Basement Complex Area such as Central Kwara, and its environs, the occurrence of groundwater in recoverable quantity is controlled by geological factors (Olorunfemi and Fasuyi, 1993; Amadi and Olasehinde, 2010; Ilugbo *et al.*, 2018). The delineation of these geological factors or fissures i.e. faults, joints, fractures, and weathered materials is very essential for better understanding of the geology in terms of their groundwater potential. Therefore to target potential bedrock aquifers that can give copious supply of groundwater, the

mentioned geologic fissures must be identified through Geophysical Investigations and intercepted by boreholes (Ilugbo and Adebisi, 2017). Considering the many cases of failed/abortive borehole that are common occurrence in this study Area, making majority of the inhabitants to depend on surface water from river, stream, and hand dug well for their daily survival. These sources of water are highly vulnerable to pollution, thereby making the people susceptible to water borne diseases. It therefore becomes a challenge to find a lasting solution to this predicament facing the Government and people of the Area. The delineation of these geologic fissures in low permeability rocks, as is the case of Central Kwara Basement Complex, requires the use of Integrated Geophysical approach, as was the case with (Adelusi *et al.*, 2013; Omosuyi *et al.*, 2003; Olorunfemi *et al.*, 1991; Okereke *et al.*, 2012; Ilugbo *et al.*, 2018) all of whom deployed Integrated Geophysical approach in different parts of the Nigerian Basement Complex, in groundwater potentials evaluation and study. More so, that Geophysical Methods are of low cost, non-invasive and can furnish broad composite images of the subsurface over large areas at relatively low cost and higher speed (Telford *et al.*, 1976).

Therefore, in this research work, Electrical resistivity methods were used in Central Kwara comprising four Local Government i.e. part of ASA, MORO Kwara East, Kwara West Local Government of the state, which are underlain by

rocks of the Precambrian Basement Complex of Nigeria with the aim of evaluating the groundwater in a clay dominated environment.

#### **Site Description and Geology of the Study Area**

The area is geographically enclosed within latitude  $8^{\circ} 31' 0''\text{N}$  to  $8^{\circ} 43' 0''\text{N}$  and longitude  $4^{\circ} 28' 00''\text{N}$  to  $4^{\circ} 34' 0''\text{E}$ , It is sandwich between four local government areas, within the Central of Kwara State in present Nigeria. Moro Local Government to the North and North Eastern part of the study area, Asa Local Government to the West, and Kwara West and Kwara East Local Government to the South of the study area. The area is made up of about forty (40) Towns and Villages accessibility is through major and minor road networks. The topography is generally undulating (Figure 1) with some areas characterized by hilly ridges and gentle steeps. The area enjoys a tropical climate with two distinct seasons, comprising of rainy season (April to October) and dry season (November to March) with the temperature ranging between  $23^{\circ}\text{C}$  to  $32^{\circ}\text{C}$  and dry season. The study area is located within north Central Basement Complex region of Nigeria. It belongs to the Precambrian Basement Complex (Figure 2). It is made up of mainly older granite towards the North Western part of the study area, while the rest is of the undifferentiated basement complex rock. The hydrogeology of the study area consists of streams, rivers, drainage and geological structures (like faults, fractures, crack, joints and weathered materials).

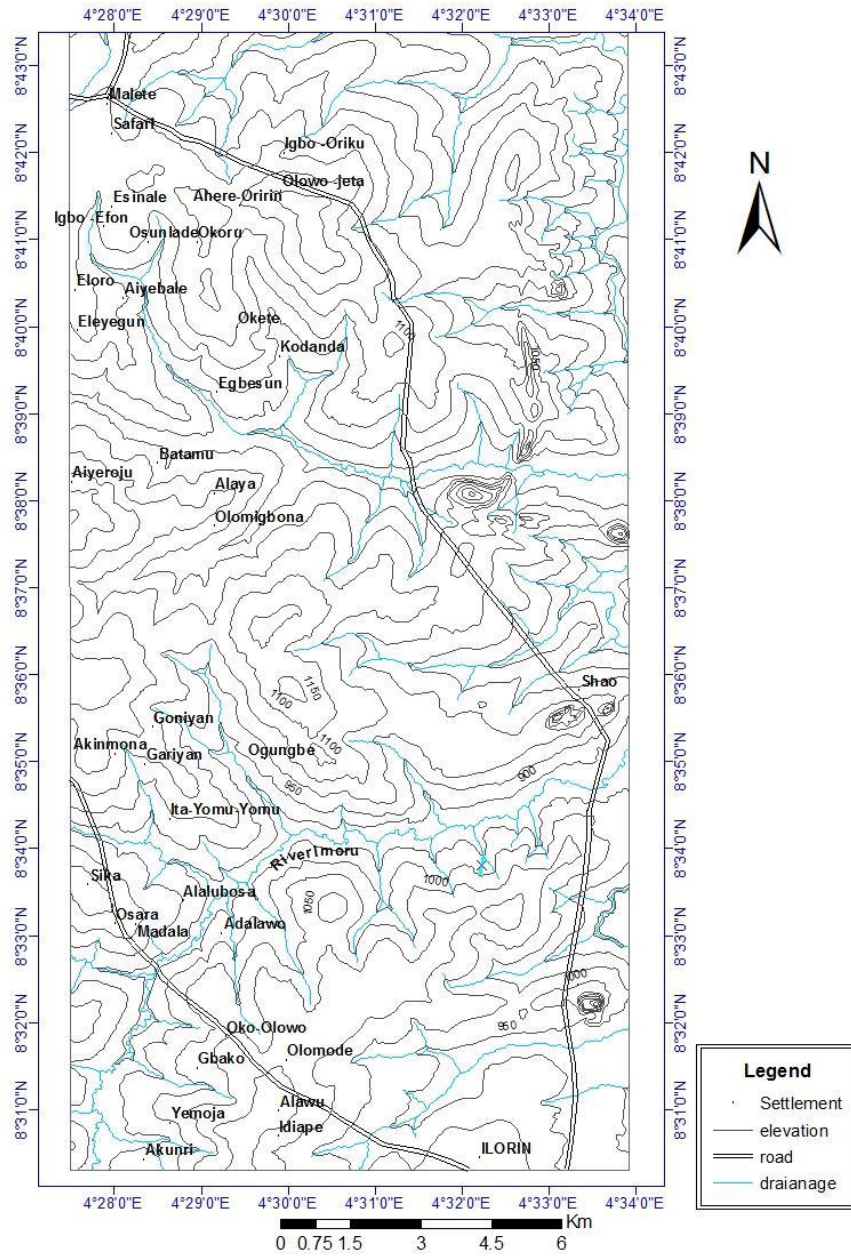


Fig.1: Location Map of the Study Area



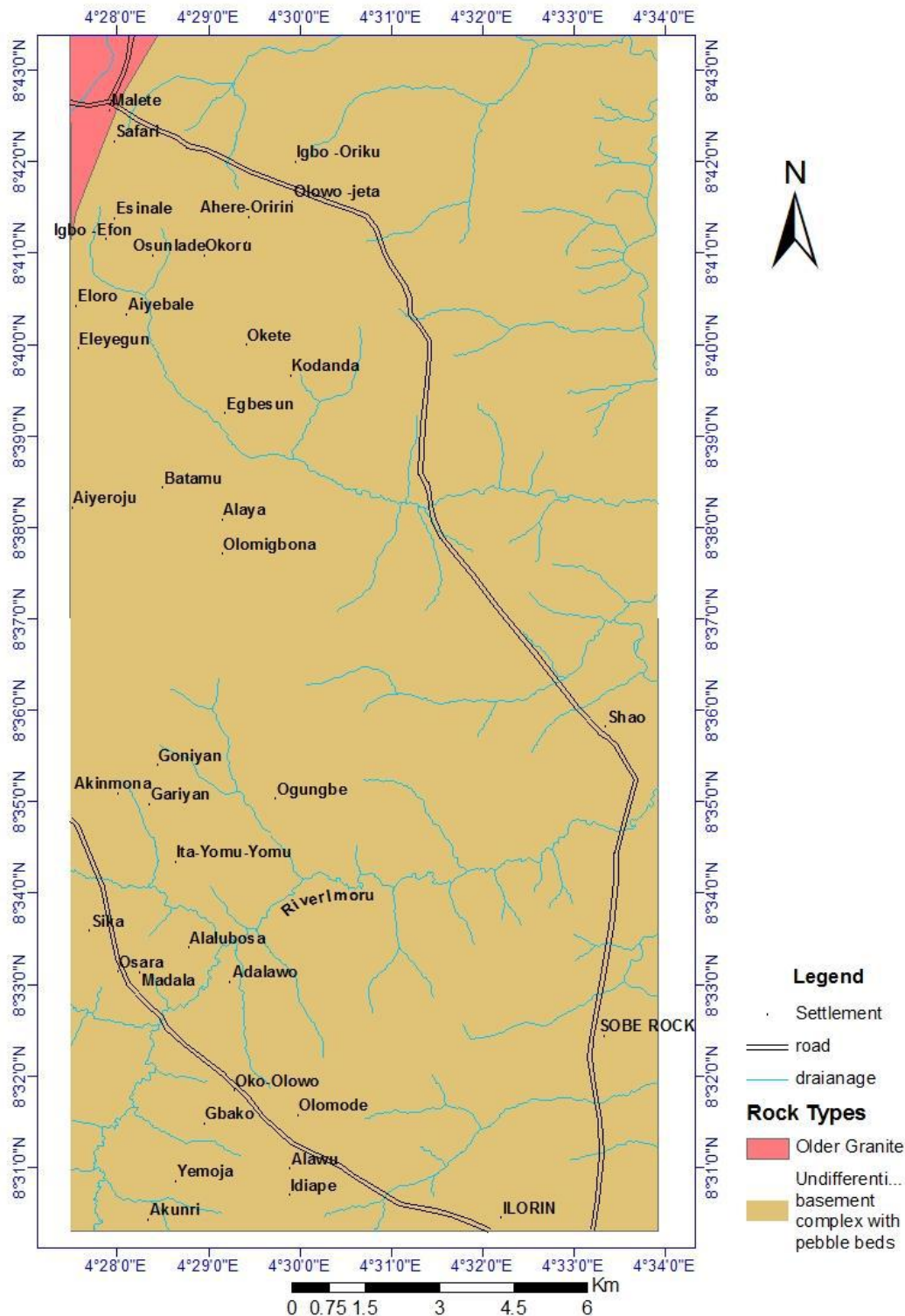


Fig.2: Geological Map of the Study Area

## II. RESEARCH METHODOLOGY

The Schlumberger depth sounding was used to investigate the change of resistivity with depth (Hoque *et al.*, 2009;

Barker *et al.*, 1996). The measured unit is the apparent resistivity,  $\rho_a$ , which is the product of a geometrical factor,  $K$ , and the quotient of the measured potential,  $\Delta U$ , and the



source current, I. The apparent resistivity is plotted versus  $AB/2$  in meters on bilogarithmic paper resulting in a vertical electrical sounding (VES) curve. The vertical electrical sounding (VES) curve showed the change of resistivity with depth, since the effective penetration increases with increasing electrode spacing. The interpretation of the VES curve is both qualitative and quantitative. The qualitative interpretation involved visual inspection of the sounding curves while the quantitative interpretation utilized partial curve matching technique using 2-layer master curve which was later refined by a computer iteration technique Resist version that is based upon an algorithm of Vander Velpen 2004. The

quantitatively interpreted sounding curves gave interpreted results as geoelectric parameters (that is, layer resistivity and layer thickness).

### III. RESULT AND DISCUSSION

Data acquired from vertical electrical sounding (VES) using Schlumberger array were interpreted, first using manual partial curve matching techniques, and later subjected to computer iterative modeling. Figure 3 (a to d) shows typical iterated VES data curves and the estimated geoelectric parameters. In the study area, four (4) curve types were identified, these are H, HA, KH and KHK. The H curve type is the most dominant curve type in the study area.

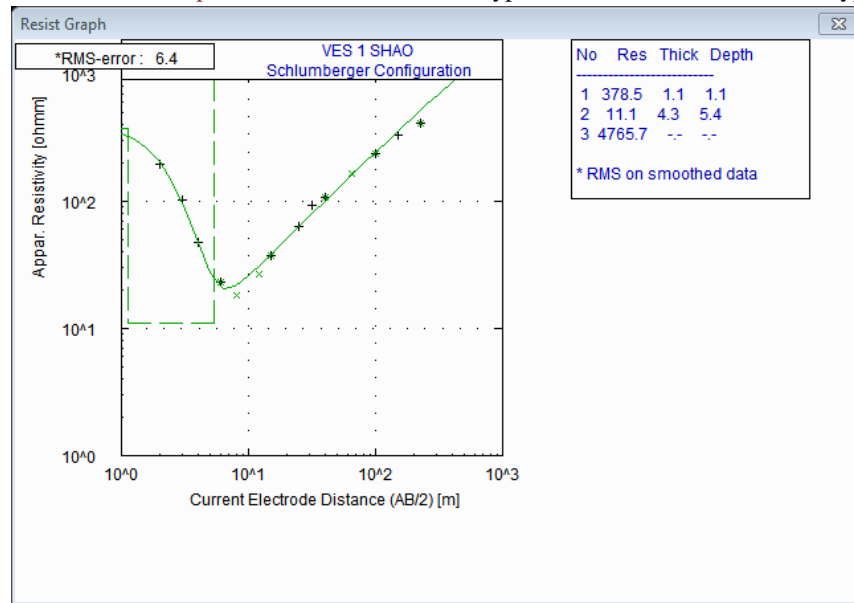


Fig.3a: Showing Typical Curve Types H Curve

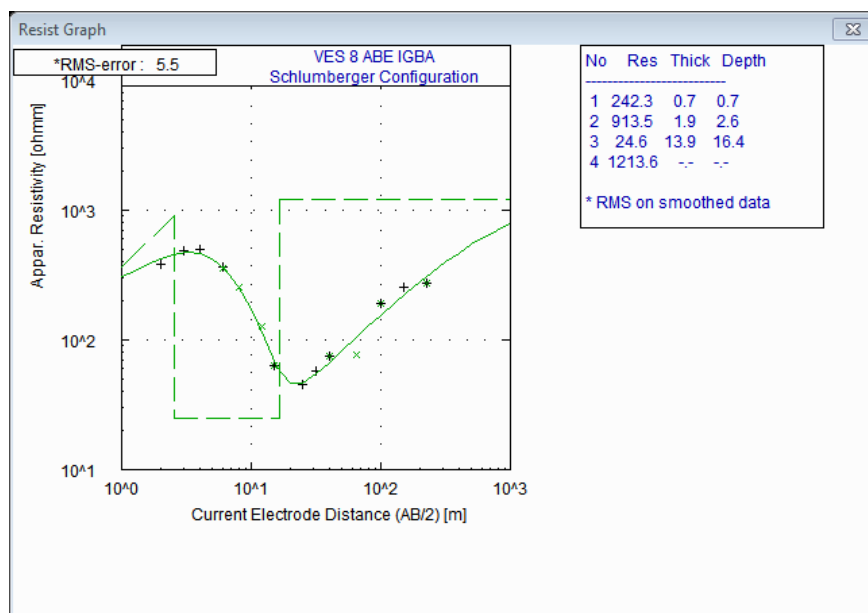


Fig.3b: Showing Typical Curve Types KH Curve

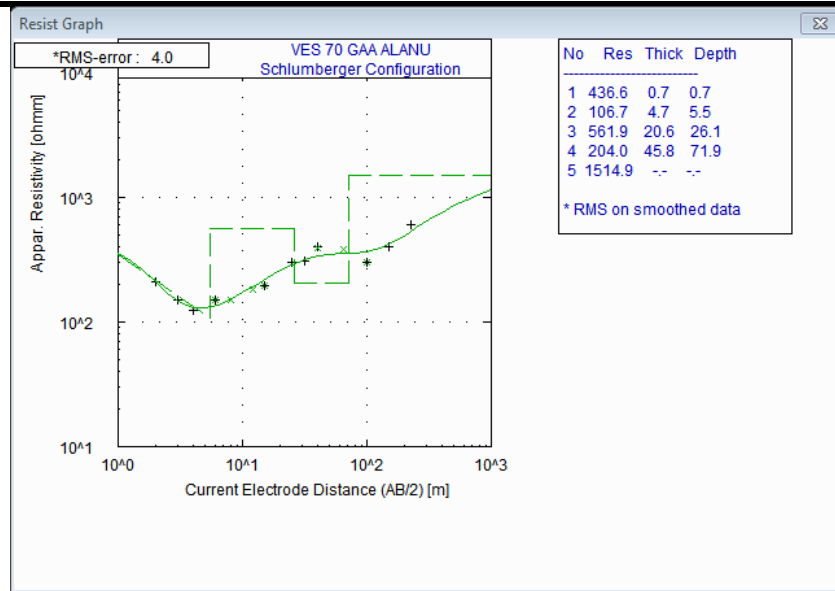


Fig.3c: Showing Typical Curve Types HKH Curve

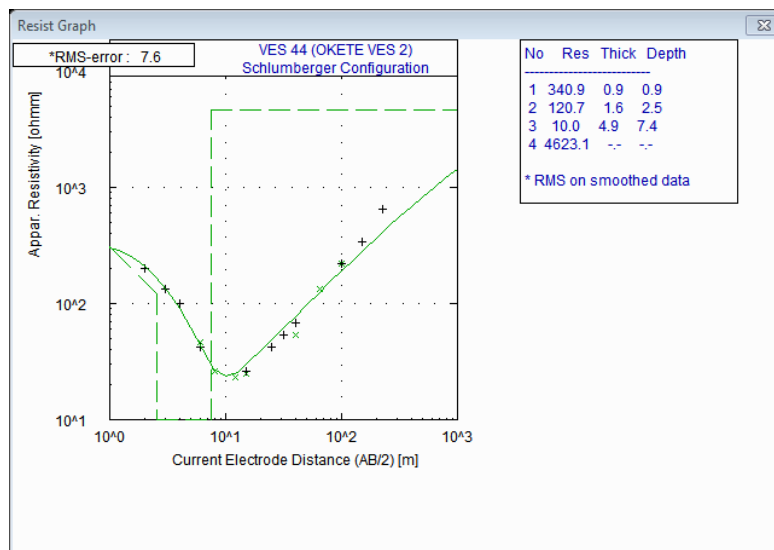


Fig.3d: Showing Typical Curve Types HA Curve

**Goelectric Section**

Goelectric section along W-E (Figure 5a): the section cuts across VES 3, VES 53, VES 57 and VES 58. This section is characterized by a thin layer topsoil of resistivity variation from 93 to 232 Ωm and layer thickness of 0.8 to 1.3 m, a thin weathered layer with layer resistivity variation of 16 Ωm, 206 Ωm, 33Ωm and 19Ωm respectively. The fresh basement has a resistivity variation from 968 to 3200 Ωm. the bedrock is generally shallow throughout this section, though a basement depression is observed but rather exaggerated due to the distance apart from one VES to another which is about a minimum of 2 kilometer apart being a regional study.

Goelectric section along SW-NE (Figure 5b): this section was taken across VES 10, VES 11, VES15, VES46 and VES 57 as it was in the earlier section bedrock is generally shallow, with layer resistivity variation of 406 to 3200 Ωm. the topsoil layer resistivity and layer thickness varies between 189 to 572 Ωm and 0.8 to 1.6 m. While the weathered layer resistivity and layer thickness ranges between 19 to 211 Ωm and 1.3 to 22.4m. The topography is generally undulating with abasement depression between VES 10 and VES 11, between VES 15 and VES 46, but is however exaggerated due to the distance apart between a VES and another which is most cases is not less than 2 kilometer being a report study.

Geoelectric section along NW-SE (Figure 5c): when compared with the two previous sections, a thicker overburden is observed throughout this section and a gently undulating topography is also observed. The topsoil layer resistivity distribution and layer thickness varies from 40 to 1578  $\Omega\text{m}$  and 0.8 to 3.2 m respectively. The topography is undulating gently, when compared with the two previous sections, but is however exaggerated due to the distance apart between a VES and another which is most cases is not less than 2 kilometer being a report study. This section is expected to have better prospect for groundwater, when compared with the two previous sections.

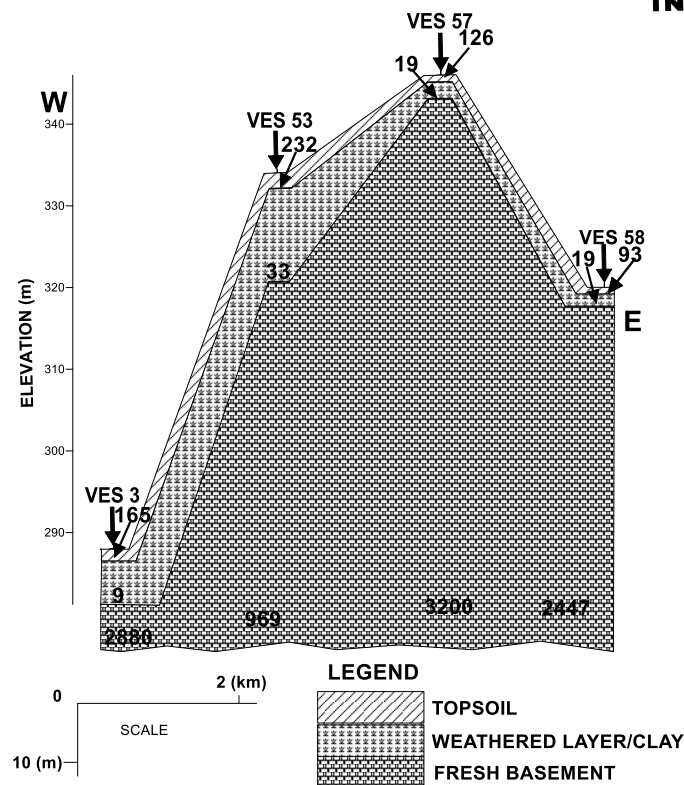


Fig.4.6a: Geoelectric Section Along W-E Direction

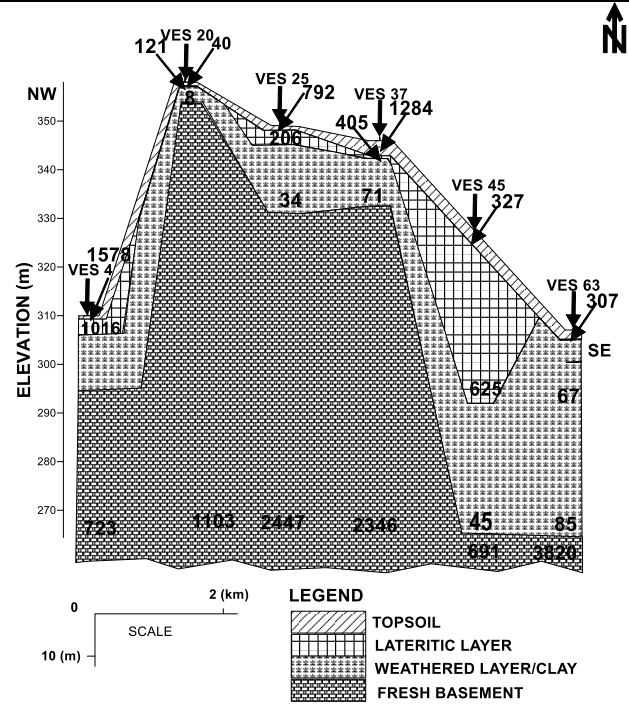


Fig.5b: Geoelectric Section along NW-SE

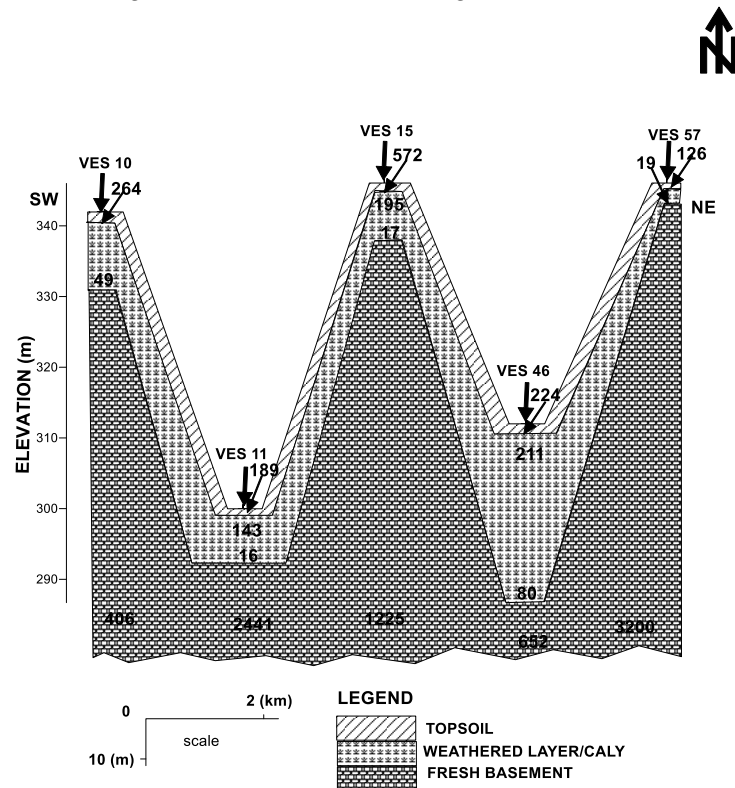


Fig.5c: Geoelectric Section Along SW-NE

**Geoelectric Map**

**Clay Horizon Resistivity Map**

Figure 6 displays clay horizon resistivity map of the study area and is based on the variation in layer resistivity within

the upper horizon below the topsoil. The value varies between 7.7 to 99.1  $\Omega$ m. This map classified into three to four region i.e. region of extremely low resistivity between 7.7 to 20  $\Omega$ m, this occurred as pockets, and were found at the northern end, part of the south and part of the south eastern end region of low resistivity between 20 to 40  $\Omega$ m, which was the case in the northern eastern end, down to the centre and towards the southern end of the study area.

Implication to the study implies good aquifer protection. This was followed by the region of moderately low resistivity between 40 to 90.1  $\Omega$ m, as obtained at the north western end, part of the centre and the south western end of the study area. Implication to the study implies moderate aquifer protection and cause low groundwater prospect around the study area.

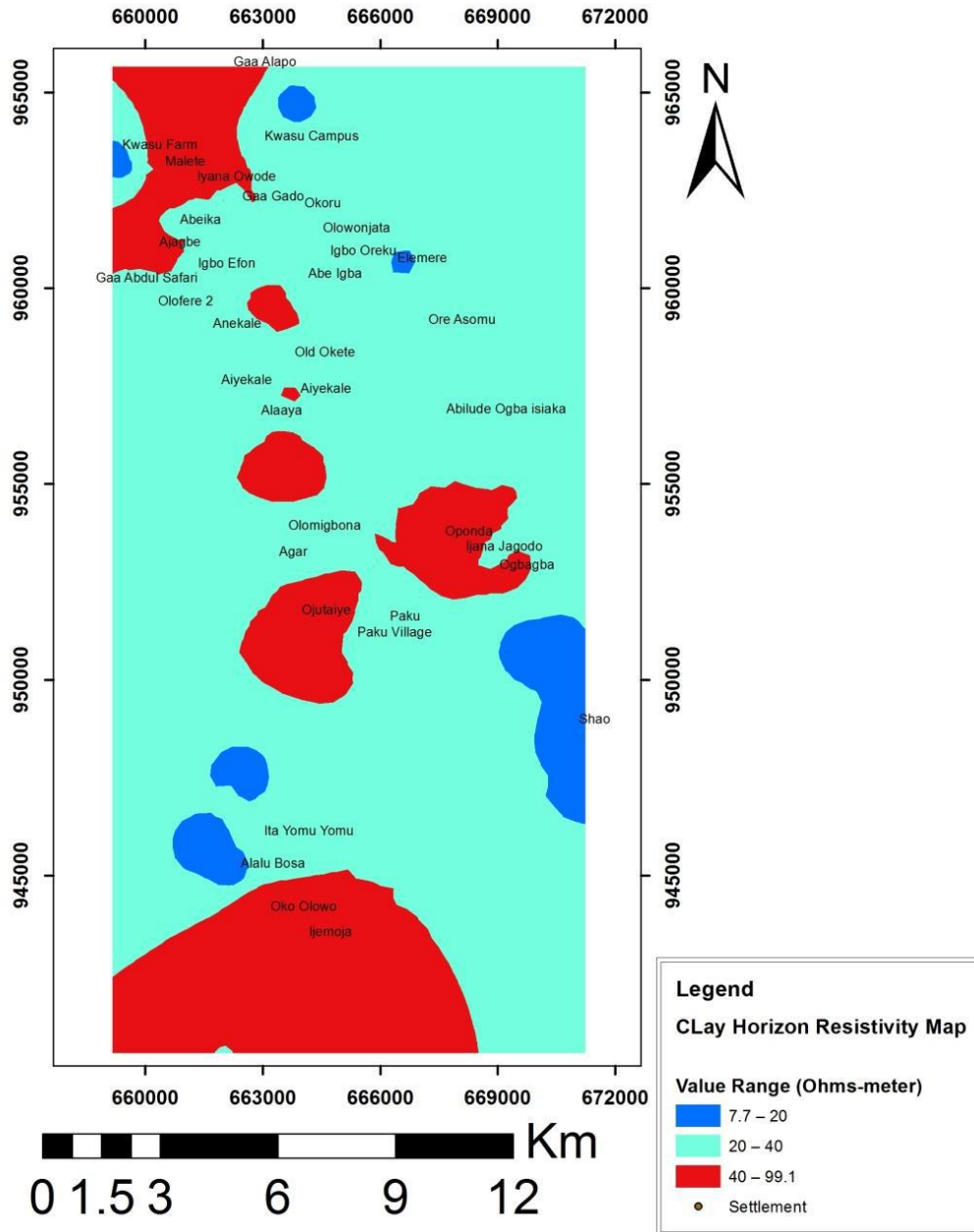


Fig.6: Clay Horizon Resistivity Map of the Study Area



### Clay Horizon Thickness Map

Figure 7 illustrates the clay horizon thickness map and was generated from the variation in thickness of the clay horizon from the study area, as the thickness of clay varies from one part of the study area to the other. The clay horizon varies between 0.9 to 20.1 m. The highest thickness between ranges from 10 to 20.1 m can be found around the centre and part of the southwestern part of the study area, while

the rest of the area is characterized by moderately thick layer of clay horizon, while a few pockets around the central south western and at the edge of south western part of the study area has a thin layer thickness between 0.9 to 5.0 m. in terms of groundwater prospect, the centre and part of the south western part of the study area has a better aquifer protective capacity low groundwater prospect.

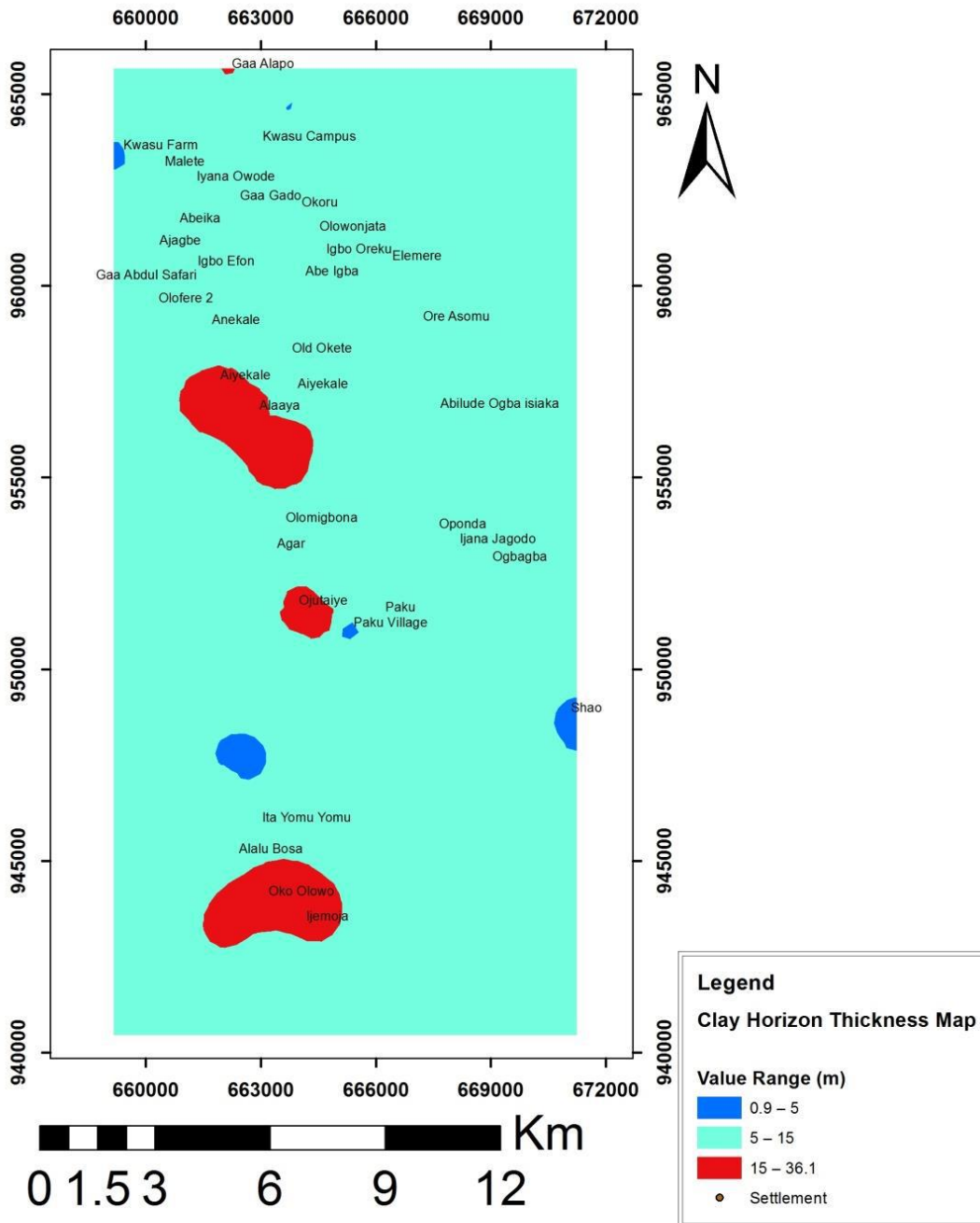


Fig.7: Clay Horizon Thickness Map of the Study Area

### Aquifer Layer Resistivity Map

Figure 8 illustrates the aquifer resistivity map of the study area. The eastern part, down to the south eastern, and up to the north eastern, part of the south western end and pocket of the northwestern end of the study area has low aquifer resistivity. While the rest of the study area is characterized by moderate aquifer resistivity and a little pocket of the northwestern end has a high aquifer resistivity. It has geologic implication to groundwater occurrence in the study area. The aquifer of the entire area is good expected for the region of low aquifer resistivity due to the existence of thick clay within the study area.

### Overburden Thickness Map

Figure 9 displays the overburden thickness map which shows the variation in overburden of the study area, from the topsoil down to the fresh bedrock. The overburden thickness varies from 1.4 to 42.7 m. the overburden thickness is very thin between 1.4 to 12 m at the north western extreme end, the central towards the eastern and part of the south western end, while it is moderately thick between 12 to 20 m in the rest of the area, expect for the part of the central and part of the south western end where the highest overburden thickness ranges between 20 to 42.7 m were recorded.

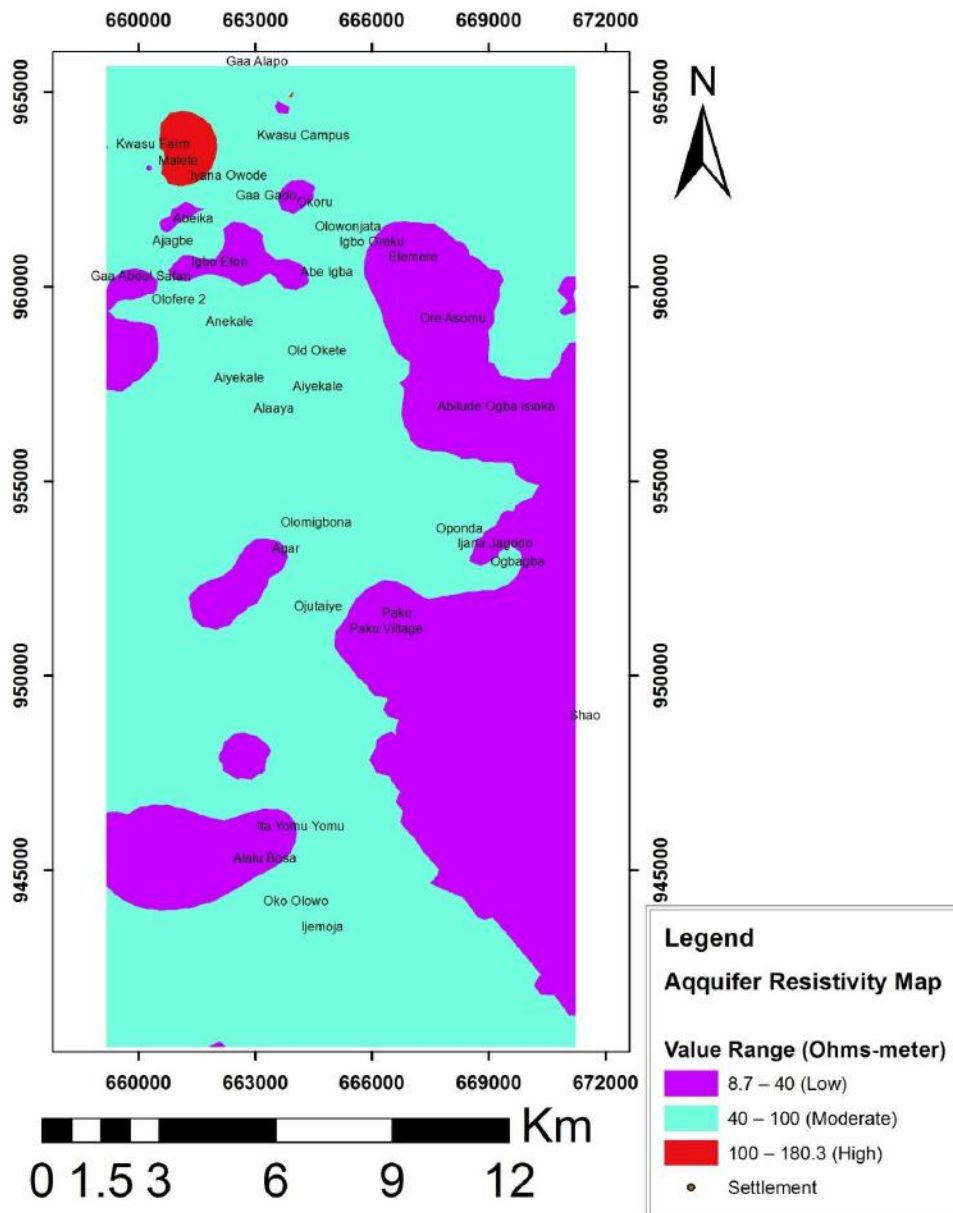


Fig.8: Aquifer Resistivity Map of the Study Area

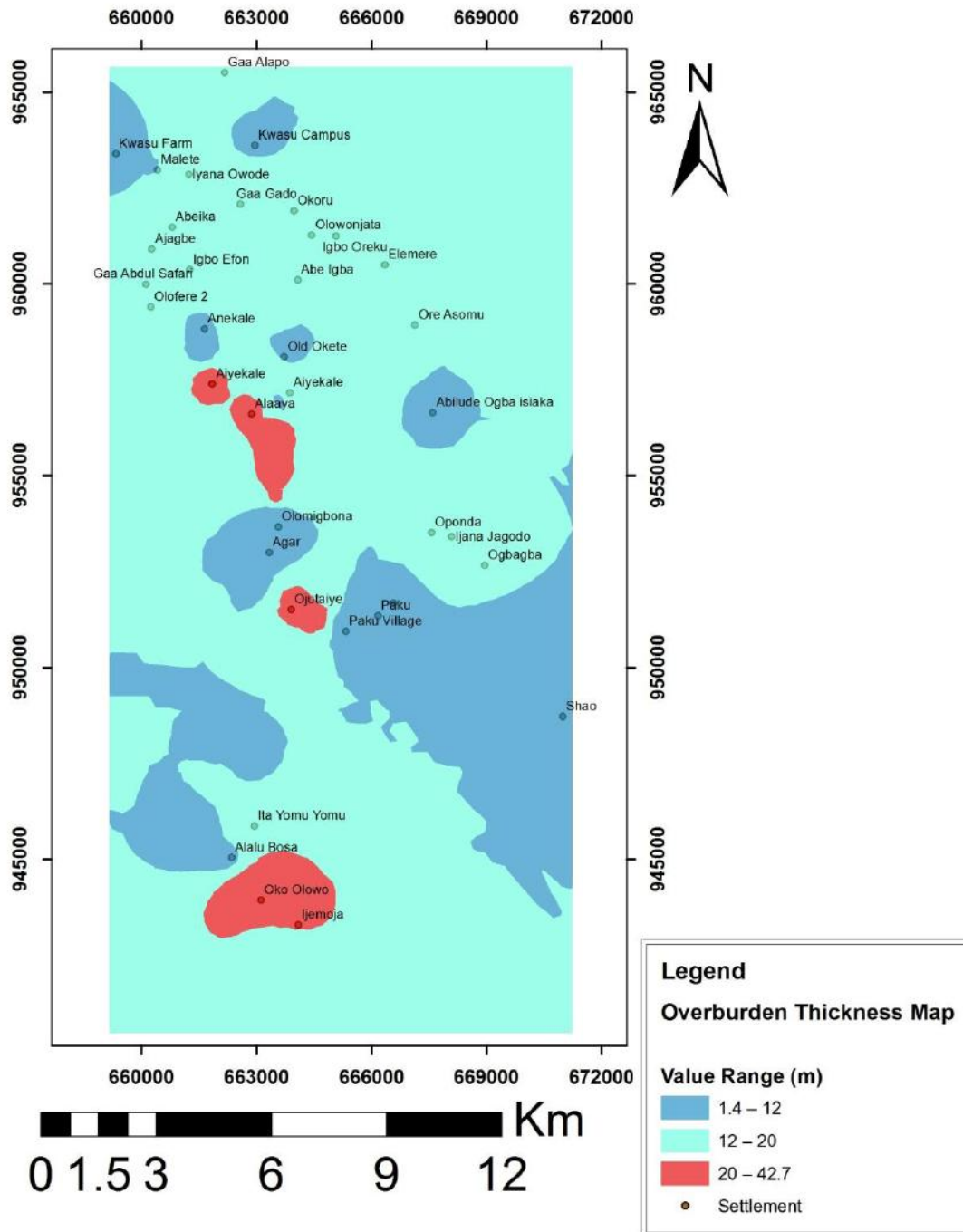


Fig.9: Overburden Thickness Map of the Study Area

#### IV. CONCLUSION

In this research, groundwater prospect of Central Kwara have been investigated using electrical resistivity method for both domestic and industrial application in the face of scarce water resources, occasioned by incessant borehole failure/low yield, has prompted researches for viable source of water. The central Kwara state falls within the basement

complex region of Nigeria known as the hard rock terrain, where availability of groundwater is dependent mainly on structural features (such as fracture, weathered basement, etc) and their dispositions to yield groundwater. The general curve types obtained from the study area were H, HA, KH and HKH types with the H curve type more prominent in the study area, while the curve types obtained from the

study area allowed for the aquifer characterization. Three geoelectric sections generated with resistivity parameters ranging between 350 to 1900 ohm-meters, 7.7 to 99.1 ohm-meter and above 3000 ohm-meter; making up the topsoil, weathered layer and bedrock respectively. The topsoil is interpreted as laterite/hard pan within thickness range of 0.4 and 2.2 m while the weathered layer zone ranged between 0.9 to 36.1 m thickness respectively; making the overburden of the area with thickness range of 1.4 to 42.7 m. The bedrock resistivity ranges from 400 ohm-meter to 8192 ohm-meter, indicative of weathered/fractured and fresh basement respectively. The result of the vertical electrical sounding were used to generate aquifer characterization vis-à-vis, the clay horizon resistivity map, clay horizon thickness map, aquifer resistivity map and overburden thickness map, . This study reveals that the study area is dominated by clay which lead to borehole failure and dry up of hand pump well because most of the hand pump well were terminated within the clayey formation.

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# Characterization of the Use and Occupation of Soil on Rural Properties Using Remotely Piloted Aircraft Systems - RPAS

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**Abstract** - *The use of remotely piloted aircraft systems allows for practicality in the collection and monitoring of study areas or in the development of rehabilitation projects for degraded areas. As such, this technology is gaining space as an alternative for applications in studies and surveys of several areas. This work is justified by the demand for projects and the search for practical alternatives that will enable the framing of rural properties according to the new Brazilian Forestry Code (Código Florestal Brasileiro) and its environmental recovery plans (Plano de Recuperação Ambiental). The objective of this study is therefore to evaluate the use of a Remotely Piloted Aircraft System in the monitoring of a rural property, seeking to include it in the framework of the Brazilian Forestry Code. To accomplish this work, information samples were taken in an area of 30.19 ha of a rural property with the use of a Remotely Piloted Aircraft System - RPAS. After the data collection, the images were treated using the QGIS software and through the generation of an ortho-mosaic, which enabled the data to be analyzed and interpreted. With the interpretation of land use and occupation data and with the generation of maps of land use and occupation, a diagnosis of the current situation of the area can be obtained. In a second phase, maps were created to include the property in the current legislative framework, seeking its regularization. After the completion of this work, the conclusion can be drawn that the use of a Remotely Piloted Aircraft System - RPAS is viable and enables the monitoring of rural areas with efficiency and speed.*

**Keywords:** *Monitoring, agriculture, environment, sustainability.*

## I. INTRODUCTION

Monitoring rural properties with Remotely Piloted Aircraft Systems (RPAS) allows for a detailed analysis of the area, and this procedure allows for the tracking and establishment of monitoring practices in the areas of study. This new technology is gaining space in the development of analyses and studies and enables adjustments and improvements in the obtained results.

According to Tomaél, Alcará and Chiara (2005) and Slompo (2013), the use of the RPAS technology allows for the improvement of monitoring practices of the earth's surface, in addition to performing the imaging of areas, characterizing the real conditions found regarding the use and occupation of the soil, with innovative practices and practicality in the monitoring of the environment.

According to Rossi et al., (2016) remote sensing procedures applied to the data collected with RPAS enable the development of Digital Elevation Models (DEM) and Digital Surface Models (MDS). These variables can be interpreted and analyzed for the inclusion of properties in the Environmental Recovery Plan (*Plano de Recuperação Ambiental* or PRA, Brazil, 2012). With the available variables, a set of actions can be applied to develop proposals in temporal and spatial scales, to carry out and monitor changes in the course of the process, apply them in line with the projected delimitations (Silva and Zaidan, 2004).

According to Fitz (2008), the procedures applied to remote sensing, part of the principle related to the interactions between the type of physical process and the incidence of electromagnetic energy on a set of objects in which this radiation.

This interaction can have different levels of reflectance depending on the type of surface on which different wave lengths are incident, i.e., for each target different characteristics or results are returned, which is called the spectral signature.

There are various pieces equipment with different technical specifications, having as important the sensors of each aircraft. RPAS have control systems that are linked to software and computers, which allows for the control of the image collection process (Watts, Ambrosia and Hinkley, 2012).

The imaging process occurs with the flight over the area of study, when a reading of the ground is made with pictures while a triangulation of the distance of the aircraft to the ground is performed. This ratio is obtained considering the time of displacement of the laser between the equipment and the ground. To improve the accuracy of the collected data, these variables are compared to data obtained with a GPS so the altitude and location of the aerial vehicle can be predicted, determining its spatial position as well as the proper positions of its imaged targets (Arana, 1994; Machado, 2006). The GPS used in conjunction with the aircraft allows for a reduction of the control points in the field (Arana, 1994).

The distribution of the control points identified with a GPS on the ground enables an improvement in the accuracy and generation of the ortho-mosaic, and the precise location of the control points from the vertical and horizontal coordinates of each image captured, triangulated with each control point in the field, also

allows for the correction and gradual reduction of errors in image processing (Andrade, 1988; Arana, 1994).

In the implementation of the imaging process the flight plan must be defined, and a good definition of the flight plan will ensure the control of the location of the aircraft as well as the quality of the images in the area of interest (Boeing, Caten and Vitalis, 2014).

The interpretation process of the data collected with the aircraft can be compared with the *in situ* information. This interaction between data enables the processing and interpretation of the variables after their processing, and permits the extraction and exclusion of several pieces of information from this set (Andrade, 1988; Arana, 1994).

In this context, this study seeks to use an RPAS as a method for the occupational characterization of rural properties, enabling the classification of land use and occupation in order to assess if the property is in compliance with the current forestry legislation and to include it in the Rural Environmental Registry (*Cadastro Ambiental Rural*, CAR) and the Environmental Recovery Plan (*Plano de Recuperação Ambiental*, PRA) (Brazil, 2012).

## II. MATERIALS AND METHODS

**2.1 - Study Location** - this study was conducted in a rural property located in the municipality of Vitorino - Paraná - Brazil, located on the geographical coordinates 26° 20' 21" S latitude, 52° 49' 42" W longitude and altitude of 850 m on the Pandini property lot, part of the Sant'Ana ranch, with a total area of 338 ha (Figure 1).

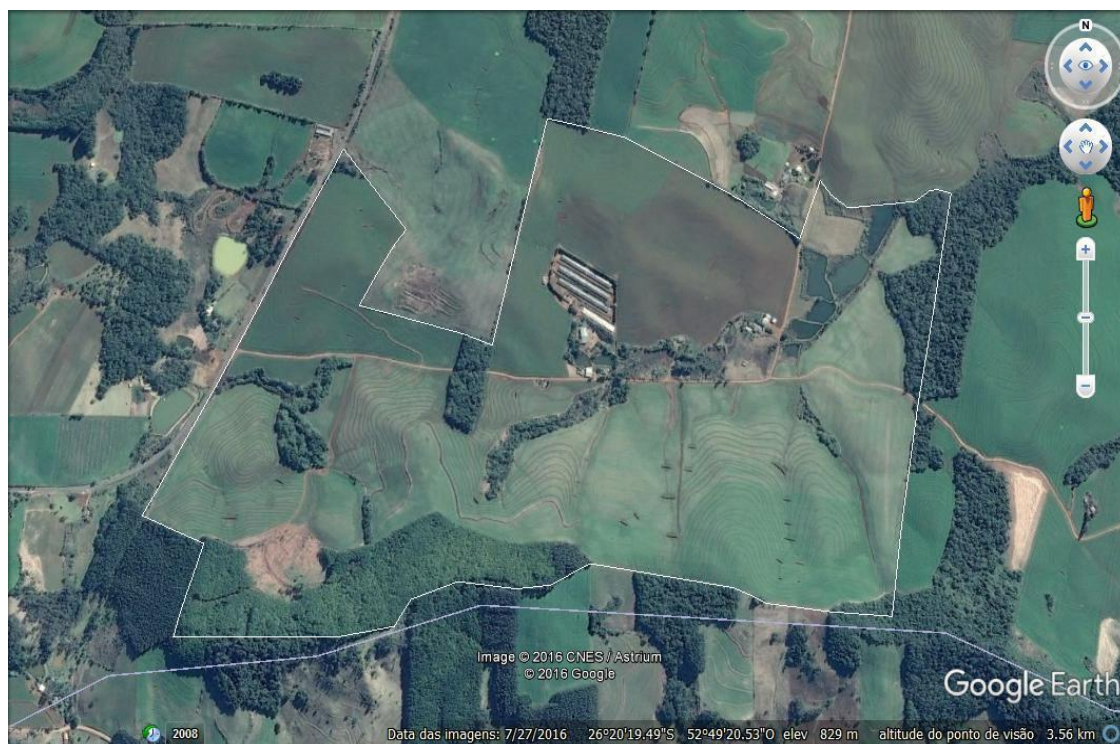


Fig. 1: Overview of the area of the property under study



**2.2 Data Collection** - the collection and characterization process of the area sought to obtain and associate data and to enable a more accurate representation of the real conditions of the study area, identifying the use and occupation of the soil. Flights were performed over the area using the RPAS to obtain data.

**2.3 Acquisition of Aerial Images** - The flight was performed with an *Innovations* UAV model aircraft (Figure 2), coupled to a multispectral camera with direct communication with a telemetry antenna that communicated with a data center. The aircraft flew over a

total area of 338 ha (of which 30.19 ha was the area in which the study was developed), in 26 minutes of flight and the flight was monitored with the aid of the software *Mission Planner*. The data of the obtained images were processed with the *Pix4D* software, obtaining a orthorectified and georeferenced mosaic. The image collection of the area started based on the development of the flight plan (Figure 3), and based on the defined plan, homologous and pre-flagged support points had to be established to assist in the auto-triangulation process (Wandresen, 2003).



Fig. 2: Aircraft used for the imaging of the area of study - Innovations UAV



Fig. 3: Representation of the flight plan

The flight plan was defined based on the *Google Earth* images, which worked as a reference for the delimitation of the overflow area. The wind speed and direction should be taken into account to identify control points on the ground, which will allow for the tethering with the GPS points collected for the same points (Slompo, 2013). Subsequently, with the retrieval of images, photogrammetry practices started being applied, which is the interpretation of information through images of one and the same element on the surface of a terrain, obtained from two approximate and delimited positions on the line of flight. The obtained product is called an orthophoto, for which a processing software is used that can interpret the information, extracting measures, area, volume and therefore interpreting the occupational situation of the area (Hoerlle et al., 2015).

**2.4 Image Treatment** - After obtaining the images, a cleaning up needs to be performed to check whether there was no interference from the environment in the capturing process that make a proper visualization for the interpretation of images impossible. This interpretation principle of aerial photos is a process known as

photogrammetry or photo-interpretation. The processing of the images after the generation of the orthophoto can be accomplished with the Quantum GIS or SPRING software in order to get geometrically corrected images in a single image, through georeferencing with the adoption of cartographic projection.

### III. RESULTS AND DISCUSSION

**3.1 Soil Use and Occupation** - The total imaging of the area with 338 ha resulted in a orthomosaic with 1,520 images, with the drone needing a flight of 26 minutes for the area of 30.19 ha, requiring 9 minutes of flight. The RGB (Red, Green, and Blue) image of the area of study can be seen in Figure 28, which used approximately 140 images with an overlap of 75%. This overlap is what allows for the generation of the orthomosaic, which is generated with the help of the *Pix4D* software. The overlay permits the identification of similar points in the images so the mosaic can be created.

With the use of the RGB image, the demarcation of the land use and occupation of the area was performed (Figure 4), with the demarcation of each feature's limit.

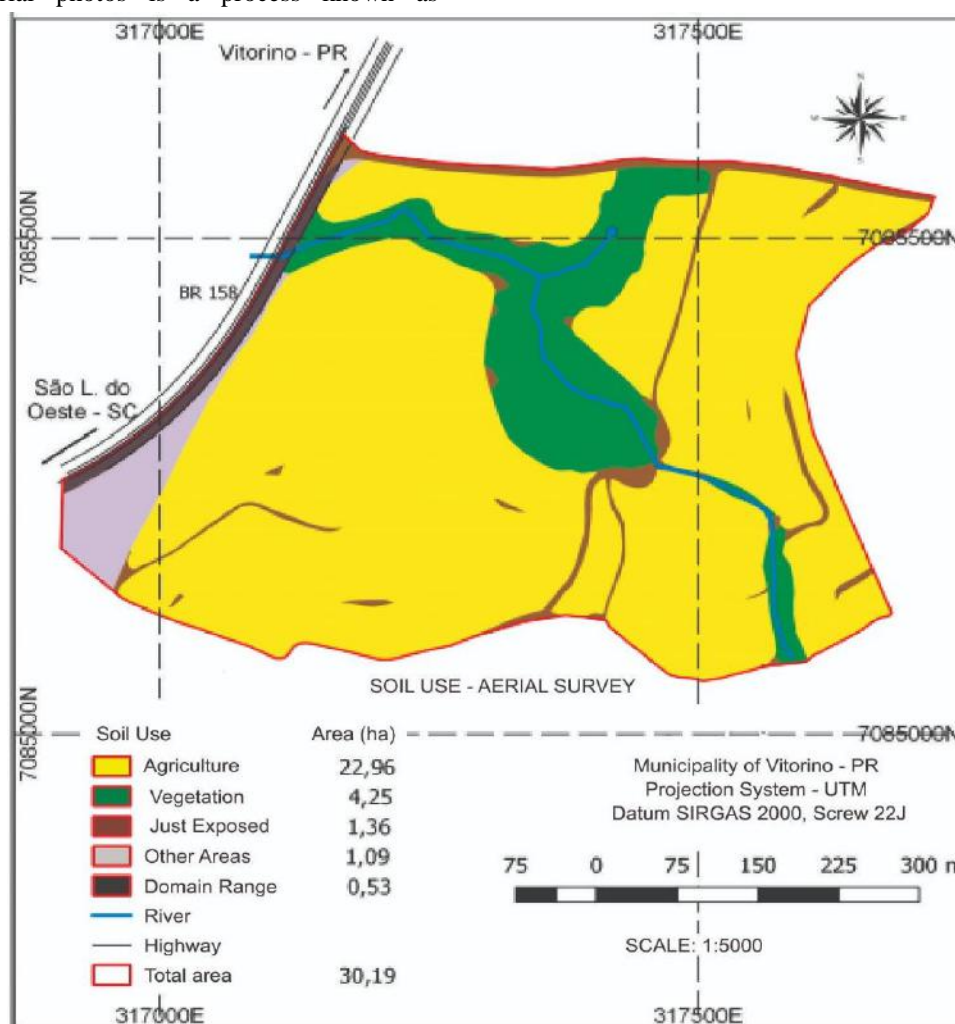


Fig. 4 - Soil use and occupation with aerial surve



Based on this image, the occupational situation of the area can be seen, reaching the variables of each polygon of occupation identified in the image. The characterization using the RPG image could define the use and occupation of the soil of the total area of 30.19 ha, with 22.96 ha being classified as crops, 4.25 ha area as vegetation, 1.36 ha as exposed soil, and the remaining areas corresponding to 1.12 ha formed of undergrowth, shrubs and rocky area and 0.53 ha to public utility areas.

**3.2 Adjustment to the Brazilian Forestry Code** - the inclusion of the property into the framework of the new Brazilian Forestry Code (*Código Florestal Brasileiro*, Law n.º 12.651) requires every real estate to develop the PRA (environmental recovery plan). This means properties will have to follow practices that meet these requirements in general. This adjustment of the property has generated data with the information collected with the flight, represented in figure 5.

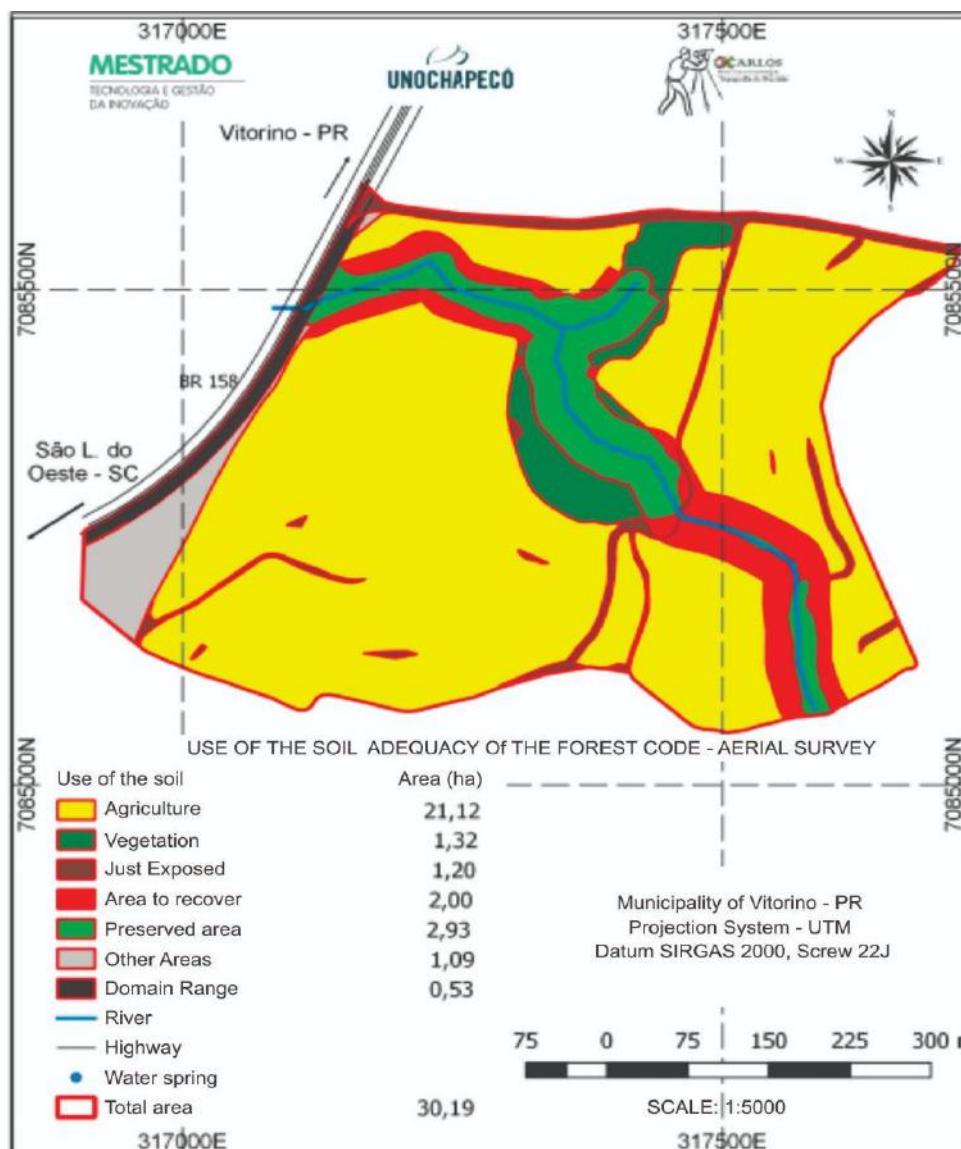


Fig. 5: Map of the adjustment of the forestry code obtained from the aerial survey

Through the imaging data, one can get to the representation of the study area with the adjustment to the Forestry Code, and so it was characterized from the aerial survey, and this can be seen in Table 1.

The data in figure 5 and in Table 1, and considering that the property has an area exceeding 10 fiscal modules (MF), which places it in the framework of the new Forestry Code, shows that it's necessary to recover land

for the permanent preservation area. Today, 2.93 ha (59.43%) is adequate for the new Forestry Code. which means a total of 2.00 ha (40.57%) that is currently being used for agricultural activities must be recovered. As to the necessity of a legal reserves, the owner must examine his property as a whole and adapt it have a minimum of 20% of preservation area, which should be presented in

the proposals for regularization in accordance with the PRA.

Table 1: Adjustment of the use and occupation of the soil to the new Forestry Code based on the aerial survey

Soil Use	Area (ha)
Crops	21.12
Vegetation	1.32
Exposed Soil	1.20
Preservation area to be recovered	2.00
Preserved preservation area	2.93
Other areas	1.09
Public utility areas	0.53
Total area	30.19

This reveals the need for technologies that optimize this practice and the PRAs reveal total viability for the implementation of these practices. The demand that properties make adjustments in accordance with the PRA requires that innovative practices and works be carried out.

The drone flight has enabled the characterization and representation regarding the use and occupation of the soil, and also returned precise variables for the representation of the terrain. This system was therefore shown to address the situation found in the property more than satisfactorily, bearing in mind that the performed characterization involved all 338 ha and that the procedure lasted 26 minutes, which demonstrates the agility in data collection for the interpretation and inclusion of properties into the PRA framework.

The analysis of the data collected in this property revealed that the required demarcations for inclusion into the regulatory framework of the new Forestry Code through the PRA can be met and that the necessary adaptations can be made.

#### IV. CONCLUSION

Considering the adaptation requirements imposed on rural properties by the Brazilian Forestry Code, through which all rural properties must be included in the Rural Environmental registry and adhere to the Environmental Recovery Plan, the results obtained in this study allow for the conclusion that the use of remotely piloted aircraft systems (RPAS) is an efficient method for the occupational characterization of rural properties and that they can be used to characterize the use and occupation of the soil.

The conclusion can also be drawn that the collection and analysis of data obtained by the RPAS optimizes work time and decreases the need for field trips to survey data.

In addition, the results show that the tool used proved to be practical and functional for the completion of the work, especially in cases of more severe degradation of the native vegetation, and that the RPAS could serve to support the monitoring and recovery of degraded areas, facilitating and expediting the work of technicians and managers who use the system.

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# Developing Multi Linear Regression Models for Estimation of Marshall Stability

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**Abstract**—Nowadays, asphalt roads are exposed to increasing traffic loads in recent times. It is important to obtain a quality and healthy asphalt road covering when considering the conditions of our country where freight and passenger transportation are carried out by roads. One of the most important issues in asphalt road design is the determination of the optimum percentage of bitumen. The Marshall stability test is utilized for optimum percent bitumen determination. In our work, instead of the long and laborious Marshall experiment process, Multi Linear Regression (MLR) Models are developed as an alternative. Models were developed for Marshall experiment result for Marshall stability prediction. In order to construct stability estimation models, pre-made test parameters are used. These parameters are; the bitumen penetration (P), weight of the sample in the weather (H), the temperature (C), the bitumen weight (G), the sample heights (Y), the bitumen percentage (W), weight of the sample in water (S), the stability (ST). In the performance evaluation of the models, the correlation coefficient (R), the mean percentage errors (MPE) and the meansquare errors (MSE) are used. It is seen that the model with the highest performance value is composed of six variable model in this study formed by the MLR. The R value of the best model is 0.571. The MSE value of the best model is 14841,81. The MPE value of the best model is 9.58.

**Keywords**—Marshall Stability Experiment, Multi Linear Regression, MSE, MPE,

## I. INTRODUCTION

Highway transportation is becoming increasingly common all over the world and due to the increase in population in our country, the increase of transportation demands and the environmental factors. Due to this reason, studies are being carried out in order to obtain better quality asphalt roads. Bituminous hot mix is used to obtain a healthy and high quality top structure in asphalt road construction[1]. Asphalt road damages occur more frequently in the binder and wear layers than in the

base and sub base layers. Deformations in the asphalt roads are deformation such as surface cracks, pits, subsidence, and breakage[2]. The stability and flexibility that asphalt shows in long-term short-term freight transit is of great importance. The performance of roadway coating is crucial for the road to be long lasting. The coating performance is determined by the stability of the asphalt concrete. Many of the deformations that occur in the coating is due to the low stability of the asphalt concrete [3]. The stability of asphalt concrete depends on properties such as bitumen hot mix, bitumen content, bitumen viscosity, softening point, asphalt construction conditions and climate [4]. Fatigue fractures occur due to the effect of repetitive loads during highway coating. These cracks are one of the important deteriorations [5]. The percentage of asphalt bitumen is of great importance for the healthy design of asphalt roads. In the use of bituminous hot blending methods, the importance of engineering and project engineers is important [6]. Much research has been done on Marshall experiment and regression analysis. Yıldız ve Gökdemir [7] the asphalt concrete abrasion layer was subjected to regression analyzes using Marshall design method and SPSS 11.0 package program to obtain optimum mix design. As a result, the results obtained with these two methods are consistent. However, it is necessary to try the Marshall in accordance with the specifications. Namlı, Kuloğlu [8] they compared the Superpave and Marshall experiments. Asphalt concrete samples were prepared and applied in accordance with the rules for both tests. Özgan, Serin, Kap [9] have investigated the effect of hot mixture parameters on Marshall stability. The parameter bitumen ratio, which is the most positive correlation with Marshall Stability, was determined. The temperature was found to be the least relevant parameter. Konak [10] have prepared hot asphalt mixtures with different impact numbers. Marshall ratio is determined. The evaluation of the results determined by the regression analysis is done. Deniz, Lav [11] investigated the effect of granular sulfur on the stability of bituminous asphalt. In order to obtain quality asphalt mixtures, it is also important to use modified



materials that are reinforced with additives as well as quality materials.

## II. MATERIAL AND METHODS

In this study, variables with Marshall Experiment parameters are examined as dependent and independent variables. Independent variables; weight of the sample in the weather, bitumen penetration, the temperature, the bitumen weight, the sample heights, bitumen percentage, weight of the sample in water. Stability value is dependent variable. Regression models are formed by these dependent and independent variables. In this study, 1050 experimental data are used.

### Multiple Linear Regression Methods for Marshall Stability Estimation

Regression analysis has been one of the most used techniques to determine the relationship between variables in research [12]. There are many types of regression. There are linear, nonlinear, simple, multiple, parametric, nonparametric, logistic, etc. regression models [13, 14, 15]. The MLR model we use in this study is as in Equation 1.

$$y(x) = \beta_0 + \sum_{i=0}^N \beta_i x_i + \sum_{i<j}^N \beta_{ij} x_i x_j + \sum_{i=0}^N \beta_{ii} x_i^2 + \varepsilon \quad (1)$$

In this form,  $x_i$  and  $x_j$  ( $i = 1, \dots, N$ ) ( $j = 1, \dots, N$ ) represent independent variables. The  $y$  in the equation represents the dependent variable,  $\beta$  represents the regression coefficients, and  $\varepsilon$  represents the error. The dependent variable  $y$  is modeled as a combination of fixed, linear, interactive, and second order terms consisting of auxiliary variables. The coefficients of the model are estimated by MLR analysis [16, 17].

Linear, Interaction, Quadratic and Purequadratic MLR methods were used in our study. It is seen that the best model among the created models is six variable models. The beta coefficients of the model were obtained at the end of the analysis in the MATLAB program. The linear regression model of this model is shown in Equation 2.

$$ST = -905,2378314 + 5,388874025 * H \\ - 4,342171288 * P + 9,301123242 \\ * C - 33,57871985 * Y - 72,1825 \\ * W - 4,429639906 * S$$

(2)

Equation 3 of the interaction regression model is seen.

$$ST = -1076,034481 - 11,51577899 * H \\ + 92,69293196 * P - 143,0209243 \\ * C - 282,6862705 * Y \\ + 220,8074527 * W + 69,30927451 \\ * S + 0,276126182 * H * P \\ - 0,042548775 * H * C \\ + 0,401606147 * H * Y \\ - 1,251214819 * H * W \\ - 0,018546838 * H * S \\ - 0,329144805 * P * C \\ - 1,253213817 * P * Y \\ - 0,60228875 * P * W \\ - 0,424118338 * P * S \\ + 2,317337895 * C * Y \\ + 1,416000019 * C * W \\ + 0,102508531 * C * S \\ + 5,295628482 * Y * W \\ - 0,737332781 * Y * S \\ + 0,977486549 * W * S$$

(3)

The coefficients of the quadratic regression are shown in equation 4.

$$\begin{aligned}
 ST = & +18054,48354 - 9,067259718 * H \\
 & + 29,37620757 * P - 346,8691251 \\
 & * C - 63,91968259 * Y \\
 & + 898,8133477 * W + 33,5450474 \\
 & * S + 0,338978055 * H * P \\
 & - 0,060892258 * H * C \\
 & + 0,741417288 * H * Y \\
 & + 0,173132269 * H * W \\
 & - 0,029464774 * H * S \\
 & - 0,189360359 * P * C \\
 & - 1,649029683 * P * Y \\
 & - 1,407600681 * P * W \\
 & - 0,487389052 * P * S + 1,95442971 \\
 & * C * Y + 1,241707794 * C * W \\
 & + 0,227220653 * C * S - 8,24161665 \\
 & * Y * W - 0,965717554 * Y * S \\
 & - 0,76027346 * W * S \\
 & - 0,010074251 * H^2 \\
 & + 0,347384307 * P^2 + 0,532139852 \\
 & * C^2 - 2,570864781 * Y^2 \\
 & - 24,91495593 * W^2 + 0,04086942 \\
 & * S^2
 \end{aligned}$$

(4)

The results of the Purequadratic regression are shown in equation 5.

$$\begin{aligned}
 ST = & -1507,569095 + 10,98246856 * H - \\
 & 66,05557092 * P - 108,2193999 * C - \\
 & 177,1409938 * Y + 92,71018452 * W + \\
 & 30,01804932 * S - 0,002177812 * H^2 + \\
 & 0,512588536 * P^2 + 0,403104664 * C^2 + \\
 & 1,139821409 * Y^2 - 17,69735793 * W^2 - \\
 & 0,025567309 * S^2
 \end{aligned}$$

(5)

### III. RESULTS AND DISCUSSION

In this study, a total of 107 ST prediction models are constructed including one variable, two variables, three variables, four variables, five variables, six variables and seven variables. Models are subjected to four different regression techniques (Linear, Interaction, Quadratic and Purequadratic) to obtain the performance values of 428 different model results. As a results of the analyzes made, the performance of the models is compared. When the performance comparison is made, the correlation coefficient, the mean square errors, and the mean percentage error values are compared. The model with the best performance is the model with six different variables.

The best model is the Quadratic regression model. The correlation coefficient is 0.57, the mean square errors is 14841.81, the mean percentage errors is %9.58 (Table 1).

Table 1: Comparison of Multiple Linear Regression Methods for ST Estimation

	R	MSE	MPE
Linear model	0,510	16288,44	10,04
Interaction model	0,553	15281,68	9,70
Quadratic model	0,571	14841,81	9,58
Pure Quadratic model	0,542	15543,28	9,76

The comparison of the actual stability value with the stability value of the regression model is given in Figure 1.

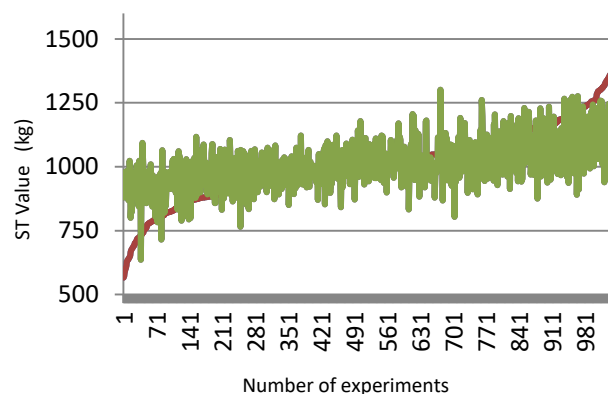


Fig.1: Comparison of actual value and best MLR results for stability value

### IV. CONCLUSION

- In this study has benefited MLR techniques that are Linear, Interaction, Quadratic and PureQuadratic regression techniques.
- The independent variables are weights of the sample in the weather, bitumen penetration, the temperature, the bitumen weight, the sample heights, bitumen percentage, weight of the sample in water.
- The value of Marshall Stability is used in the regression models as the dependent variable.
- To find the best regression model, 428 MLR models were fitted.
- The best MLR model has been a six-variable with quadratic regression method.
- The R value of the best MLR model is 0.571.
- The best MSE for the model is 14841,81.

- The best model has the MPE value of 9.58.
- It is seen that there is a weak interaction between the independent variables and the dependent variables by MLR techniques.
- However, artificial intelligence techniques can be used to achieve better results than regression models in further studies.

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# An analysis of rainfall based on entropy theory

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**Abstract**— *The principle of maximum entropy can provide consistent basis for analyzing rainfall and for geophysical processes in general. The daily rainfall data was assessed using the Shannon entropy for a 10-years period from 189 stations in the northeastern region of Brazil. Mean values of marginal entropy were computed for all observation stations and isoentropy maps were then constructed for delineating annual and seasonal characteristics of rainfall. The Mann-Kendall test was used to evaluate the long-term trend in marginal entropy for two sample stations. The marginal entropy values of rainfall were higher for locations and periods with highest amount of rainfall. The results also showed that the marginal entropy decreased exponentially with increasing coefficient of variation. The Shannon theory produced spatial patterns which led to a better understanding of rainfall characteristics throughout the northeastern region of Brazil. Trend analysis indicated that most time series did not have any significant trends.*

**Keywords**— *Mann-Kendall test, Information transfer, Measure the disorder.*

## I. INTRODUCTION

The concept of entropy was advanced later in the works of in quantum mechanics, and was reintroduced in information theory by Shannon (1948) as a measure of information, disorder or uncertainty. The Shannon entropy has since been employed in numerous areas (Singh and Rajagopal, 1987), such as mathematics (Dragomir et al., 2000), economics (Kaberger and Mansson, 2001), ecology (Ricotta, 2002), climatology (Kawachi et al., 2001), medicine (Montaño et al., 2001) and hydrology (Singh, 1997). One measure of uncertainty or disorder of a variable is entropy. Entropy can be calculated if the probability distribution function or probability density

function of the random variable is given in a discrete or continuous form, using the informational entropy theory.

An interesting application of entropy has been for reducing the gap between information needs and data collected by monitoring networks (Krstanovic and Singh, 1993a; Krstanovic and Singh, 1993b; Al-Zahrani and Husain, 1998; Agrawal et al., 2005; Chen et al., 2007). In this application, stations are evaluated by transmission of information to and from stations (Markus et al. 2003). Likewise, entropy has been used for assessing the space variability of rainfall, one of the primary constraints to water resources development and water use practices (Silva et al., 2003; Mishra et al., 2009). The main point here is to measure the disorder or uncertainty of the occurrence of rainfall by entropy (Maruyama et al. 2005).

Chen et al. (2007) suggested that the variability of rainfall can be more appropriately measured by the Shannon entropy and hence rainfall characteristics of 1-day resolution time series can be described. Thus, the entropy theory, comprising the Shannon entropy, seems to have much potential that remains yet to be fully exploited. Most of works have mainly focused on the spatial and temporal variability of rainfall using information theory for temperate zones while less attention has been given to methodologies that include rainfall in tropical climate zones for improving the estimates of rainfall variability at a time scale from years to days by exploiting the time series structure. The identity of the cumulative sources of uncertainty in rainfall remains practically unknown and have not yet been investigated in systematic manner. To address this issue, we used the Shannon entropy to quantify the variability of rainfall in the northeastern region of Brazil and assess long-term trends in marginal entropy of annual and seasonal rainfall using the Mann-Kendall test.

**II. MATERIAL AND METHODS**

*Shannon entropy*

The discrete form of the Shannon entropy was obtained by (Kawachi et al., 2001):

$$H(p_1, p_2, \dots, p_k) = -k \sum_{i=1}^{i=n} p_i \ln p_i \quad (1)$$

where  $p_i$  is a probability of the  $i$ th outcome of a discrete random variable,  $n$  is the number of events and  $k$  is a positive constant, which depends on the choice of measurement units. For all same  $p_i$ s the entropy is  $H = \log_2 n$ , which is a monotonically increasing function of  $n$ . The units of entropy depend on the base of the logarithm in Eq. (1), and are bits (binary digits) for base 2, and napiers or nats for base  $e$ , while the term Hartley has been proposed for base 10. Taking  $k = 1$  and the base of the logarithm as 2, bit is used as a unit of measurements of entropy. Entropy  $H(p_i)$  is also called marginal entropy of a univariate variable  $p$ .

The annual rainfall ( $R$ ) for each hydrologic event can be obtained by:

$$R = \sum_{i=1}^{i=365} r_i \quad (2)$$

where  $r_i$  is daily value of rainfall for the  $i$ th day of the year. The occurrence probability of the rainfall amount on the  $i$ th day was expressed as the relative frequency ( $p_i$ ) as:

$$p_i = \frac{r_i}{R} \quad (3)$$

*Mann-Kendall test*

The Mann-Kendall non-parametric test (Mann 1945; Kendall 1975) was applied for assessing the trend of rainfall time series. This test is based on statistic  $S$  defined as:

$$S = \sum_{i=2}^n \sum_{j=1}^{i-1} \text{sign}(x_i - x_j), \quad (4)$$

where  $x_j$  are the sequential data values,  $n$  is the length of the time series and  $\text{sign}(x_i - x_j)$  is  $-1$  for  $(x_i - x_j) < 0$ ,  $0$  for  $(x_i - x_j) = 0$ , and  $1$  for  $(x_i - x_j) > 0$ . The mean  $E[S]$  and variance  $V[S]$  of statistic  $S$  may be given as:

$$E[S] = 0 \quad (5)$$

$$\text{Var}[S] = \frac{n(n-1)(2n+5) - \sum_{p=1}^q t_p(t_p-1)(2t_p+5)}{18} \quad (6)$$

where  $t_p$  is the number of ties for the  $p$ th value and  $q$  is the number of tied values. The second term represents an

adjustment for tied or censored data. The standardized test statistic ( $Z_{MK}$ ) is computed as:

$$Z_{MK} = \begin{cases} \frac{S-1}{\sqrt{\text{Var}(S)}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{\text{Var}(S)}} & \text{if } S < 0 \end{cases} \quad (7)$$

The presence of a statistically significant trend was evaluated for testing the null hypothesis that no trend existed. A positive  $Z_{MK}$  value indicates an increasing trend while a negative one indicates a decreasing trend. To test for either increasing or decreasing monotonic trend at  $p$  significance level, the null hypothesis was rejected if the absolute value of  $Z_{MK}$  was greater than  $Z_{1-p/2}$ , which was obtained from the standard normal cumulative distribution table. In this study, the significance levels of  $p = 0.01$  and  $0.05$  were applied. The non-parametric estimate of the magnitude of the slope of trend was obtained as follows (Hirsch et al. 1982).

$$\beta = \text{Median} \left[ \frac{(x_j - x_i)}{(j - i)} \right] \quad \text{for all } i < j \quad (8)$$

where  $x_j$  and  $x_i$  are the data points measured at times  $j$  and  $i$ , respectively.

*Study area*

The northeastern region of Brazil, bounded to the north and east by the Atlantic Ocean, covers an area of about 1.5 million square kilometers. Approximately 60% of this region is a semi-arid area. The area is inhabited by more than 30 million people and the economy is mainly based on subsistence rainfed crop production. The northeastern region is influenced by several large-scale precipitation mechanisms. The rainy-season occurs between January and June and the dry-season between July and December. The wet-season occurs between March and May and the normal annual rainfall ranges from 400 to 2000 mm (Silva, 2004). The region is dominated by semi-arid climate with heterogeneous vegetation cover and the mean air temperature varies between 15 and 33 °C (Silva et al., 2006).

The temporal trend in the entropy time series was analyzed using data from two weather stations. These stations are located in the state of Ceará, namely Icó (latitude: 6°24'04" S; longitude: 38°51'44" W; altitude: 153.4 m above sea level) and São Luiz do Curu (latitude: 3°40'12" S; longitude: 39°14'36" W; altitude: 38.4 m above



sea level). The isoinformation contours are then drawn showing areas of greater or less information transfer. The results of the study are compared to the variance approach. Variance is a measure of dispersion and its simplicity remains its major attraction. Variance has had a primordial role in the analysis of variability (Mishra et al., 2009)

#### Rainfall data

Daily time series of rainfall recorded at 189 stations for a minimum period of 10 years in the northeastern region of Brazil were analyzed and annual totals of marginal entropy were obtained. The mean entropy values computed for observation stations were employed to construct the isoentropy maps in order to delineate rainfall characteristics. Annual period and rainy and dry season rainfall time series were used to assess long-term trends in marginal entropy and their coefficients of variation from two sample stations: Icó station for a period of 1957 to 2001 and São Luiz do Curu station for a period of 1968 to 2001.

### III. RESULTS AND DISCUSSION

Mean values of marginal entropy and the coefficient of variation (CV) of rainfall at two sample stations in northeastern region of Brazil for the annual and dry and rainy seasons are shown in Table 1. For both stations, marginal entropy values of rainfall were low during the dry season and high during the rainy season. The values of mean annual entropy were very similar to those for the rainy season, when the total rainfall during the dry season was comparatively smaller than that of rainy season. The variability of annual time series has higher disorder in comparison to constituent seasonal time series. Different seasons contribute differently to the variability of annual rainfall time series. The rainy season variability contributes more to the variability of annual time series, whereas dry season contributes less to the annual variability.

For Icó station, 86% of the annual entropy of rainfall was observed in the rainy season. Similarly, for the São Luiz do Curu station, 87% of the annual entropy of rainfall was observed in the rainy season. In general, the coefficient of variation was high. The CV values of the marginal entropy reached a maximum of 114.7% at the São Luiz do Curu station for rainy season rainfall and a minimum of 34.2% at the Icó station for annual rainfall. The most common statistic used to describe variability is variance, which measures the spread in a data set. However, the variability of rainfall time series can be quantitatively measured by using entropy which can be described in spatial and temporal terms (Mishra et al.

(2009). The opinions are conflicting between variance and entropy for analyzing variability in times series. For example, Soofi (1997) considers that the interpretation of variance as a measure of uncertainty must be done with caution. However, according to Maasoumi (1993), entropy can be an alternative measure of dispersion. According to Ebrahimi et al. (1999), both these measures reflect concentration but their metrics for concentration are different.

The coefficients of determination of 0.95 and 0.99 were obtained in Luiz do Curu station and Icó station, respectively (Figure 1). As expected, a good relationship is evident because marginal entropy is also a variability measure of time series. Silva et al. (2003) who assessed the evaluation of the rainfall variability in Paraíba state, Brazil, using entropy theory showed that for any time series the entropy decreases exponentially with increase of standard deviation. Our results also showed that there was no an indefinite exponential increase of marginal entropy for rainfall since such increase occurred until it reaches the maximum entropy. This is consistent with the second law of thermodynamics which states that the entropy of an isolated system tends to increase until it reaches equilibrium. In this context, Ebrahimi et al. (1999) examined the role of variance and entropy in ordering distributions and random prospects, and concluded that there is no universal relationship between these measures in terms of ordering distributions.

Annual and seasonal values of marginal entropy of rainfall for São Luiz do Curu and Icó stations are shown in Fig. 2. Despite decreasing trends in annual and rainy season rainfall at both stations (Table 2), an increasing trend of marginal entropy in rainfall was observed during the year and rainy and dry seasons. Trend analysis indicated that most time series did not have any significant trends. Although Shannon entropy is a quantification of the amount of information within a dataset, its static probabilistic nature cannot capture the temporal variability of information. It therefore shows no sensitivity in time. Results support the theoretical observations that Shannon entropy is strongly related to the CV relationship, and it is suggested that this is likely to provide a more robust measure of variability than those in CV. This issue is particularly relevant because entropy is insensitive to timing errors. This makes it dangerous as a stand-alone measure, but potentially provides a useful diagnostic in spatial variability. Rainfall data presented an increasing trend during the dry season at Icó station, but the time series was not statistically significant based on the Mann-Kendall test. These results suggested that the temporal trend of entropy was not influenced by the original data.

On this issue, Kawachi et al. (2001) showed that average annual entropy and average annual rainfall were less mutually related with a coefficient of correlation of 0.19. Our results evidence that the trend in marginal entropy was statistically significant for annual rainfall at São Luiz do Curu station based on the Mann-Kendall test ( $p < 0.05$ ) and for dry season ( $p < 0.01$ ).

Spatial distributions of isoentropy in annual and rainy and dry rainfall in the northeastern region of Brazil are shown in Fig. 3. The isoentropy lines of marginal entropy of annual and dry season rainfall were higher throughout coast east of the region (Figs. 3A, 3C). However, higher values of isoentropy during the rainy season were located in the northern part of the region (Fig. 3B). As a natural consequence, higher rain might occur alternately during other periods of the year over the northeastern region. Minimum and maximum values of isoentropy in rainfall are observed in the same area for all analyzed periods. For instance, marginal entropies values of annual rainfall were minimum in the central area of northeastern region of Brazil, which corresponded to most of the semi-arid region.

The entropy values of rainfall were maximum in eastern and northern areas of the region which corresponded to most northeastern rainy areas. During the rainy season, the entropy decreased from 5.5 in the north to 1.5 bits in the south for rainfall. On the other hand, during the dry season entropy values of rainfall reached minimum values as compared to the other two periods as a consequence of the rainfall reduction. Mishra et al. (2009) also used marginal entropy to investigate the temporal variability of rainfall time series for the State of Texas, USA. They observed distinct spatial patterns in annual series and different seasons and that the variability of rainfall amount as well as number of rainy days within a year increased from east to west of Texas. The spatial distribution of marginal entropy was practically uniform during the dry season over almost the entire region, particularly for rainfall, with a mean value about of 0.5-1.5 bits. Martín and Rey (2000) analyzed the role of entropy to provide some mathematical arguments for justifying the use and interpretation of entropy as a measure of diversity and homogeneity.

As shown in Fig. 3, the isoentropy lines of rainfall divided the whole study region into two clusters, at left with higher values in entropy and at right with lower values of entropy. The marginal entropy of rainfall was high in areas and periods with the highest amount of rainfall. Results also demonstrate that the rainfall variability is higher in the semi-arid areas than in coast areas of the northeastern region. This indicates the

availability of water resources is low and should be used within the constraints. To meet the perennial water demands, proper planning is to be made to reduce the wastage of water as well as to store the excess water during time of precipitation. When performed a study to assess the stream gaging network in the State of Illinois, USA, Markus et al., (2003) showed that the correlation coefficient between entropy and least square regression method are inversely proportional to the information transmitted. Besides, stations located in an area of high gage density tend to receive and transmit more information. Inversely, gages having less significant regional value transmit substantially less information than they receive.

Despite large variations of marginal entropy for rainfall between periods and even between stations, the overall analysis showed much less variation of entropy during the dry season. Rainfall constitutes the primary input to the hydrologic cycle, and can thus be perceived to represent the potential water resources availability of an area. The disorder or uncertainty in the intensity and occurrence of rainfall in time is one of the primary constraints to water resources development and the water use practices. Distinct spatial patterns in annual series and different seasons were observed. For the three analyzed periods the entropy decreased from South to North. The results also indicated that highly disorderliness in the amount of rainfall during rainy season.

#### IV. CONCLUSIONS

The entropy concept was used in this study to determine the spatio-temporal variability/disorder of rainfall in northeastern region of Brazil. Entropy leads to a better understanding of time and space structure rainfall in the study area. It is shown that entropy can be effectively used for assessing the rainfall variability in both in space and time. The rainfall variability could satisfactorily be obtained in terms of marginal entropy as a comprehensive measure of the regional uncertainty of these hydrological events. The coefficient of variation is exponentially related to marginal entropy of rainfall, with the coefficient of determination close to 1. The Mann-Kendall test suggests that the temporal trend of entropy in rainfall is not influenced by the eventual trend of the original data.

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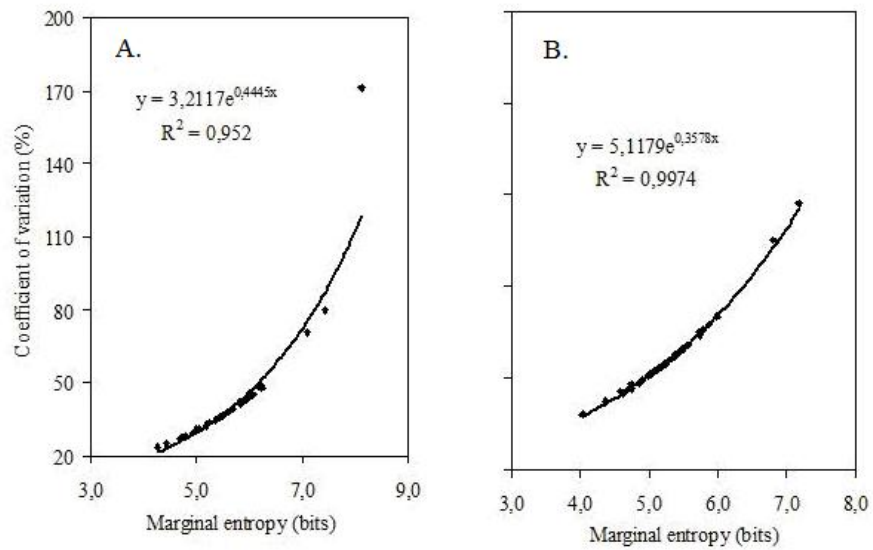


Fig.1

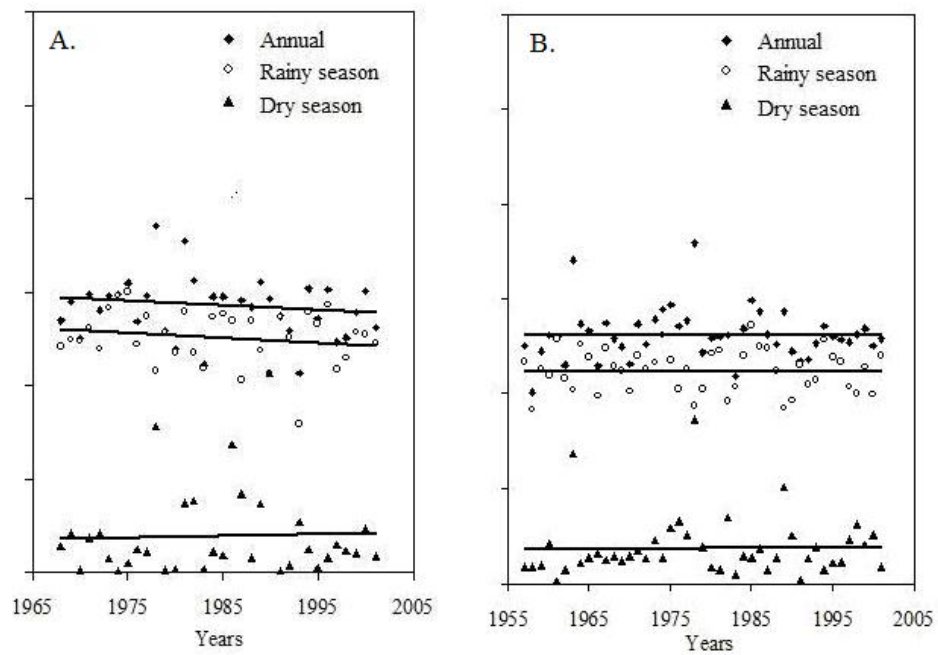


Fig.2

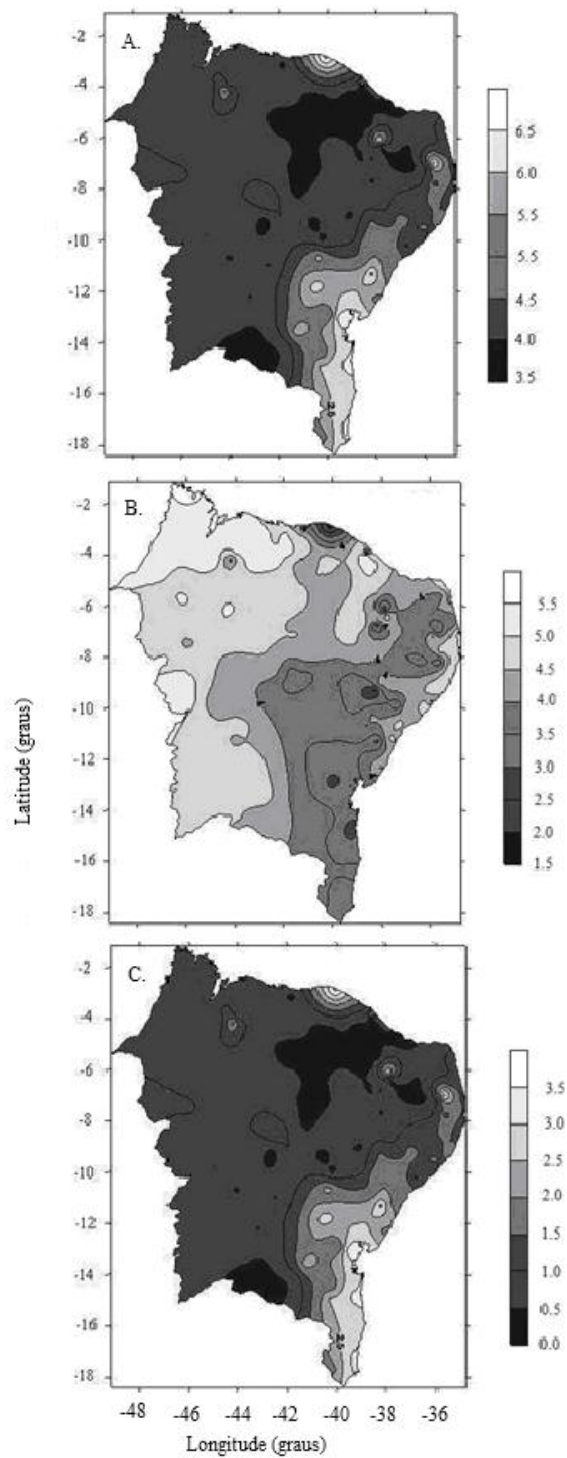


Fig.3

Table.1

	Icó station		
	Annual	Rainy	Dry
Marginal entropy bits)	5.2	4.5	0.8
CV (%)	34.2	44.9	39.2



São Luiz do Curu station			
Marginal entropy bits)	5.7	5.0	0.7
CV (%)	44.4	114.7	84.4

Table.2

Variables	Annual		Rainy season		Dry season	
	Trend	p-value	Trend	p-value	Trend	p-value
Icó station						
Rainfall (R)	-0.84	0.952	-0.502	0.741	0.4429	0.332
Marginal entropy in R	0.004	0.787	0.0013	0.667	0.0025	0.204
São Luiz do Curu station						
Rainfall (R)	-6.60	0.496	-5.67	0.447	-0.21	0.920
Marginal entropy in R	0.04	0.003	0.011	0.733	0.034	0.001

# Photocatalytic and Thermal Properties Consideration of nanocomposites preparation of $\text{La}_2\text{Ti}_2\text{O}_7$ -Zeolite-MCM-41

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**Abstract**— In this paper, nanocomposite  $\text{La}_2\text{Ti}_2\text{O}_7$ -Zeolite-MCM-41 is synthesized by optimization of physical properties of MCM-41 Zeolite and Nano powder  $\text{La}_2\text{Ti}_2\text{O}_7$  sol-gel method in stearic acid media. In the first step, the  $\text{La}_2\text{Ti}_2\text{O}_7$  Nano powder was prepared by sol-gel process and then nanocomposites of  $\text{La}_2\text{Ti}_2\text{O}_7$ -Zeolite-MCM-41 with (5, 10, 15 and 20) percent weight. Then we have prepared of sol-gel at 700-900 and 1000 and for further confirmation of structure used of x-ray and XRD.

Result of SEM, the size of the  $\text{La}_2\text{Ti}_2\text{O}_7$  Nano powder (29nm) and nanoparticles in nanocomposite  $\text{La}_2\text{Ti}_2\text{O}_7$ -Zeolite-MCM-41 20%, (29nm) were shown EDX the purification of nanoparticles and nanocomposite are convenient.

The BET method was showed the differential porosity value in comparison of zeolite and nanocomposite  $\text{La}_2\text{Ti}_2\text{O}_7$ -ZMCM-41 the calcination condition, weight percent nanoparticles, the type of reagents PH and indicator concentration are influenced on nanocomposite. Properties by optimization of mentioned parameters, the best results for 10% and 20% nanocomposite in 900 temperature calcination with (29 nm) particle size are yield. The UV methylene blue in 80 and 100% are out come respectively. All results were confirmed by spectroscopies data.

**Keyword**— Composition- Synthesized- Nanocomposite- Calcination- Zeolite.

## I. INTRODUCTION

The composite is a multicomponent material that its properties are better than each component, while the different components improve each other performance (1). Generally, a composite material is defined as the physical mixture made of two or more different materials in the macroscopic scale that these materials kept its physical and chemical properties and form the specific boundary

together (2). The composites have distinguished mechanical properties and possess the suitable flexibility in the design and their fabricate procedures are rather easy. The composites are light, corrosion and impact resistance materials with excellent fatigue resistant, strength and permanency and they are capable of transforming into a product with the part.

The composites are divided to 5 groups according to the material shapes in the composite:

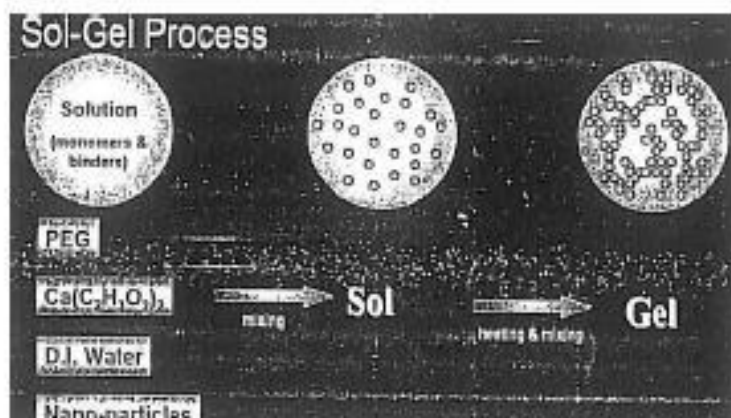
1. Fiber composites
2. Laminar composites
3. Particle composites
4. Flake composites
5. Filler composites

The nanocomposite which is synthesized in this study is a  $\text{La}_2\text{Ti}_2\text{O}_7$ -ZMCM-14 composites type in which zeolite plays a matrix role and  $\text{La}_2\text{Ti}_2\text{O}_7$ -ZMCM-14 nanoparticles have a reinforcement role. These nanoparticles have been added to improve the physical and chemical properties of zeolite. We blend or composite them to change and optimize the physical and chemical properties of materials. In fact, the purpose of composite creation is to obtain the combinational material with expected properties (1). The nanocomposites components have the better properties due to the surface interaction between the base material and filler materials. The kind and amount of interactions have an important role in their different properties of nanocomposites such as solubility, optical properties, electrical and mechanical properties (3, 4).

The particular properties of nanocomposite are explained as follow:

1. The composite Nanopowders have a suitable area-volume ratio.
2. Most of atoms are on the surface of the composite Nano powders and the microstructure nanocomposite grain boundaries (3, 4).

The Fabrication method of Nanocomposite



1. The Sol- gel method
2. In situ polymerization using the applicative finding in the receiver- acceptor system chemistry
3. The composite of emulsion polymerization for replacing the mineral components in the organic matrix

The sols are dispersed colloidal particles with dimension of 1 to 100 nanometers in solution which remain suspended form since these particles are small in the solution.

Elman produced the silica gel for the first in 1864 and Kasa could produce alumina gel in 1870. Also, Pichini presented a method to modification in 1967. There are the different methods to fabricate a mineral composition such as SiO<sub>2</sub> which can be based on melting of the primary mineral compositions and quenching.

Zeolites have general formula (AlO<sub>2</sub>)<sub>x</sub> (SiO<sub>2</sub>)<sub>y</sub> Mh<sub>2</sub>O Mx/n. Although, the zeolites chemically were being confined to aluminum silicates until 1982, but recently the range of these compounds has extended so that about 10 other elements Ti, As, P, Zn, Co, Mn, LI, Ng, and B are also included in the range besides previous known elements i.e. Fe, Ge, Ga, AI, Si (7).

According to Demoor theory, one of the valuable properties of zeolites is the reversible quenching.

Although, all of zeolites have 10 to 20 % water in their composition. This amount of water can be lost at 350 ° C.

The meso-pore structure and its kind control by choosing a suitable frame (surfactant) with adjustment of temperature situation, pH, and synthetic solution composition.

The molecular structure of zeolites is a tetrahedral that the oxygen atoms are around a silicon atom (SiO<sub>4</sub>) (6, 8).

The MCM- 41 synthesis zeolite has the general chemical formula SiO<sub>2</sub>(<sub>0.9875</sub>(Al<sub>2</sub>O<sub>6</sub>)<sub>0.0125</sub> . × H<sub>2</sub>O) and the hexagonal symmetry.

Lanthanum titanate is a white oxide of mineral collection with La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub> chemical formula whose two chemical compounds TiO<sub>2</sub> and La<sub>2</sub>O<sub>3</sub> dissolve difficultly in acids and they are in the perovskite category (9).

II. EXPERIMENTAL

STEP 1- experimental method

The solid stearic acid was poured in the crystallizer and it began to melt in 70°C and a transparent liquid was obtained after fully melting of stearic acid, then lanthanum acetate was slowly added to it in stoichiometric content and was stirred by a stirrer.

The metallic salt was fully melted in 85°C. Then, titanium butoxide was added drop by drop in the stoichiometric content and was stirred severely, so that a transparent and homogeneous gray-white sol was obtained. The resulting sol was transferred to porcelain crucible to be cold in the ambient temperature and was dried at 120°C in 12 hours. Subsequently, the resulting gel was put in a furnace and was calcinated duration of 4 steps.

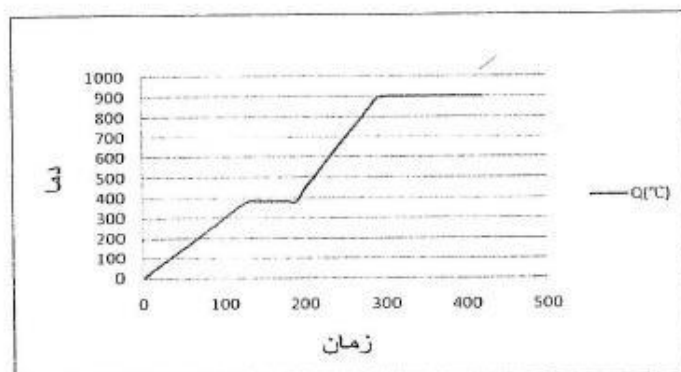


Diagram 1.2: the temperature control of nanoparticles fabrication process

**STEP 2- Lanthanum titanate MCM-41 zeolite Nanocomposite synthesis using the sol-gel method**

For 4 kinds of composites, all of the steps were done same as the first method with the different weight percentages of 5, 10, 15, and 20 and at the temperatures of 700, 900, and 1000 °C.

**STEP 3 - Test with methylene blue color**

The 0.1 g methylene blue was diluted with deionized water. A 1000 ppm concentration solution of methylene blue color was obtained.

250 ml of 1 ppm methylene blue with 0.1 mg Nanocomposite were weighted and was added to methylene blue color solution. The beaker is put on the magnetic stirrer and under the UV source.

In this test, temperature and UV visible light intensity factors were kept stable and pH factor was investigated.

**Investigation of pH factor:**

For this work, at first, pH of methylene blue solution was measured by pH meter. This pH was neutral and around 7.

For this purpose, the pH factor was investigated in both acidic and alkaline range.

**Test with H<sub>2</sub>O<sub>2</sub>:**

1 g methylene blue color dilute with the deionized water. The solution with 1000 ppm concentration obtains from methylene blue color. For this work, 100 ml of main solution with 1000 ppm concentration was diluted with the deionized water, then was picked up 2.5 ml of 100 ppm methylene blue solution by scaled cylinder and was transferred to a volumetric flask of 250 ml and then was diluted with the deionized water so that a 1 ppm concentration solution of this color was obtained.

The respective flask was closed and the UV light was radiated. The sampling was done every 15 min until 60 min.

Then, the samples were centrifuge at 3000 rpm until 15 min to powder was separated from the sample and then, its UV visible spectrum was lost.

The following table illustrates the phase index compatibility of MCM- 41 and La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub> zeolite nanoparticles with XRD standard carts study in 900°C.

**III. RESULT AND DISCUSSION**

Intensity, standard carts, sample, lanthanum titanate, zeolite

(Severity %)	Standard Carts	Sample	MCM-41
100%	00-045-0406	23/2904	2θ <sub>1</sub>
99/18%	00-045-0406	23/0169	2θ <sub>2</sub>
97/78%	00-045-0406	20/9495	2θ <sub>3</sub>
97/51%	00-045-0406	22/7482	2θ <sub>4</sub>

**SPECTROSCOPY of (XRD) La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub> 9000C**

La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub>	Sample	Standard Cards	(%) Severity
2θ <sub>1</sub>	38/4250	00-027-1182	100%
2θ <sub>2</sub>	27/6670	00-027-1182	96/36%
2θ <sub>3</sub>	33/5239	00-027-1182	94/31%
2θ <sub>1</sub>	38/4250	00-027-1182	100%

**SPECTROSCOPY of (XRD)**

Zeolite MCM-41	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> 900°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 20 % 700°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 20% 900°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 20% 1000°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 15% 900°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 10% 900°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 5% 900°C
2θ <sub>1</sub> = 23/29	2θ <sub>1</sub> = 38/42	2θ <sub>1</sub> = 25/62	2θ <sub>1</sub> = 32/98	2θ <sub>1</sub> = 28/91	2θ <sub>44/1n.m</sub>	2θ <sub>1</sub> = 29/86	2θ <sub>1</sub> = 27/67
2θ <sub>2</sub> = 23/01	2θ <sub>2</sub> = 27/66	2θ <sub>2</sub> = 3/16	2θ <sub>2</sub> = 32/99	2θ <sub>2</sub> = 32/71		2θ <sub>2</sub> = 32/25	2θ <sub>2</sub> = 21/04



$2\theta_3 = 20/94$	$2\theta_3 = 33/52$	$2\theta_3 = 27/79$	$2\theta_3 = 29/80$	$2\theta_3 = 33/49$		$2\theta_3 = 33/02$	$2\theta_3 = 29/82$
$2\theta_4 = 22/74$	$2\theta_4 = 78/04$						

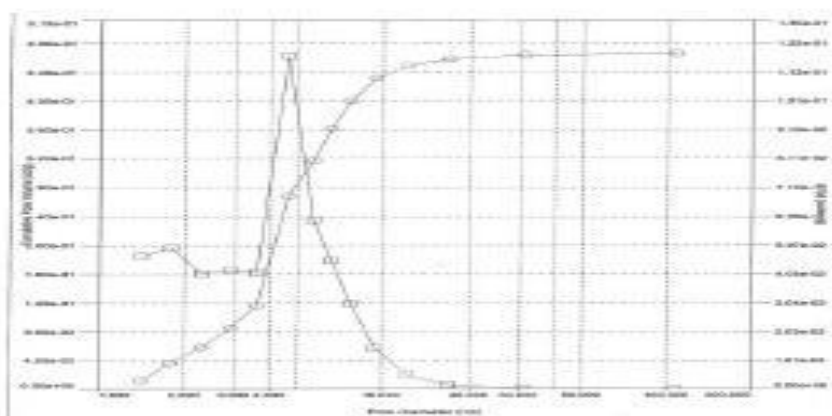
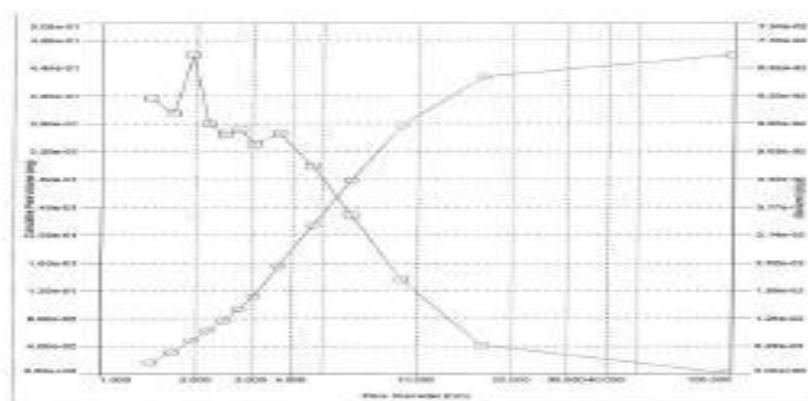
**SPECTROSCOPY OF (BET)**

Sample	MCM-41	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 20% 900°C	Unit
$V_m$	300	52	$[cm^3 g^{-1}]$
$a_{s,BET}$	3/836	5/80	$[m^2 g^{-1}]$
Total pore volume	4/618	8/002	$[cm^3 g^{-1}]$
Average pore Diameter	4/815	5/511	$[nm]$

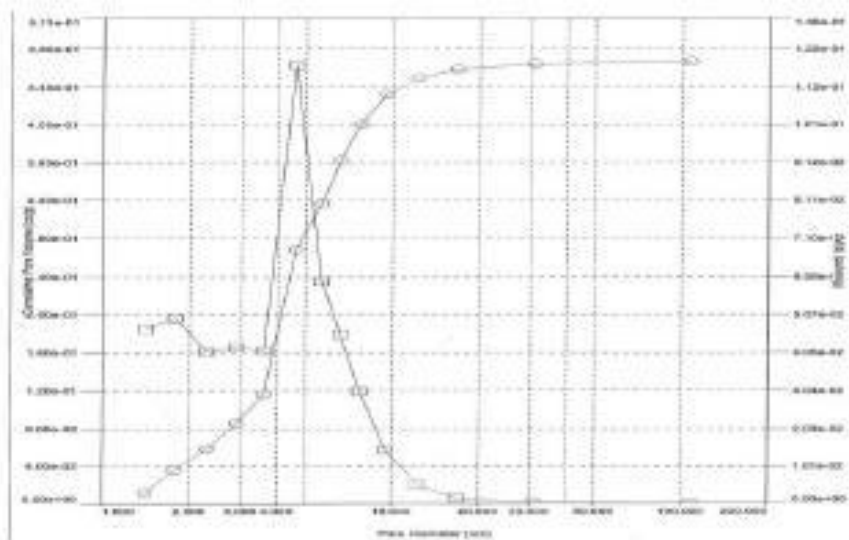
Unit, sample

The BJH analyze diagram of MCM-41 zeolite

$V_m$	300	$[cm^3 g^{-1}]$
$a_{s,BET}$	3.836	$[m^2 g^{-1}]$
Total pore volume	4.418	$[cm^3 g^{-1}]$
Average pore Diameter	4.815	$[nm]$



Isothermal absorption and de-absorption analyze diagram of MCM- 41zeolite



The BLH analyze diagram of MCM-41 zeolite  
 SPECTROSCOPY of BJH

MCM-41		La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> -MCM-41 20% 900°C	
Plot data	Adsorption branch	Plot data	Adsorption branch
$V_p$	0/459 [ $cm^3 g^{-1}$ ]	$V_p$	0/084 [ $cm^3 g^{-1}$ ]
$r_{p,peak}(Area)$	1/938 [nm]	$r_{p,peak}(Area)$	1/188[nm]
$a_p$	408/914 [ $m^2 g^{-1}$ ]	$a_p$	76/214 [ $m^2 g^{-1}$ ]

Volume table, radius, the surface of pore, the diagram peak

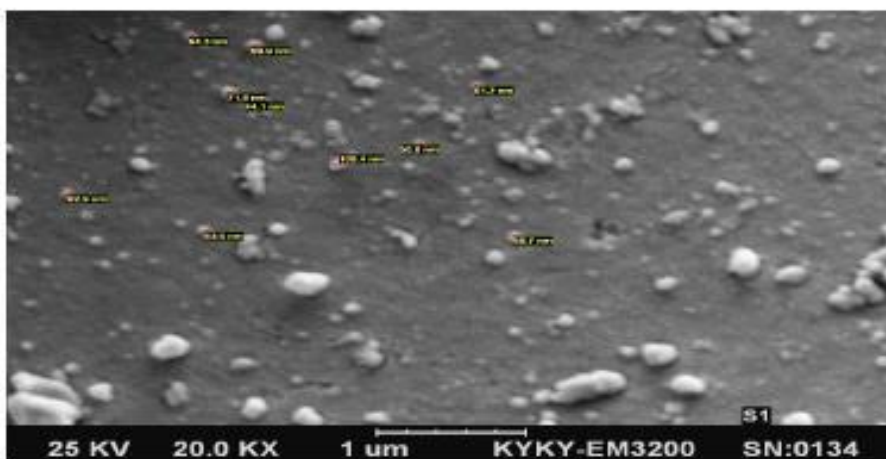
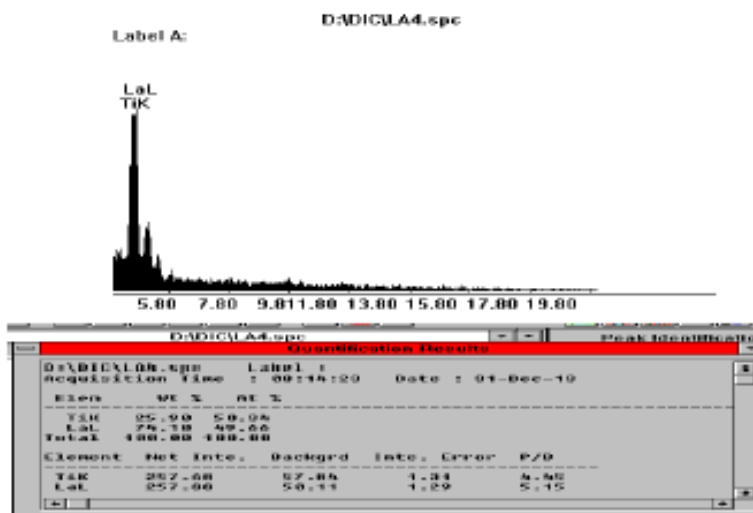
**SPECTROSCOPY of SEM  $La_2Ti_2O_7$**

In the obtained images, the light points show the eminence surface and the darker areas illustrate the pores and concavity of surface.



SEM image of  $La_2Ti_2O_7$  (24.8 nm lanthanum titanate nanoparticles) in the calcination temperature of 900°C  
 The following image illustrates the lanthanum nanoparticles [24.8 nm] EDX in the calcination temperature of 900°C.

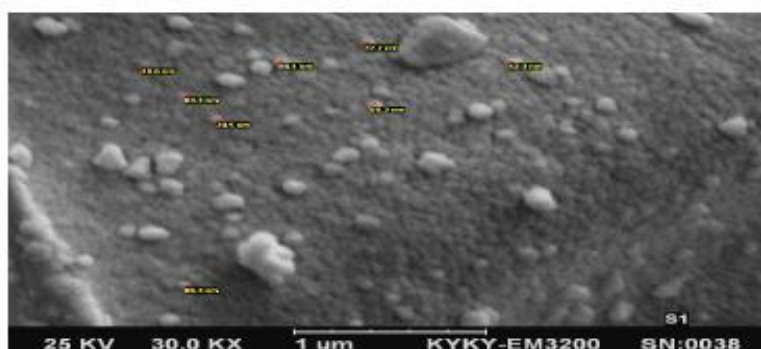
**SPECTROSCOPY OF EDX**



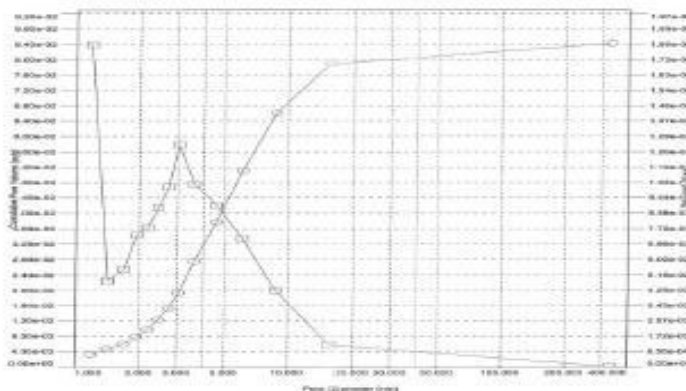
SEM image of  $\text{La}_2\text{Ti}_2\text{O}_7$  – MCM-4 samples in the calcination temperature of  $900^\circ\text{C}$ . In the above SEM image, the lanthanum titanate nanoparticles with the size of 44.1 nm are observable.

**SPECTROSCOPY of SEM Zeolite- MCM-41:**

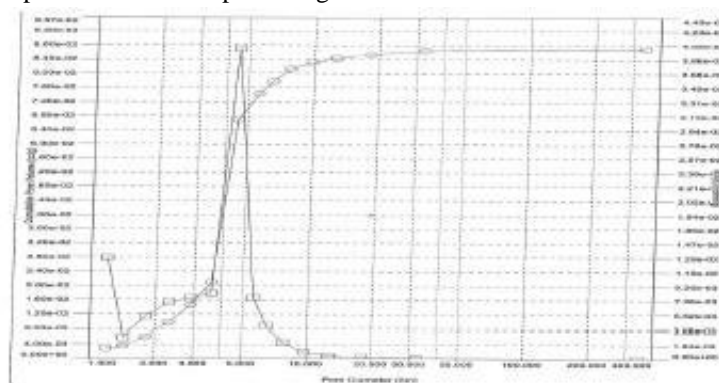
In this image, MCM-41 zeolite particles with size of 40.6 nm are observable.



SEM image of MCM-41 zeolite has illustrated the isotherm absorption and de-absorption diagram.



Isothermal absorption and de-absorption diagram of La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub> Zeolite- MCM-41 nanocomposite



The BJH analyze diagram of MCM-41 zeolite

Plot data	Adsorption branch
$V_p$	0/084 [ $cm^3 g^{-1}$ ]
$r_{p,peak}(Area)$	1/188[nm]
$a_p$	76/214 [ $m^2 g^{-1}$ ]

Volume table, radius, the surface of pore, the diagram peak

**FT-IR**

SPECTROSCOPY of (FTIR)

FTIR $cm^{-1}$						
MCM-41	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> 900°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> - MCM-41 20% 900°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> 1000°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> - MCM-4120% 1000°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> 700°C	La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> - MCM-4120% 700°C
3441.68 $cm^{-1}$	3439.89 $cm^{-1}$	1640.04 $cm^{-1}$	1419.16 $cm^{-1}$	1104.33 $cm^{-1}$	3434.23 $cm^{-1}$	3445.86 $cm^{-1}$
1636.04 $cm^{-1}$	1629.38 $cm^{-1}$	1047.15 $cm^{-1}$	1116.90 $cm^{-1}$	788.20 $cm^{-1}$	1628.42 $cm^{-1}$	1636.17 $cm^{-1}$
1085.83 $cm^{-1}$	1386.18 $cm^{-1}$	803.01 $cm^{-1}$	872.77 $cm^{-1}$	553.03 $cm^{-1}$	1485.04 $cm^{-1}$	1078.15 $cm^{-1}$
926.97 $cm^{-1}$	1139.11 $cm^{-1}$	643.38 $cm^{-1}$	539.50 $cm^{-1}$	458.21 $cm^{-1}$	1384.28 $cm^{-1}$	818.51 $cm^{-1}$
799.10 $cm^{-1}$	664.29 $cm^{-1}$	465.88 $cm^{-1}$	458.13 $cm^{-1}$		775.89 $cm^{-1}$	465.88 $cm^{-1}$
465.87 $cm^{-1}$	540.76 $cm^{-1}$				663.51 $cm^{-1}$	
	463.55 $cm^{-1}$					

It can be seen from the above table that the FT-IR spectrum of the 20% La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub>-ZMCM-41 nanocomposite in the three temperatures of 700, 900 and 1000°C is differ from La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub> Nano powder structure in these temperatures and MCM-41 zeolite due to the essential variations in the crystal lattice. Consequently, this led to change the lattice formation energy and the unit crystalline energy and finally change the tensile and transfer frequency of each bond in the structure.



FUNCTIONAL GROUP	FREQUENCY(cm <sup>-1</sup> )	INTENSITY
Water OH stretch	3700-3100	Strong
Alcohol OH stretch	3600-3200	Strong
Carboxylic acid OH Stretch	3600-2500	Strong
N-H stretch	3500-3350	Strong
≡C-H stretch	~3300	Strong
=C-H stretch	3100-3000	Weak
-C-H Stretch	2950-2840	Weak
-C-H aldehydic Stretch	2900-2800	Variable
C=C stretch	~2250	strong
C≡C stretch	2260-2100	variable
C=O aldehyde	1740-1720	strong
C=O anhydride	1840-1800, 1780-1740	weak, strong
C=O ester	1750-1720	strong
C=O ketone	1745-1715	strong
C=O amide	1700-1500	strong
C=C alkene	1680-1600	weak
C=C aromatic	1600-1400	weak
CH <sub>2</sub> bend	1480-1440	medium
CH <sub>3</sub> bend	1465-1440, 1390-1365	medium
C-O-C stretch	1250-1050 several	strong
C-OH stretch	1200-1020	strong
NO <sub>2</sub> stretch	1600-1500 and 1400-1300	strong
C-F	1400-1000	strong
C-Cl	800-600	strong
C-Br	750-500	strong
C-I	~500	strong

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# Removal of vegetation in the state of Mato Grosso: a perspective based on the actions of IBAMA between 1998 and 2016

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**Abstract**— *The State of Mato Grosso in the Midwest region of Brazil has, in recent decades, become the main area of agricultural production in the country.<sup>1</sup> By positioning itself as the new agricultural frontier, the state has instigated a constant conflict between agriculture and environmental protection. In this context, this study briefly discusses and analyzes deforestation in the region based on data on sanctions issued by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute for the Environment and Renewable Natural Resources; IBAMA), the Brazilian environmental regulatory and inspection agency, between 1998 and 2016. Annual vegetation removal reached its highest values in 2003 and 2004 (1,109 km<sup>2</sup>) and then decreased from 2005 to 2008 (4,353 km<sup>2</sup>) before stabilizing at the lowest level between 2009 and 2016 (1,138 km<sup>2</sup>).*

**Keywords**— *Brazil, forest, deforestation, biodiverse, environmental.*

## I. INTRODUCTION

The State of Mato Grosso in the Midwest region of Brazil has, in recent decades, become the main area of agricultural production in the country.<sup>2</sup> By positioning itself as the new agricultural frontier, the state has instigated a constant conflict between agriculture and environmental protection. In this context, this study briefly discusses and analyzes deforestation in the region based on data on sanctions issued by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute for the Environment

and Renewable Natural Resources; IBAMA), the Brazilian environmental regulatory and inspection agency, between 1998 and 2016. Annual vegetation removal reached its highest values in 2003 and 2004 (1,109 km<sup>2</sup>) and then decreased from 2005 to 2008 (4,353 km<sup>2</sup>) before stabilizing at the lowest level between 2009 and 2016 (1,138 km<sup>2</sup>). A total of 1,593 lawsuit filings were registered, with 70% of the individuals and/or entities receiving a formal notification and 58 individuals receiving two notifications; furthermore, the same individual/entity received 16 notifications. The actions were concentrated in the center and north of the state, with a high concentration of notifications in the municipalities of Cotriguaçu, Querência and Nova Ubiratã, and there was a negative relationship between the number of legal notifications and the total deforested area. Vegetation removal was higher in the areas with fewer notifications, which could have been due to the positive impact of supervision and penalties in reducing deforestation. However, these notifications could also have been associated with the increasing number of areas devoted to large-scale agriculture for export.

## II. INSTITUTIONAL CONTEXT, REGULATORY FRAMEWORK AND DEFORESTATION

According to the Ministry of the Environment (2010), Brazil is a “forested country,” with 60.7% of its territory consisting of natural and planted forest, and a significant portion of this forest, especially natural forest, is in the northern region of the country, which is characterized by the Amazonian biome. Although Brazil contains the most biodiverse biome in the world, it has been considered the world leader in deforestation, converting an average of 19 million km<sup>2</sup> of natural vegetation to agriculture between 1996 and 2005 and emitting between 0.7 to 1.4 Gt of CO<sub>2</sub> into the atmosphere (Nepstad *et al.* 2009).

<sup>1</sup>According to CONAB (the National Supply Company), the 2016/2017 estimated grain crop yield for Mato Grosso State was approximately 52.7 million tons.

<sup>2</sup>According to CONAB (the National Supply Company), the 2016/2017 estimated grain crop yield for Mato Grosso State was approximately 52.7 million tons.

It is important to understand the characteristics of the Brazilian productive matrix, the structure of which has changed over time. At the beginning of the 20<sup>th</sup> century, an essentially coffee-based monoculture export economy was established in the southeast region of the country, particularly in the so-called Planalto Paulista, and throughout the 20<sup>th</sup> century, especially since the 1950s, there was a strong movement towards industrialization in this region, especially in the state of São Paulo. This economic diversification, until then unprecedented in the country, strongly concentrated income in the southwest region.

From the 1970s onwards, mainly due to technical innovations developed by EMBRAPA,<sup>3</sup> the cultivated area strongly expanded to the midwestern region of the country. The traditional cattle production in the area gave way to grain production characterized by the development of crop varieties adapted to local edaphoclimatic conditions. It also involved a high degree of intensive land use, with high technical inputs and the mechanization of production, which, combined with irrigation, resolved the problem of the seasonality of the water supply in the region. This expansion began in the southern part of the midwestern region of the country, near the border between the states of São Paulo and Goiás, and it then gradually expanded towards the northern region to the area called Amazônia Legal. In February 1989, this latter agricultural expansion led to the Brazilian government creating, through Law 7.735, the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute for the Environment and Renewable Natural Resources; IBAMA), which was the combination of four different institutions: the Instituto Brasileiro de Desenvolvimento Florestal (Brazilian Institute for Forest Development; IBDF), the Superintendência de Pesca (Fisheries Superintendency; SUDEPE), the Superintendência da Borracha (Rubber Superintendency; SUDHEVEA), and the Secretaria Especial do Meio Ambiente (Special Environment Secretariat; SEMA).

This new institutional framework, created after 1989, came on the heels of the 1988 Constitution, after which a new legal framework emerged with the creation of a significant number of new environmental laws (Table 1) between 1988 and 2012 (Araújo, 2013).

Table.1: Environmental laws created between 1988 - 2012

Law	Theme
Law 7.679/1988	Prohibition of fishing during the

	breeding season
Law 7.754/1989	Protection of vegetation at the headwaters of rivers
Law 7.797/1989	National Environmental Fund Law
Law 7.802/1989	Pesticides Law
Law 7.803/1989	Amendment to the Forest Code
Law 7.704/1989	Amendments to the National Environmental Policy Law (Lei da Política Nacional do Meio Ambiente; PNMA)
Law 7.875/1989	Collection of park entry fees – change in the CF (Federal Constitution)
Law 8.723/1993	Vehicle Pollution Law
Law 9.111/1995	Change in the Wildlife Protection Law
Law 9.433/1997	Water Resources Law
Law 9.605/1998	Criminal and administrative infractions (Environmental Crimes Law)
Law 9.795/1999	National environmental education policy
Law 9.960/2000	Environmental inspection fee – change in the PNMA
Law 9.960/2000	Water pollution by oil
Law 9.974/2000	Post-consumer responsibility – change in the Pesticides Law
Law 9.985/2000	National Conservation Unit System (Sistema Nacional de Unidades de Conservação – SNUC) Law
Law 10.165/2000	Environmental inspection fee – change in the PNMA
Law 10.203/2001	Change in the Vehicular Pollution Law
Law 10.650/2003	Access to information from environmental agencies
Law 11.132/2005	Provisional administrative restriction – change in the SNUC Law
Law 11.284/2006	Public Forest Management
Law 11.428/2006	Protection of the Atlantic Forest
Law 11.516/2007	Adjustments to environmental licensing (and creation of the Chico Mendes Institute)
Law 11.794/2008	Scientific use of animals
Law 11.959/2009	Fishing
Law 12.114/2009	National Climate Change Fund
Law 12.305/2009	National Solid Waste Policy
Law Complemental 140/2011	Environmental cooperation between federated institutions
Law 12.651/2012	New Forestry Law

<sup>3</sup>Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Company).

Law 12.727/2012	Changes to the New Forestry Law
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Source: Based on Araujo (2013)

Synergies between the 1988 Constitution, the founding of IBAMA in 1989, and the post-1988 consolidation of a clear regulatory framework on environmental issues allowed the country to, for the first time, consider and reorient its growth model based on the newly established environmental policies. However, the profusion of laws in the period between 1988 and 2012 also contributed to a certain level of uncertainty about how agricultural production would be balanced against the role of IBAMA in environmental inspection.

Between 1998 and 2016, IBAMA issued 1,593 legal notifications in the state of Mato Grosso. Of these, 70% of individuals and/or entities received a single notification, but there were cases in which two (58 cases), three (four cases), four (three cases), six (one case) and 16 (one case) citations

applied to the same individual or entity. The National Institute of Colonization and Agrarian Reform (INCRA) received the most notifications in the state, with 16 registered infractions.

The number of notifications increased between 1998 and 2013 followed by a decrease between 2013 to 2016 (Figure 1A). With respect to deforestation, the annual deforested area reached its highest values in 2003 and 2004 (annual average of 11,109 km<sup>2</sup> deforested), decreased continuously between 2005 to 2008 (annual average of 4,353 km<sup>2</sup> deforested), and stabilized at its lowest level between 2009 and 2016 (annual average of 1,138 km<sup>2</sup> deforested) (Figure 1A). This stabilization of deforestation since 2009 may be related, at least partially, to a possible positive impact of the “New Forest Code” (Law 12.651) that was promulgated in 2012 and provided IBAMA with greater control over deforestation in the region.

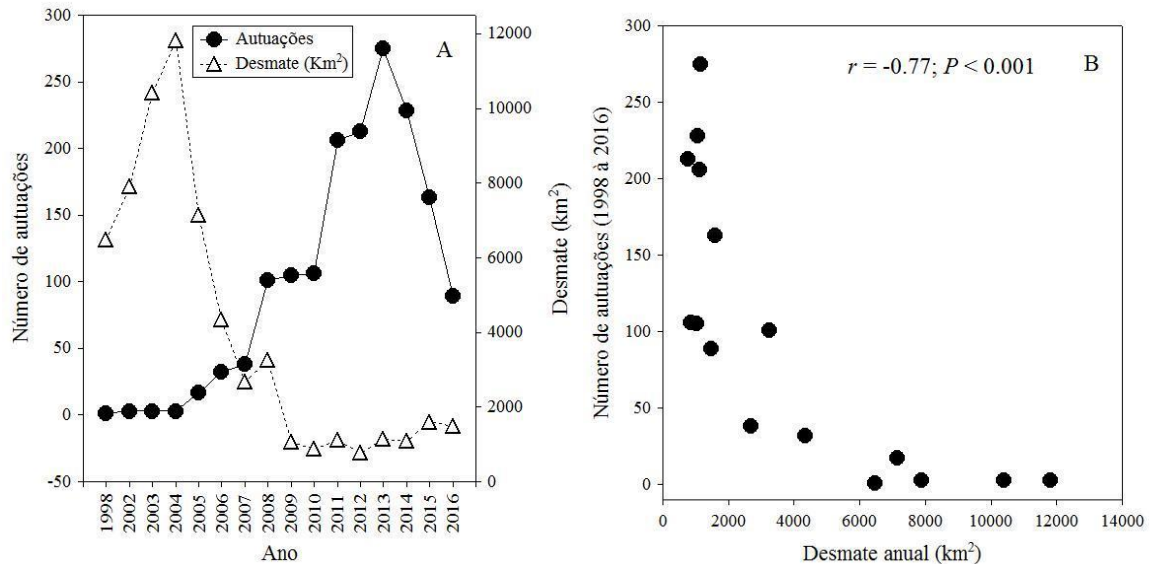


Fig.1: Relationship between deforestation and legal notifications issued in the state of Mato Grosso between 1998 and 2016. (A) Temporal dynamics of the number of notifications and the deforested area. (B) Relationship between the number of notifications by IBAMA and the total annual deforested area (Pearson correlation)

There was a negative relationship between the number of notifications issued by IBAMA and the total deforested area (in km<sup>2</sup>) in the State of Mato Grosso between 1998 and 2016 ( $r = -0.77$ ;  $P < 0.001$ ) (Figure 1B). Thus, the years with high levels of deforestation were those with a lower number of infractions, indicating a positive effect of the inspection and citations by IBAMA on reducing deforestation as well as the efforts of the federal government to cancel credits to illegal deforesters and to pressure the buyers of products from these areas (Nepstad *et al.* 2009). However, there may be alternative explanations. For

example, it is possible that these notifications apply to large areas devoted to large-scale agricultural production, which, in turn, indicates a large expansion of the agricultural frontier for export-oriented production.

### III. CATEGORIES OF INFRACTIONS

The notifications by IBAMA are divided into 52 categories, with only nine accounting for 93% of all fines issued. These nine categories can be divided into two groups: (i) notifications related to deforestation (categories 1 to 4) and

(ii) notifications related to sales and services (categories 5 to 9) (Table 2).

Table.2: Main categories of infractions registered by IBAMA in the state of Mato Grosso between 1998 and 2016

Notifications related to deforestation	Notifications related to sales and services
<ol style="list-style-type: none"> <li>1. Non-authorized destroying, deforesting, or damaging of forests or any native vegetation or planted native species in a specially protected public or private legal reserve or forest easement.</li> <li>2. Flora infraction (non-classified - mobile).</li> <li>3. Destroying or damaging forests or other forms of vegetation in specially protected areas under Art. 225 of the Federal Constitution/1988 (Amazônia Legal Region), Art. 50 of Law number 9.605/98, and Art. 37 of Decree number 3.179/99.</li> <li>4. Destroying or damaging forests or cutting trees or other types of natural vegetation in permanently protected areas or involving species under special protection without authorization from the competent authority or in violation of their instruction.</li> </ol>	<ol style="list-style-type: none"> <li>5. Building, renovating, expanding, installing, or operating potentially polluting works or services or natural resource use without license or authorization from the competent environmental agencies or in violation of the license obtained.</li> <li>6. Environmental quality infraction (non-classified - mobile).</li> <li>7. Selling, offering for sale, warehousing, transporting, or storing timber, firewood, charcoal or other products of plant origin without a valid license for the entire transportation or storage period granted by the competent authority.</li> <li>8. Harvesting or damaging forest or any type of native vegetation or planted native species located outside a public or private legal nature reserve without the prior approval of the competent environmental agency.</li> <li>9. Carrying out potentially environmentally degrading activity without an environmental license.</li> </ol>

Among the main types of notifications, the most common were in categories 1 and 2 (Table 2), which accounted for 51% and 30% of all cases, respectively (Figure 2A). Therefore, the high level of notifications by IBAMA can be considered a result of the activities in group 1

(deforestation). In addition, there was a high concentration of infractions in the municipalities of Cotriguaçu and Querência, which incurred more than twice as many citations as Nova Ubiratã, the municipality with the third most notifications (Figure 2B).

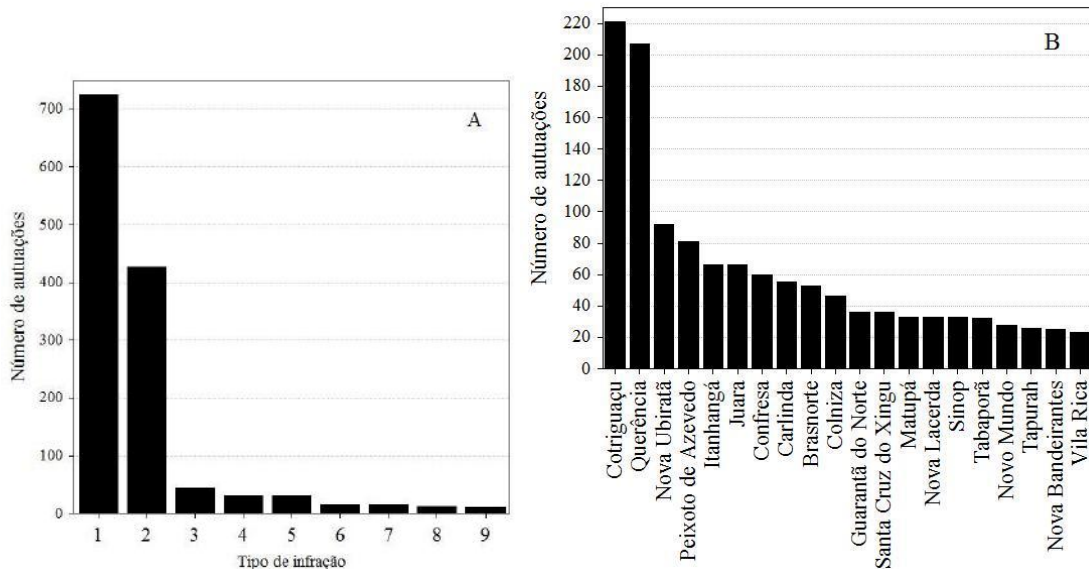


Fig.2: Main categories of infractions (A) and the municipalities where infractions occurred (B) as recorded by IBAMA between 1998 and 2016 in the state of Mato Grosso

IV. SPATIAL DISTRIBUTION



The number of notifications were concentrated in the north-central part of the state of Mato Grosso, a region popularly known as the “arc of deforestation” (Figure 3A). The number of notifications increased significantly in the center of the state, in the transition area between the cerrado and Amazon biomes, and the volume of deforestation increased closer to the Amazon biome. Notably, in the region bordering the state

of Pará, in the cities of Alta Floresta, Paranaíta, Novo Mundo, Guarantã do Norte, and Vila Rica, deforestation reached 40% to 86% of the municipal area. In contrast, municipalities such as Nova Bandeirantes, Cotriguaçu, Peixoto de Azevedo, Santa Cruz do Xingu, and Matupá had levels of deforestation below 40% (Figure 3A).

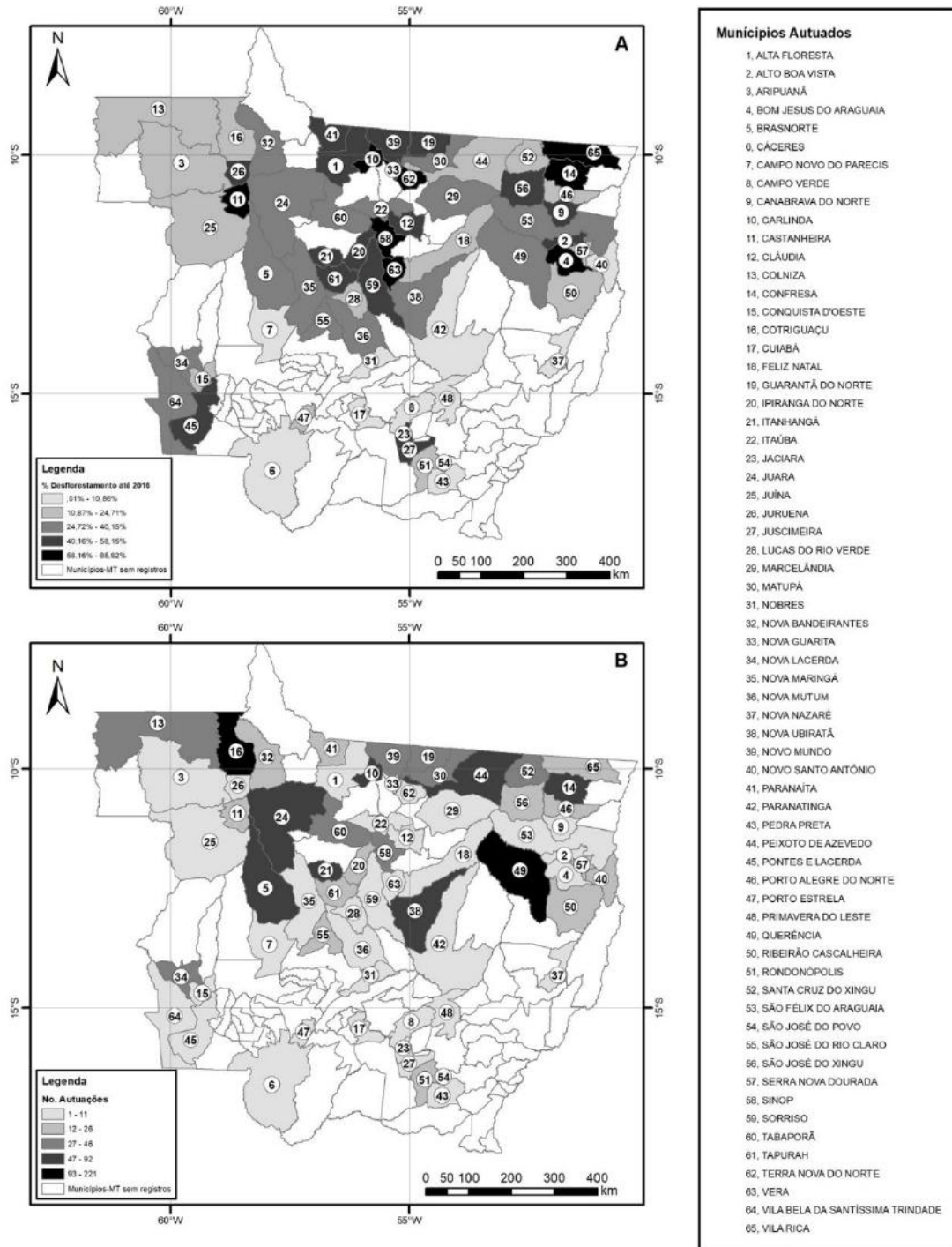


Fig.3: Deforestation (A) and notifications by IBAMA in the state of Mato Grosso up to 2016 (B) by municipality

It is interesting that the municipalities with greater deforestation did not have a significant number of notifications, but the municipalities of Cotriguaçu and Peixoto Azevedo had a high number of notifications (Figure 3B). This partially indicates that the high degree of action by IBAMA through inspections and eventual citations may be reflected in a reduction of deforested area.

Other municipalities in the central part of the state with high deforestation include Sinop, Vera, and Bom Jesus do Araguaia, with deforestation values between 58% to 86%.

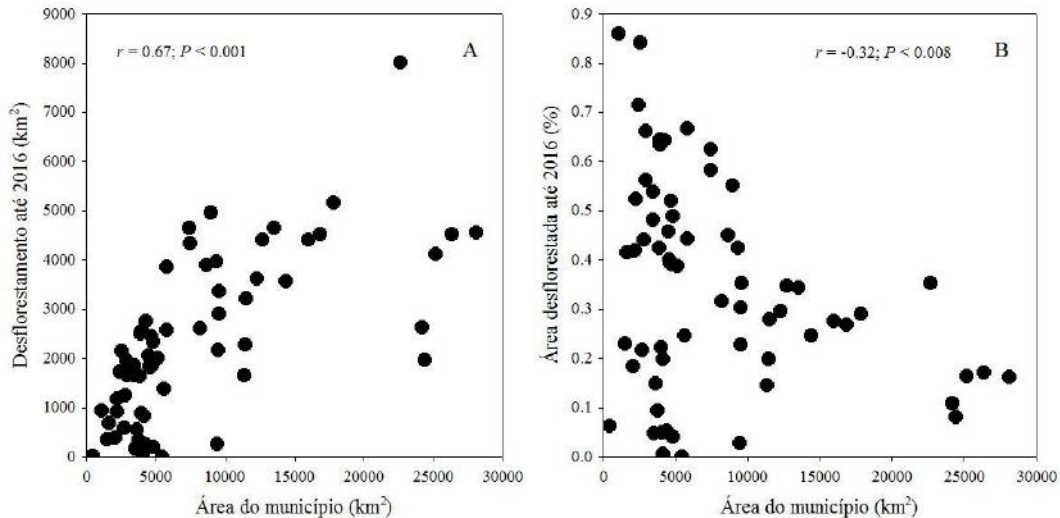


Fig.4: Pearson correlation between municipal area ( $\text{km}^2$ ) and deforested area (in  $\text{km}^2$  and as a percentage of municipal area) up to 2016

Additionally, in municipalities with areas up to  $6,000 \text{ km}^2$ , there was great variability in forest degradation, which ranged from 0.001 to 87% of the area being deforested (Figure 4B), so deforestation is lower in smaller municipalities. On the other hand, larger municipalities also tend to have larger deforested areas. Because this is a trend, this observation cannot be considered out of context; other aspects should be considered, such as being located within the transition area between the cerrado and Amazon biomes.

## V. CONCLUSIONS

In conclusion, one of the greatest current challenges is producing sufficient food to meet the needs of an exponentially growing global population with greater longevity and purchasing power (Crist *et al.* 2017, Gerland *et al.* 2014), but human activities, including agriculture, must be carried out sustainably to ensure the preservation of biodiversity and the full functioning of ecosystem services (DeFries and Nagendra 2017, Johnson *et al.* 2017, Steffen *et al.* 2015). In an ideal scenario, agricultural production and environmental conservation should not be in opposition but

However, the number of notifications in these municipalities can be considered low, with Sinop in the range of 12 to 26 notifications and Vera and Bom Jesus do Araguaia in the range of 1 to 11 notifications. Once again, the lack of action by IBAMA tends to increase the amount of deforested area.

There was a positive relationship between municipality size and deforested area, with larger municipalities having larger deforested areas (Figure 4A). However, the proportion of deforested area decreases as the size of the municipality increases (Figure 4B).

be complementary and harmonious activities. If there are conflicts between these two goals, the results of this study show that there are important relationships between the number of environmental notifications by federal institutions, the number of individuals and entities notified, the geography of the areas, the municipalities, and their size. These effects should be considered in the decision making and actions by surveillance institutions, such as IBAMA, that play a fundamental role in performing inspections and ensuring compliance with current legislation.

## ACKNOWLEDGEMENT

This work was developed during Project RADIS and financed by Finatec (Foundation of Scientific and Technological Developments).

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# Evaluation of the Stiffness Effect of Pipe Supports in Relation to Static and Dynamic Loads in a Flexibility Analysis

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**Abstract**— Piping flexibility analysis is done to ensure structural integrity in all operating conditions that may occur over the life of a system, whether static or dynamic. In industrial designs generally the rigidity of the support is neglected in the analysis of flexibility. The work presents an evaluation of the loads transmitted the structures in function of the rigidity of the pipe support. The evaluation was done through computer simulation using finite element techniques. The computational simulation made possible the evaluation of the forces transmitted to the support structures of an existing project of an orifice station, when considering the rigidity of the support. The work also shows that it is possible to refine projects when taken into consideration the influence of the rigidity of the supports, making a more adequate sizing the structure, portraying more faithfully the behavior of the system. The work also evaluates the influence, advantages and disadvantages in the use of stiffness in the supports with regard to the load transmitted to the support structures (support, base and tube).

**Keywords**— *Stiffness, Pipe, Dynamics, Flexibility Analysis, Finite.*

## I. INTRODUCTION

Due to the disturbances that can occur during the operational life of a pumping system, the project must take into consideration besides the static loads to the dynamic loads. Dynamic loads may occur due to flow disturbances or due to the mode of excitation caused by positive displacement pumps. These loads generate in the systems abrupt changes of pressure, velocity and acceleration along the pipe, thus generating the dynamic loads. With the advancement in computational tools, it is common to simulate structural elements to determine rigidity and as a consequence to evaluate the dynamic behavior of the system under various operating conditions. The work shows that by considering the rigidity of the supports can obtain economic gains due to reduction in the volume of concrete to support the pipe.

The objective of the work is to evaluate the effect of the forces transmitted to the support structures when using the rigidity of the supports that was modeled by the finite element method. Evaluate the advantages and disadvantages of this use by means of a case study.

## II. METHODOLOGY

All real systems are complex. The mathematical model simplifies the physical system and allows it to be analyzed. The finite element method is a technique that allows to evaluate real systems through mathematical modeling. With this technique physical arrangements can be studied according to their behavior, evaluating the response of the system to undergo the action of external and internal efforts.

As one of the techniques used in this study, the linear elastic analysis for static loading adopts the following assumptions: static condition: all loads are applied slowly and gradually to achieve their total magnitudes. After reaching the total magnitude, the charges remain constant (they do not vary with time); Linearity condition: the relationship between loads and the induced responses are linear. The linearity condition is met if all model materials are in accordance with Hooke's law (Eq. 01), which states that the stress is directly proportional to strain, if the induced displacements are small enough to ignore the change stiffness caused by loading, and whether the boundary conditions do not vary during load application. The loads must be constant in magnitude, direction and distribution. They do not change while the model is being deformed.

In industrial designs standards are used with guidelines and considerations for the sizing of piping system. Discharge pipe and pipeline projects are generally used as standard ASME B31.4, this standard deals with stresses in pipes but does not address the rigidity of supports. In this way it is usual in industrial projects to consider rigid supports in the analysis of flexibility as a conservative condition of the modeling. However, the rigidity of the supports changes the response of the system, which in

some cases can be detrimental to the dimensioning leading to oversizing or undersizing of the structures.

The case study was done at an orifice station which carries tailings to a dam. The orifice station functions as a charge-loss station in order to control the rejection pressures. The main transport tubing is 24 inches in diameter and a 14 inch shunt where the rupturing disc acts which is sized to break to 52kgf / cm<sup>2</sup>. The analysis was done for three cases static (Hydrostatic testing, operation, solar radiation), dynamic and three cases (Stop by power failure, improper closure of the blocking valve and normal stop). According to the hydraulic system report, the rupture disk will rupture in the condition of improper closure of the valve.

The program used for the flexibility analysis was CAESAR II which considers infinite stiffness equal to 1012 N / cm. As a conservative practice of projects, the supports are considered as rigid in the modeling of piping systems, believing that in this condition the dimensioning would be more conservative. In special cases where they are subject to severe loads, such as long-distance pumping, this consideration can generate significant errors in both the dynamic behavior of the system and the load results. Flexibility analyzes were performed using CAESARII software modifying only the rigidity of a specific support. This program evaluates the dynamic behavior of the system by means of solution matrices of the dynamics equation (Eq.03). The stiffness of the support was determined by the finite element method, applying a load in the three directions (x, y and z), and obtaining the displacements of the structure using Newton's second law and Hooke's law for the determination of rigidity of the support.

$$\text{Hooke's law } F = k \cdot x \text{ [N]} \quad (\text{Eq.01})$$

$$2^\circ \text{ Lei de Newton } \sum F = m \cdot a \text{ [N]} \quad (\text{Eq.02})$$

$$\text{Dynamic equation } F(t) =$$

$$M \cdot \ddot{x} + C \cdot \dot{x} + Kx \text{ [N]} \quad (\text{Eq.03})$$

Where: F - applied force [N]; K-Stiffness matrix [N / m]; C - Damping Matrix [-]; M-mass matrix [kg]; a - acceleration [m / s<sup>2</sup>]; x - displacement [m]; x' - Speed [m / s]; x'' - acceleration [m / s<sup>2</sup>].

### III. RESULTS AND ANALYSIS

The support evaluated and modeled was a support type guide which restricts the 2 movements, the translation in Y and Z. In the model was considered a friction factor of 0.3 (usual for steel / steel contact). The generated physical model can be seen in Fig. 1.

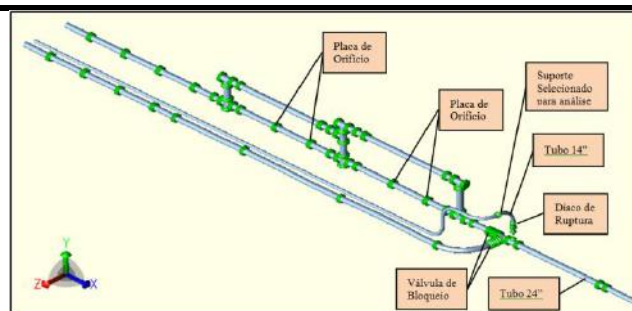


Fig. 1: 3D model of the orifice station elaborated in CAESARII software.

The orifice station was evaluated under the conditions shown in table 1

Table.1: Operating conditions of the system for static and dynamic loads.

Carga Estática		Carga Dinâmica	
E1 - Teste Hidrostático	T=21°C, P=30,0Kgf/cm <sup>2</sup> ; ρ=1000kg/m <sup>3</sup> .	D1 - Parada normal do sistema	T=35°C, ΔP=32,0Kgf/cm <sup>2</sup> ; Tempo de manobra 120s.
E2 - Condição de operação	T=35°C, P=30,0Kgf/cm <sup>2</sup> ; ρ=1420kg/m <sup>3</sup> .	D2 - Parada por queda de energia	T=35°C, ΔP=42,0Kgf/cm <sup>2</sup> ; Tempo de manobra 10s.
E3 - Insolação	T=60°C, P=NA; ρ=NA.	D3 - Parada devido a fechamento indevido da válvula de bloqueio	T=35°C, ΔP=52,0Kgf/cm <sup>2</sup> ; Tempo de manobra 60s.

The carrier selected for analysis was the carrier inserted into the 14-inch rupture disk line. In the region of this support a significant pressure variation occurs when the rupture disk ruptures caused by the transient overpressure in the event of improper closing of the blocking valve (accidental case D3). The propagation of the shock wave due to improper closure of the valve causes an overpressure of the order of 52 kgf / cm<sup>2</sup> and can be seen in the graph shown in figure 2, the transient analysis was developed using the AFT impulse software. The hydraulic transient data calculated in the AFT are presented in the time domain, these data are transformed to the frequency domain for evaluation of the flexibility by means of the Fourier transform. This transformation is done by CAESAR II itself.



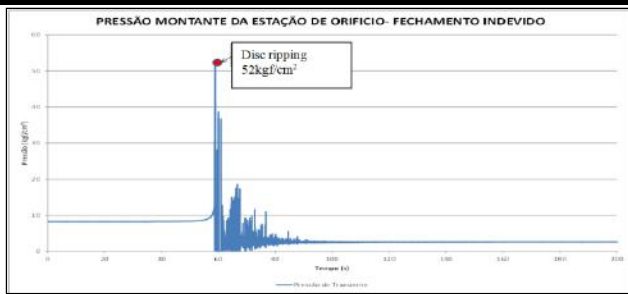


Fig. 2: Hydraulic transient upstream of the orifice station closing valve.

The study support was evaluated using the Ansys 16.0 software for structural analysis. The support model and the mesh test are shown in Fig 3.

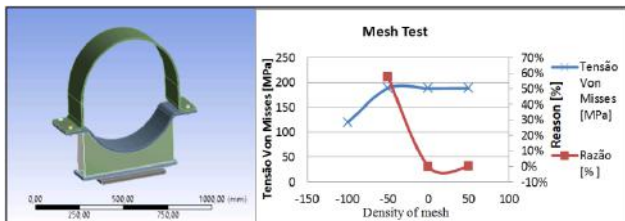


Fig. 3: 3D model of the support in FEA the left and the right mesh test.

The mesh test showed that the mesh used is not influencing the result for a mesh density greater than zero,

obtaining a deviation of less than 0.1% in relation to the Von Mises voltage. With this model a support rigidity was obtained in the X, Y and Z directions as shown in table 2. The displacements were obtained in the center of the pipe.

Table.2: Stiffness obtained by the finite element model.

Rigidez [N/cm]		
X	Y	Z
8,7E+06	1,4E+06	6,5E+06

With the rigidity obtained for the designed support, simulation with and without stiffness was done in order to verify the response of the system loading. The study presented reduction of static and dynamic loads with the reduction of stiffness as shown in table 3. Taking into account the rigidity of the designed support, the load showed a decrease of the transmitted load of up to 8% in the static load and of approximately 5% for the load. dynamic loading. An even more refined study can be developed for each system support in order to determine the optimal rigidity for that loading without impairing system operation.

Table.3: Result of static and dynamic loading with and without support rigidity.

Modelo	Condições Operacionais	Avaliação Carregamento Estático				Condições Operacionais	Avaliação Carregamento Dinâmico			
		FX [N]	FY [N]	FZ [N]	Módulo [N]		FX [N]	FY [N]	FZ [N]	Módulo [N]
		Rigid Z; Rigid GUI					Rigid Z; Rigid GUI			
Projetado	E1	-256	-1752	-13713	13827	D1	7747	6799	17153	20012
	E2	39907	13032	-3532	42129	D2	244469	216941	234060	402011
	E3	40144	14582	6805	43249	D3	256589	34377	66526	267293
	MAX	40144	14582	-15130	45311	MAX	256589	216941	234060	402011
Modificado com Rigidez do Suporte	E1	-165	-1579	-13134	13230	D1	7156	4290	18965	20719
	E2	36451	11988	-3610	38541	D2	218036	223558	220484	382271
	E3	36617	13406	6291	39498	D3	230404	32965	80524	246286
	MAX	36617	13406	-14495	41601	MAX	230404	223558	220484	382271
Redução de Carga		8,8%	8,1%	4,2%	8,2%		10,2%	-3,1%	5,8%	4,9%

An extrapolation of the stiffness of the support was done through computer simulation to evaluate the impact of the same in static and dynamic loads. The study showed that by acting on the stiffness of the support there can be a significant gain in the reduction of static and dynamic loads. However, the dynamic load presented smaller gains in relation to the static load, this can be explained by the change in the mode of vibration of the system, because making the system more flexible also becomes more subject to greater amplitudes of vibration, changing the response of the system .

Figure 4 shows the decrease in modulus of the transmitted forces in relation to the decrease in the stiffness of the support. It is observed that the decrease in stiffness shows

significant gains for the static loading, while the dynamic loading there are more moderate gains as the stiffness decreases.

In this way in industrial projects submitted to great efforts, the system must be designed for a reduction of stiffness that guarantees the operation without that the same enters resonance or has great amplitudes. A suitable working range for the case under study would be a stiffness greater than  $1E + 5 \text{ N / cm}$ , as very low stiffness can lead to excessive vibrations and damage to structures.

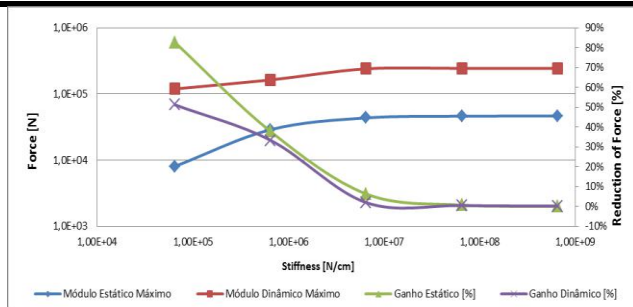


Fig. 4: Fall of the transmitted efforts with the decrease of the rigidity of the support and its respective percentage in relation to the projected effort.

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#### IV. CONCLUSION

The study showed that using the stiffness of the designed support, a reduction in modulus of the loads transmitted to structures of approximately 5% with respect to the load anticipated in the initial design corresponding to a reduction of effort of 2 tons transmitted the structures is possible;

Special attention should be given to the vibration modes of the system to avoid amplitude increase when decreasing stiffness;

The study of the stiffness of the support can contribute significantly to the reduction of the load transmitted the support structures, and in the case studied could be reduced by up to 50%, if the support was suitable for a rigidity in the order of  $1.0E + 5N / cm$ .

As a suggestion of refinement and continuity of this study it is suggested an evaluation of the loading considering the non-linearity of the material under conditions of dynamic loading (short interval of time), and to evaluate the effects of the loads by allowing in sporadic events that the support works in the region of plasticity.

#### ACKNOWLEDGEMENTS

To Puc Minas University for the support and incentive to this research

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# Experimental Design and Optimization of Conical Horn of Ultrasonic Amplitude

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**Abstract**— Based on the basic principle of particles and the simple mechanical vibration system, then according to the wave equation and the traditional design theory of the amplitude transformer, we design an amplitude transformer commonly used in the equipment of Ultrasonic machining. Then, the structure is analyzed by the finite element analysis software ANSYS in the modal and harmonic response module and further optimized to obtain the design parameters of the amplitude transformer with good performances. Finally, the amplitude transformer is made according to optimized parameters and later it is analyzed by the impedance analyzer. And then the designed transformer is further modified to achieve better performance.

**Keywords**—Conical ultrasonic amplitude horn; Finite element analysis; Impedance analysis.

## I. INTRODUCTION

The recent development of modern hi-tech industries has resulted in the creation of a range of new materials. These include steels and alloys of high strength, stainless and resistant to heat, titanium, ceramics, composites and other non-metallic materials. These materials may not be suitable for conventional machining processes due to scaling or fracturing of the surface layer or even the whole of the component and lead to poor quality of the product. Similarly, the creation of new materials often highlights some insoluble problems within a framework of traditional technologies. In some cases, these problems are caused by the construction of the object and the requirements peculiar to it. For example, in microelectronics, it is often necessary to connect certain components without heating them or to add intermediate layers. This prohibits the use of traditional methods such as welding or welding. Many of these and similar problems can be solved successfully using ultrasonic technologies [1].

The use of ultrasonic phenomena is increasingly used in many industries. Ultrasonic vibrations have been exploited with considerable advantages for a variety of applications such as ultrasonic cleaning, plastic welding etc. Has proven to offer benefits in a number of other applications. These applications include automotive industry, food preparation, medical assembly, textile and manufacturing

industries. Significant increase in performance and qualitative improvements are obtained by using ultrasonic vibrations in the machining process. Applications of ultrasonic vibration energy in machining technologies are realized by two different approaches. The first approach, called ultrasonic machining, is based on the abrasive Principle of shrinking materials. The tool that is shaped in the exact configuration to Crushed in the piece and is attached to a vibrating horn. The second approach is based on conventional machining technologies [2-4].

In ultrasonic machining, ultrasonic vibrations are transmitted directly to the cutting tools or directly to a cutting process. These techniques are used for high-precision machining and for non-fragile materials and materials that are difficult to cut, such as hardened steels, nickel based alloys, titanium metal matrix composites and aluminum-SiC. The high repetitive frequency the vibro-impact mode brings unique properties and improvements in the metal cutting where the interaction between the work piece and the cutting tool is transformed into a micro-vibro-impact process. The application of ultrasonic vibration energy in the machining process offers many advantages and improvements in the cutting process[5].

The performance of ultrasonic machining equipment depends on the design of the sonotrode (Horn). The sonotrode is the only part of ultrasonic machining and unique system for each process. They are used in various shapes and sizes, depending on the application, but as other components should be resonant at the operating frequency. The sonotrode material used is a compromise between the needs of ultrasound and application - alloys of titanium, steel, stainless steel. The shape of ultrasonic horn depends on the technological process for which it will be used. The most frequently used forms of ultrasonic horns are: cylindrical, conical, exponential and climbed. To achieve optimum performance of the ultrasonic machining system, all relevant effects and parameters that affect the dynamics of the system must be taken into account. One of the most important elements of the sonotrode ultrasonic system must have the dynamic properties, which must be determined already in the design phase[6].

## II. TRADITIONAL METHOD OF HORN DESIGN

The traditional design method for acoustic horns is based on the differential wave equation of (1) (Fig. 1)

$$\frac{\partial(A\sigma)}{\partial x} dx = A\rho \frac{\partial^2 \xi}{\partial t^2} dx \quad (1)$$

In the formula: **A** For the function of the cross section of the stem, **A = A(X)**  $\sigma$  Stress function, Particle displacement force function  $\sigma = \sigma(x) = \frac{E\partial\xi}{\partial x}$ ,  $\xi = \xi(x)$ .

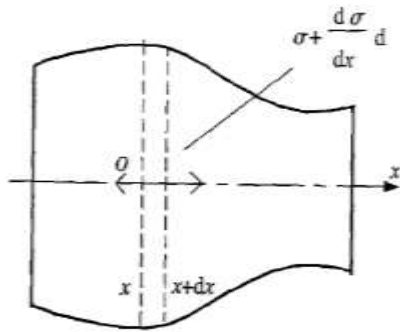


Fig.1: Longitudinal vibration of the variable section stem

In the case of a simple harmonic vibration, equation (1) can be written:

$$\frac{\partial^2 \xi}{\partial x^2} + \frac{1}{A} \cdot \frac{\partial A}{\partial x} \cdot \frac{\partial \xi}{\partial x} + K^2 \xi \quad (2)$$

In the formula: **K** Round wave number,  $K = \omega / c$ ; **c** P-wave in the horn

The speed of propagation,  $C = E / \rho$ . The formula (2) is the wave equation of the longitudinal vibration of the variable section rod. According to the boundary conditions  $[(\xi / x) x = 1 = 0, (\xi / x) x = 0$  and  $(u) x = 0 = 0$  initial amplitude, the resonance induced transformation can be calculated. The length of the band and amplitude amplitude change at this length. However, this formula can only be used to design horns whose section functions change according to certain rules, such as exponential, catenary, stepped and conical horns. For composite horns with complex section shapes, equation (2) cannot provide an analytical solution, which makes it difficult to design and use the horn.

## III. THEORETICAL DESIGN OF CONICAL HORN

### 3.1. Particle displacement and velocity EQUATION

It is assumed that the horn is uniform and isotropic, excluding mechanical losses, and that plane longitudinal waves propagate in the axial direction. The horn satisfies the wave equation in a one-dimensional condition.

$$\frac{\partial^2 \xi}{\partial x^2} + \frac{1}{S} \frac{\partial S}{\partial x} \frac{\partial \xi}{\partial x} + k^2 \xi = 0 \quad (3)$$

In the formula: For the particle displacement function,  $S$  is the cross section,  $k = \omega / c$ ,  $k$  is the wave number,  $\omega = 2\pi f$

$c = \sqrt{E/\rho}$  is the velocity of propagation of the longitudinal wave,  $E$  is the modulus of elasticity of the material and  $\rho$  is the density of the material. The diameter at the origin of the coordinate is  $X = 0$ .

The diameter at the origin of the coordinate is  $D_1$ ,  $X = L$ , where  $D_2$ , and its zone function is, where is, its zone function is  $S = S_1(1 - \alpha x)^2$  (4)

$$D = D_1(1 - \alpha x) \quad (5)$$

$$\alpha = \frac{D_1 - D_2}{D_1 L} = \frac{N - 1}{NL}, N = \frac{D_1}{D_2} \quad (6)$$

The force and vibration acting on both ends of the horn

$$F_1, \dot{\xi}_1 \quad F_2, \dot{\xi}_2$$

The velocities are and respectively, the sum and the boundary conditions Substituted in equation (1), the resulting solution is:

$$\xi = \frac{1}{x - \frac{1}{\alpha}} (A_1 \cos kx + B_1 \sin kx) \quad (7)$$

After looking for the first derivative

$$\frac{\partial \xi}{\partial x} = \frac{1}{x - \frac{1}{\alpha}} (-A_1 k \sin kx + B_1 k \cos kx) - \frac{1}{(x - \frac{1}{\alpha})^2} (A_1 \cos kx + B_1 \sin kx) \quad (8)$$

### 3.2 Frequency equation and resonance LENGTH

$$\text{By boundary conditions } \left. \frac{\partial \xi}{\partial x} \right|_{x=0} = \left. \frac{\partial \xi}{\partial x} \right|_{x=L} = 0$$

Substitution Equation (6) gives the frequency equation:

$$tg(kl) = \frac{kL}{1 - (k/\alpha)^2 (\alpha L - 1)} \quad (9)$$

The length of the horn satisfies:

$$L = \frac{\lambda}{2} \cdot \frac{(kL)}{\pi} \quad (10), \quad \lambda \text{ (Wavelength for propagation of waves in the medium)}$$

**3.3 NODE OF DISPLACEMENT**

The displacement node satisfies the equation:

$$tg(kx_0) = k/\alpha \quad (10)$$

**3.4 MAGNIFICATION FACTOR**

$$M_p = \left| N(\cos kL - \frac{N-1}{N} \sin kL) \right| \quad (11)$$

The horn is made of 45 # steel. The main parameters are: modulus of elasticity E = 209.2 GPa, Poisson's ratio  $\gamma = 0.28$ , density  $\rho = 7850 \text{ kg/m}^3$ . The horn has two central hole diameters M18x1.5 and M12x1.7, end face diameters of 50 mm and 20 mm and a horn length of 136 mm. The designed horn is used in rotary ultrasonic machining equipment whose main parameters are: operating frequency range 20 to 50 kHz.

**IV. FINITE ELEMENT ANALYSIS OF THE HORN**

**4.1 MESH DIVISION**

The quality of 45 # stainless steel is chosen as horn material with a working frequency of 20 kHz. Stainless steel offers good characteristics for the use of ultrasonic horns. They have high strength, stiffness, wear resistance and corrosion resistance. They can be used over a wide temperature range. In addition, due to the good machinability during manufacturing, the 45 # was chosen on other horn materials. The properties of stainless steel, 45 # are given in Table 1.

Table.1: Properties of the material used for the horn

MATERIAL	45# STEEL
Density $\rho \text{ /kg/m}^3$	7850
Young's Modulus E/GPa	209.2
Sound speed C/m/s	5162
Poisson's ratio	0.28

The allowable stress of the steel 45 is = 300MPa the finite element software ANSYS is used to establish the finite element model and the mesh. The number of nodes is 37880 and the number of units is 2574, as shown Figure 1:

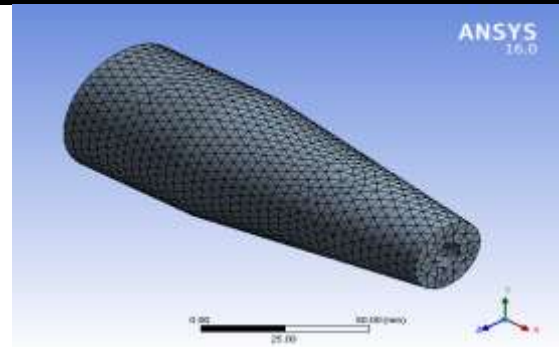


Fig .1: Meshed geometry of the conical horn

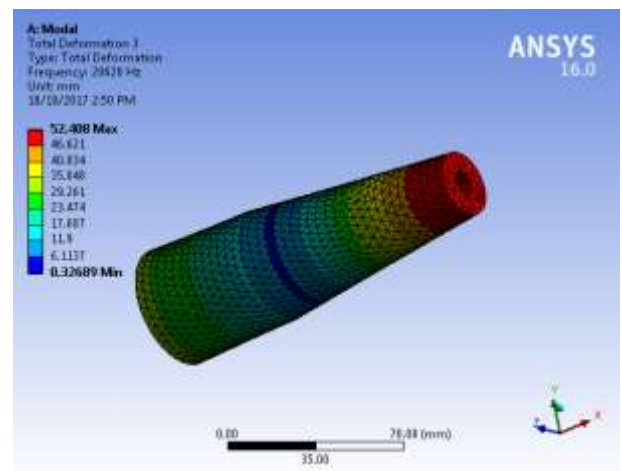


Fig.2: Longitudinal displacement distribution cloud

**4.2 MODAL ANALYSIS**

The modal analysis deals with the analysis of the free vibrations of a body / structure. The goal is to find the shapes and frequencies at which the structure will amplify the effect of a load. The method of the block lancets allows to perform a modal analysis on the model of the free horn at both ends, the search frequency is between 15 kHz and 30 kHz, the result is chosen in the solver and the natural frequency is 19 788 Hz. Near 20000Hz, for the results we need.

**4.3 HARMONIC REPOSE**

Harmonic analysis is used to determine the response of the load structure at a given frequency. It predicts the dynamic behavior of the structure by checking whether the structure is resistant to resonance, fatigue and other adverse effects. Case of our horn, the analysis of the harmonic response and apply in an axial displacement of 5 $\mu\text{m}$  to the large section of the horn. According to the amplification by the horn, the displacement is 15.1 $\mu\text{m}$  and the magnification is 2 , 4 times, the position of the knot is about the largest. The equivalent maximum stress is 38,556 MPa, which corresponds to the displacement curves and the equivalent stress distribution are illustrated



in Figure 3 and Figure 4.

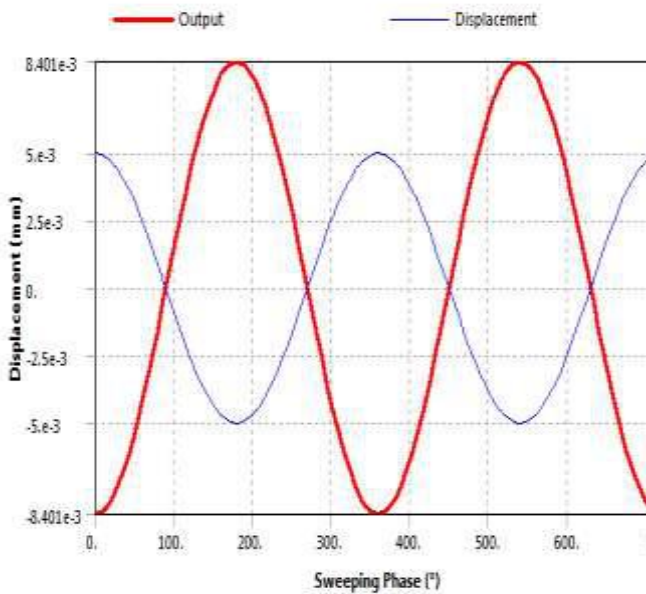


Fig.3: longitudinal curve of vibration displacement

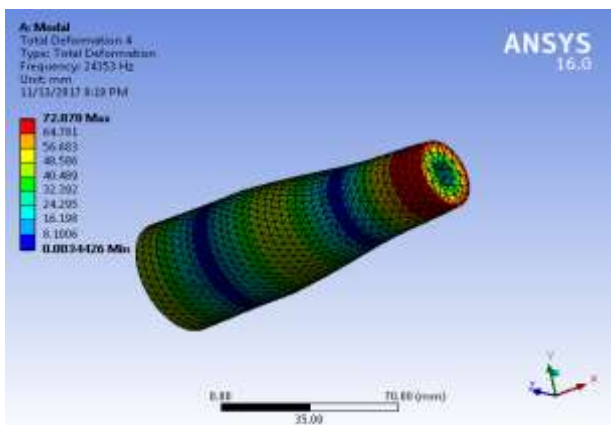


Fig.4: Axial Equivalent Stress Distribution Cloud

## V. IMPEDANCE ANALYSIS

The impedance analyzer can perform accurate measurements over a wide range of impedances and frequencies, It also adds low frequency current at different frequencies through the transducer, The natural frequency of the vibration system consisting of a transducer and of a horn is calculated by impedance.

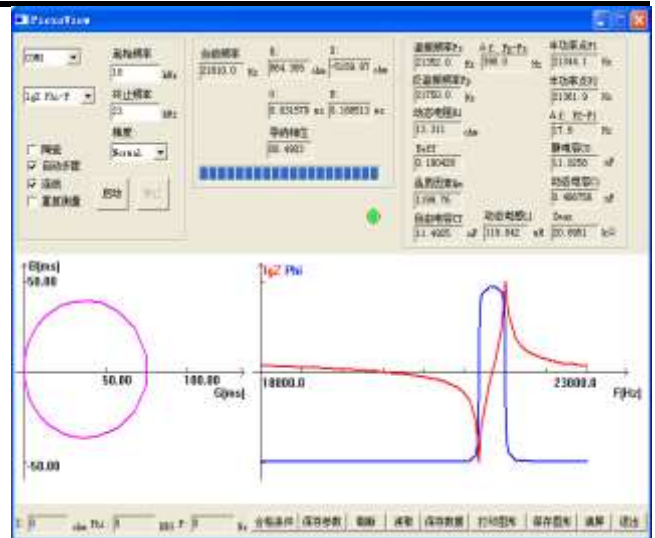


Fig.5: Result of the horn impedance analysis

After connecting the transducer and the horn, the ultrasonic vibration system was analyzed using a PV70A impedance analyzer manufactured by Beijing Commonwealth Electronic Technology Co., Ltd. The actual measured resonance frequency is 21352.0 Hz and the frequency error of the simulation results is less than 3%. Figure 5 shows that the circle of admittance is single circle and relatively regular, and the conductance curve has only a pair of maximum and minimum values, which shows that the design of the horn and the assembly with the transducer are relatively successful.

## VI. CONCLUSION

Based on wave theory, a conical ultrasonic horn was designed, ANSYS finite element analysis software was used to analyze horn dynamics, a horn was fabricated and an impedance analysis was performed with better performance. It shows that this method of analysis - the finite element method combined with the horn design method is efficient and allows to design more complex horns.

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# Measurement of a superficial texture by applying the alpha parameter on the profile P, for measuring a manual transmission gear

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**Abstract**— *The objective of this work is to demonstrate the P Profile application in the measurement of superficial texture of the cone seat of the synchronization ring gear of a Mechanical Transmission.*

*It is known that this superficial texture is an essential factor for the good performance and durability of a Mechanical Transmission, since the variation of this texture is directly linked to the synchronization failure, premature wear of the synchronization ring coupling guides, gear and sleeve.*

**Keywords**—*Superficial Texture, P Profile, Manual Transmission Synchronization.*

surface quantified by vertical deviations of a real surface from its Ideal geometric form, which is that prescribed in design, as shown in figure 1 [3].

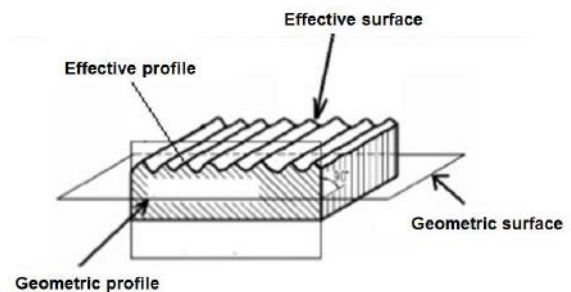


Fig. 1: Geometric surface and Effective surface

## I. INTRODUCTION

The term surface integrity cannot be defined only by superficial texture or geometric shape. The characteristics of layers below the service surface must also be considered because the process to obtain a machined surface is very broad, considering plastic deformation, rupture, elastic recovery, heat generation, vibrations, residual tension and even chemical reactions in some cases [1].

The superficial texture of a machined component is the result of the combination of several factors, that can be divided into roughness, waviness and faults [2]. It is characterized as roughness the irregularities or micro geometric errors existing on a surface due to the cutting process, such as tool wear, tool advance marks and APC fragments [1]. The waviness are superficial irregularities or geometric errors for which the spacing is bigger than the irregularities considered as roughness, usually caused by vibrations, tool flexing (due to shear forces), temperature, tool or tool fixing errors. In addition, faults are defined as interruptions in the typical topography of a surface. They can be caused by defects inherent to the material, such as inclusions, cracks, voids, or may also arise during the cutting process [1].

The superficial roughness expressed in thousandths of a millimeter ( $\mu m$ ), is the measure of the texture of a

We can find in the literature several parameters of roughness, but by convention, 2D roughness is represented by "R" followed by additional characters that indicate the mathematical and statistical method used for its calculation. In Brazil, this parameter is based on the depth of the roughness measured according to the midline system (M) [4], according to figure 2 [3].

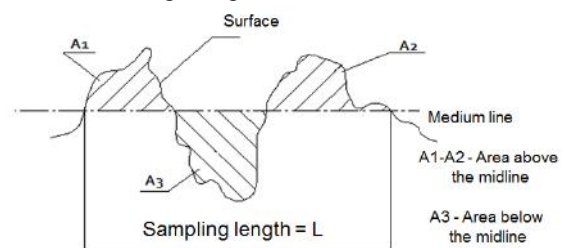


Fig. 2: Roughness Measurement System - Midline

The Ra parameter is the most widespread and the most used. This parameter is calculated from the arithmetic average of the profile deviations, taking as reference the midline and it is defined over a sampling length "l" as shown in FIGURE 3 [5].

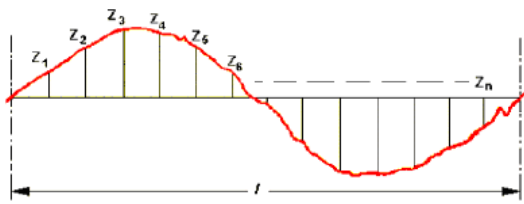


Fig. 3: Ra - Roughness Average

Ra is mathematically expressed by the following equation:

$$R_a = \frac{z_1 + z_2 + z_3 + \dots + z_n}{n} \rightarrow Ra = \frac{1}{l} \int_0^l |Z(x)| dx$$

It is characterized as Tp, the percentage of the contact area generated by the truncation of the peaks to a certain depth [6], configures figure 4.

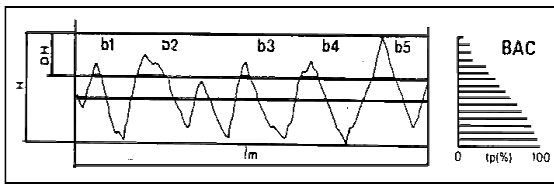


Fig. 4: Tp representation

Tp is mathematically expressed by the following equation:

$$Tp = \frac{b_1 + b_2 + \dots + b_n}{lm} \times 100(\%)$$

The analysis of superficial texture can be demonstrated as follows: analysis without filtering (profile P), roughness analysis (profile R), waviness analysis (profile W) and shape analysis. Profile P contains roughness, shape and waviness. The profile R only contains roughness and the profile W only contains waviness. The form is a macrogeometric analysis and is analyzed separately [5].

This work has the objective of analyzing two gears, one of those has presented a problem in the final operation due to the failure of synchronization (difficult to engage gears) and on the other one this fault has not been verified. Through comparing the measured characteristics according to the standard drawing between the two gears, we studied the values found and proposed other possibilities using the analysis in the R and P profile in the surface texture, as well as a mathematical interpolation, in order to define the ideal parameter P for the application.

## II. EXPERIMENTAL PROCEDURES

Two second speed driving gears for the C513 manual transmission were used. Both forged on 19 Cr Mn material, cemented and tempered. These two parts were grinded in the NOVA grinding machine, built in 1994 year, using a conventional aluminum oxide grinding wheel, with 0.30 mm over material to be grinded. In the end of the grinding machining process, expected to obtain a cone roundness of 4.0 μm, Ra of 0.45 to 0.75 μm and Tp of 1.8 > 50%, according to Figure 5.



Ra	0,45 a 0,75 μm
Tp	1,8 > 50%
Roundness	4,0 μm

Fig. 5: 3rd speed conductive gear with finishing parameters

The roughness was measured in a Taylor Hobson rugosimeter, TalySurf Series model.

The experiments with the gears were performed with production vehicles, driven by a test driver, using the plant test track.

## III. METHODOLOGY

The two tested gears, one of which presented a problem in the final operation due to the failure of synchronization (difficult to coupling gears) and another on which this failure was not verified were submitted to the measurements specified by design.

We compared the macro and micro geometric differences between two gears to define what characteristic was linked directly with the problem. This way of comparison between OK and Not ok parts to define the root cause problem, resemble to the stage of RedX methodology, called *Component Search*. This stage proposes the change between OK and Not ok components, individualizing the component that is linked to the problem for further in-depth analysis for the discovery of the real characteristic that turns the problem on and off.

## IV. RESULTS

Measuring the standard gear drawing specifications regarding the Not OK gear rejected in the test track due to synchronization problems, we found the following results, according to the table below:

Characteristic	Specification	Real
Roundness	4μm	3,23 μm
TP 1,8	> 50%	99,98%
Ra	0,45 to 0,75 μm	0,62

We observed that the gear, despite presenting a synchronization problem in the test track, was in accordance with the drawing specifications.

We needed to define a superficial finishing parameter that would serve as a reference for the machining area to define good and bad parts. As the synchronization problem is related to the three previously mentioned parameters (Ra,



TP and Roundness), we proceeded to analyze the possible variables of these three parameters. Applying the measure of TP in the profile P that we will call it from now on alpha parameter due to being intellectual property of the company, we obtained the following results:

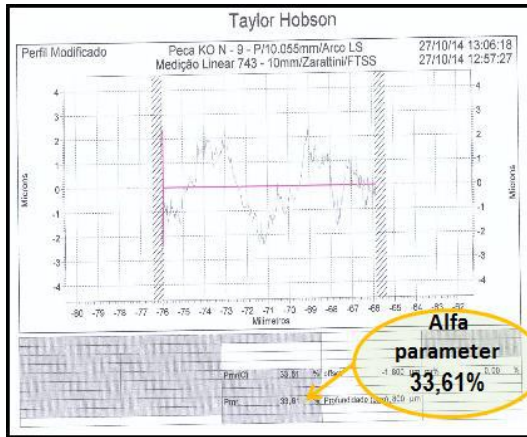


Fig. 6: Alpha parameter control result of the gear that presented synchronization problem - Alpha = 33,61%

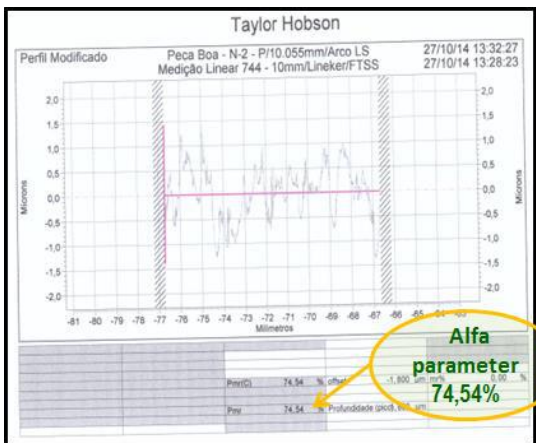


Fig. 7: Alpha parameter control result of the gear that do not presented synchronization problem - Alpha = 74,54%

As we can see, the Not ok part had all the characteristics provided for drawing accordingly. When applying the new control parameter (Alpha) for the Not ok part, presented value of 33.61%. For an OK part the value found was 74.54%. In this way we find a value that differentiated a good part from a bad one based on Profile P.

Considering that the practical result showed that for an alpha parameter of 33.61% we have a Not ok part and for 74.54% we have an ok part, we applied a mathematical modeling to define what would be the minimum alpha parameter for terms only good parts.

In figure 8 we have the mathematical calculation used for the adequacy of the curve with the alpha parameter data available.

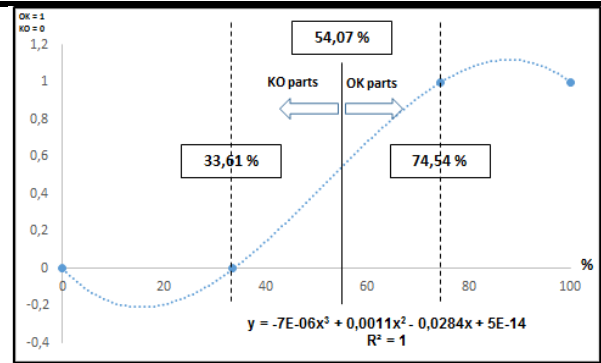


Fig. 8: Mathematical modeling to define the ideal Alpha parameter point

## V. CONCLUSION

Using the TP measured in the R profile, in which only the microgeometric errors of the surface roughness are recorded, the macrogeometric errors are eliminated, therefore, the problem could not be perceived.

Using the measured TP in the profile P called in this article as alpha parameter, we were able to observe a smaller fraction of contact, because, in this profile, macrogeometric errors are taken into account during the measurement. With a smaller fraction of contact the synchronizer ring does not brake causing it to affect directly in the synchronization. The large number of harmonics found in circularity measurement are responsible for the low contact area between the gear cone and the synchronizer ring.

With a set parameter for control of the gears, in this case called the alpha with 54,07%, it will allow the production to be able to manufacture gears that do not present synchronization problems.

## ACKNOWLEDGEMENTS

We are thankful for FCA - Fiat Chrysler Automobiles to the data, materials and laboratories availability for the analysis. The Pontifical Catholic University of Minas Gerais for the support. Finally thankful to the FCA colleagues, Márcio Zarattini, Alcides Pizeta and Odilon Andrade for the effective action in the definition of the alpha parameter.

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# Epidemiological Profile of Precocious Neonatal Mortality in the Period 2008 to 2015 in Porto Velho, Rondonia, Brazil

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**Abstract**— The objective of this study was to describe the epidemiological profile of precocious neonatal infant mortality in the city of Porto Velho, Rondonia. A quantitative, descriptive study with an ecological approach was carried out. The data source used was secondary, originating from the linkage between SINASC and SIM databases, from the Health Surveillance Agency

of the Rondonia Health Department. For treatment, absolute frequency analyzes were performed. The neonatal infant mortality rate was 9.7 deaths per thousand live births, with a predominance of the preterm neonatal patient: 7.2 deaths per thousand live births. Of the deaths, 482 (72.8%) occurred in the precocious neonatal period (0 to 6 days) and 164 (24.7%) in the late neonatal 7 to 27

days of life. The findings indicate the need to improve the quality of health care services available in the city, both prenatal and obstetric care in the neonatal period.

**Keywords— development, neonatal mortality; maternal and child health.**

## I. INTRODUCTION

The infant mortality rate (death of children under one year per thousand live births - NVs) is a sensitive indicator of social, economic development and above all health care in a given geographic space and time.

Infant mortality is still divided into neonatal mortality (death 0-27 days) and post-neonatal mortality (27 days for deaths until 364 days of age). Since neonatal mortality and also divided into two periods, precocious neonatal (0 to 6 days) and late neonatal (7 to 27 days).

Although the global rate of infant mortality (under five years) has reduced by 49% between 1990 and 2013 - from 90 to 46 deaths per thousand NVs - 74% of these deaths corresponded to children under one year and 44% occurred in the neonatal period (zero to 27 days of life).

Data from a survey conducted by Moreira, et al (2014) in the city of Porto Velho, showed a predominance of deaths in children under years born to mothers aged 20 to 34, whose percentage ranged from 26.0% in 2006 29.0% in 2010, with percentage swings in other years.

Over this period, the study showed an increasing trend from premature deaths. Between 2006 and 2007 this percentage was maintained in 50.0%, increasing to 53% in 2008 and in 2010, representing 54.0% of deaths in children under 1 year, featuring intense incidence of neonatal mortality in preterm (MOREIRA et al, 2014).

In 2013, the leading causes of neonatal death in the world were complications from premature birth (35%) and labor (24%) and attributed to sepsis (15%), considered one of the leading causes of death in this age group in Brazil.

This situation and due to the more pronounced reduction in deaths in the post-neonatal period, which reflects social inequalities, coverage and quality of health care. Already neonatal deaths have close relationship with the health care provided to pregnant women and newborns during the antepartum, delivery and immediate care to child at birth. Another relevant situation and the high proportion of neonatal deaths in the first day and the first week of life, which shows the relationship of neonatal mortality with the health care provided to pregnant women and newborn and the need to consider the targeted actions the improvement of such assistance (LORENZO, Brunken and LUPPI, 2013).

One of the biggest current challenges to reduce infant mortality in our country and the proper care of the newborn, in addition to monitoring the entire cycle pregnancy until the birth of the baby, with quality service at all levels of complexity.

The timely and effective access to obstetric and neonatal care quality, from the prenatal care, delivery care, postpartum and care received by the newborn also contribute to reducing the incidence of diseases and, consequently, a higher survival rate of newborn -born, especially newborns risk.

Thus, the aim of this study was to identify and characterize the epidemiology of neonatal infant mortality in Porto Velho, from 2008 to 2015.

## II. METHODS

It is a quantitative study of descriptive character with ecological approach. Data collection was performed using a previously tested instrument adapted Oliveira (2009), which extracted the secondary data information infant deaths neonatal period defined stratified from the following sources of information: Information System born Alive - SINASC; Mortality Information System - SIM, coming from the State Agency of Health Surveillance of Rondônia-RO-AGEVISA.

Deaths were described according to the main groups for deaths from causes listed on the death certificate obtained by linkage of the research bank with the SIM and the causes registered in the records. This list of causes groups the codes of 10<sup>th</sup> revision of the International Classification of Diseases (ICD-10).

Data were analyzed using absolute and relative frequency of the selected variables.

For the last step, it was carried out GIS data of deaths in the neonatal period, distributed in the city, from 2008 to 2015. The data were spatially on a vector basis of the urban area of the Old Port district headquarters, purchased from the Secretary of Old Port of City planning - SEMPLAN (2017), so that each neighborhood presents a value corresponding to the processed data. It was used as a tool of expertise and building maps: Geographic Information System - GIS, through Software Quanto Giz - Qgis, version 2.8.1.

## III. RESULTS

In the period 2008-2015, n = 65 967 born children, children of mothers living in Porto Velho. These n = 1,002 died less than a year old.

*CMI was 9.7 neonatal deaths per thousand live births, with precocious neonatal predominant component: 7.2 deaths per thousand live births. Of the deaths, 482 (72.8%) occurred in the precocious neonatal period (0 to 6 days) and 164 (24.7%) in the late neonatal (7 to 27 days).*

Table 1 shows the results for the leading causes of deaths in the neonatal group in this study. The conditions in the perinatal period were responsible for n = 492 (74.43%) of deaths in this period, n = 152 of these (30.8%) were caused by Bacterial Septicemia of the newborn.

The causes of higher prevalence of neonatal deaths in this study with a percentage equal to 25% are related to bacterial septicemia RN, being considered deaths from preventable causes.

Bacterial sepsis is considered a disease originated in the perinatal period and should be understood as a preventable cause. Originates in precocious pregnancies, this cause is defined as a clinical syndrome characterized by nonspecific and systemic inflammatory response correlated to the presence of bacteria in sterile body fluids. Precocious sepsis is related to pregnancy and / or peripartum factors, and the etiological agents originating from the maternal genital tract or maternal bacteremia. *Streptococcus agalactiae*, *Escherichia coli* and *Listeria monocytogenes* are the main bacteria responsible for precocious onset of disease. Among the most common clinical signs in sepsis stand-disordered breathing (Aquino et al, 2009).

This feature explains the finding of n = 105 neonatal deaths that were diagnosed with respiratory distress, associated with septicemia.

On this, Malta et al (2010) reports that in developing countries, infant mortality is high and a significant portion of this number is due to perinatal and neonatal mortality. The main causes of perinatal mortality are associated with prematurity, to bacterial septicemia,

asphyxia, the intrauterine infections, toxemia of pregnancy and multiple birth defects as those referred to the neonatal period are the intrauterine acute infections, respiratory problems, birth defects, the prematurity and postnatal infection, is taking an amount that varies depending on operating conditions of the Maternity and Nursery.

In recent decades, the mother's obituary declined to almost vanish; By that time, perinatal losses did not follow the same rhythm when considering the balance between the scientific and technological progress and the possibility that these resources are available to the pregnant woman, the fetus and the newborn, in countries not in the first world (BRAZIL, 2015).

In maternity wards of the least favored regions, such as the northern region, the nurseries have little equipment resources, limited physical area, large numbers of newborns at risk and especially small number of personnel (nurses, aides, etc. .), often not well trained.

A preventable death is one whose occurrence is related to medical intervention and quality health services. The preventability now considered according to various criteria to organize and cover the different factors that contribute to the occurrence of these deaths, in addition to analyzing the effectiveness of the health system (Pereira et al., 2016) It is considered that the birth weight is alone, the major risk factor related to neonatal mortality (Faria et al, 2014).

Table.1: Distribution of neonatal infant mortality indicators in Porto Velho per biennium second major cause of death.

Variables	Neonatal Mortality (%)			
	2008-2009	2010-2011	2012-2013	2014-2015
<b>Classification of causes of death</b>				
<b>Infectious and parasitic diseases (A00-B99)</b>	4 (2,2)	3 (1,6)	4 (2,8)	6 (3,8)
<b>Afecções originadas no período perinatal (P00-P96)</b>	138 (77,5)	129 (68,9)	105 (74,4)	120 (76,9)
<b>Originating in the perinatal period (P00-P96)</b>	27 (15,1)	48 (25,6)	26 (18,4)	21 (13,4)
<b>Others</b>	9 (5)	7 (3,7)	6 (4,2)	9 (5,7)
<b>Total</b>	<b>178</b>	<b>187</b>	<b>141</b>	<b>156</b>

Source: Santos et al, 2018.

With regard to the second deaths birthweight, which was evidenced during the study period, there were n = 169 (25.5%) neonatal deaths in infants who weighed less than 1 kg, followed n = 108 (16.3%) with less than 1.4 kg (Figure 1).

Gizaw et al, (2014) reported that low birth weight is an important indirect cause of death, but maternal complications at work are at high risk of neonatal death, and poverty is also strongly associated with an increased risk.

The highest proportion of low birth weight neonates, ie, birth weight less than 2.5kg, found in the studied population, shows that low birth weight is a risk factor for neonatal mortality, and that as the weight birth increases the risk of death decreases significantly.

Corroborating these findings cite the study by Potrich et al. (2011) with data from the city of Santa Maria - Rio Grande do Sul, in the database of the Department of the Unified Health System (DATASUS) with RNs to identify mortality, where it was found that from 2000 to 2008 there was a higher frequency of deaths weighing less than 1.5 kg.

Another study conducted in the state of Pernambuco through information contained in the SIM database showed that a total of 8,055 deaths from 2009 to 2011, 63.1% (n = 5,083), ie, most were neonates weighing less than 2.5 kg (Pereira et al, 2016).

In relation to birth weight, 60% of infant deaths are infants with low birth weight. On the other hand, that the longer the lifetime, the greater the proportion of weight not informed on the death certificate.

This proportion reaches 28.5% of infant deaths occurred in the post-neonatal period, which may compromise the analysis of that feature.

Regarding the mode of delivery, 41.2% of deaths occurred during the study period, there mothers whose type was cesarean delivery.

It is considered high prevalence of cesárias recorded in the city of Porto Velho, during the period studied.

Moreira et al, (2014), evaluated the cesarean rate in the 2006 to 2010 period, pointed out in his study that the cesarean rate ranged between 35.0% and 47.0% of births.

In Brazil, cesarean section is one of the highest percentages in the world, around 36.4% of hospital births (Victoria et al, 2011).

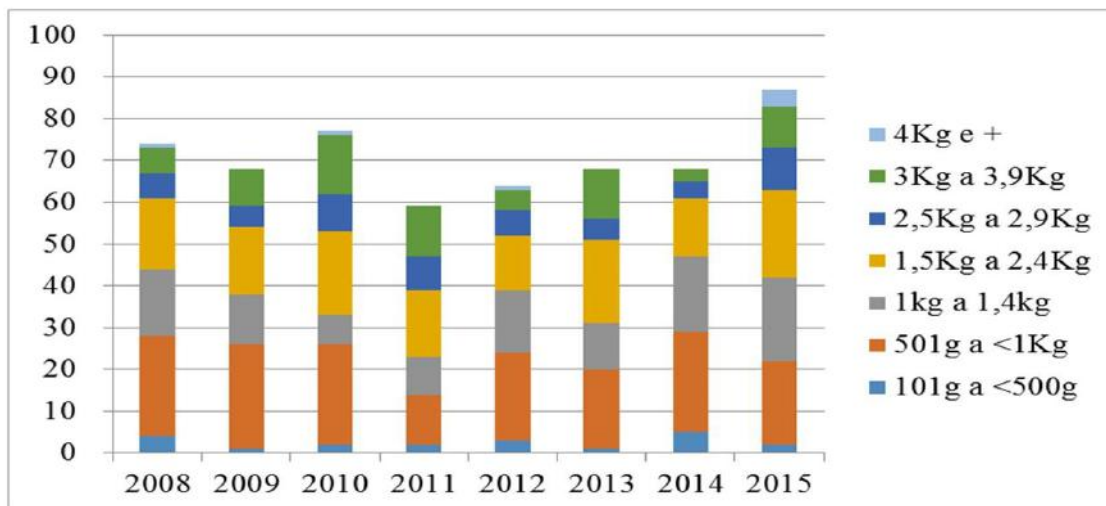


Fig.1: Distribution of neonatal deaths per year in Porto Velho, according to birth weight. Porto Velho, Rondônia, 2016.

Source: Santos et al, 2018.

On the findings regarding sex of the child who died in the neonatal period, Figure 2 below shows that in all the years of the study period, there was a predominance of males. The epidemiological behavior presents an average of 82.7 deaths per year, with a higher prevalence in newborn males (57%).

The sex of the RN showed association with neonatal mortality in this study also was observed by Pereira et

al. (2016) and Gaiva, Fujimori & Sato (2015) found that high risk for male RNs.

According Knupp (2010) compared to female, male newborns have an increased risk of neonatal death among in all weight ranges and gestational age. The author also explains the difference in neonatal mortality between the sexes because boys exhibit a slower global ripening.

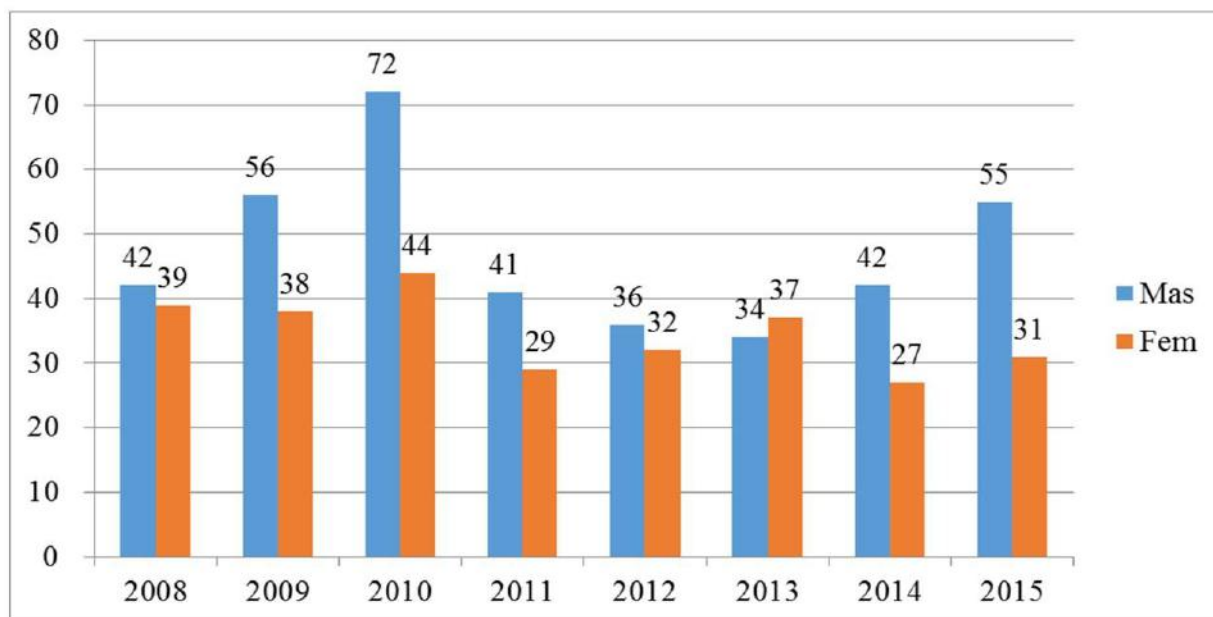


Fig.2: Distribution of children neonatal deaths per year, according to sex of the newborn. Porto Velho, Rondônia, 2016.

Source: Santos et al, 2018.



In this study, the  $n = 482$  neonatal deaths occurred in the period,  $n = 191$  (47.6%) were mothers residing in area neighborhoods east of the city of Porto Velho (Figure 3). This area of the city comprises 39.5% coverage of the Health Strategy Porto Velho family, with the performance of  $n = 30$  eSF in 06 Basic Health Units of the Family. This brings us to the thought that these women had some kind of contact with health services or performed some sort of prenatal care. The neighborhood by death records represent the correlation been reported in other studies, the association

between neonatal infant death to local development. The neighborhoods presented the findings point to the discussion about the infrastructure of these geographic areas and existing health services. This association reflects the nature of multiple determination causes of infant mortality as a strategic indicator for achieving the much desired (but still distant) social development in Brazil. Not surprisingly, the reduction of IMR is one of the goals advocated by Brazil in the context of the Millennium Development Goals, MDGs (WHO, 2005).

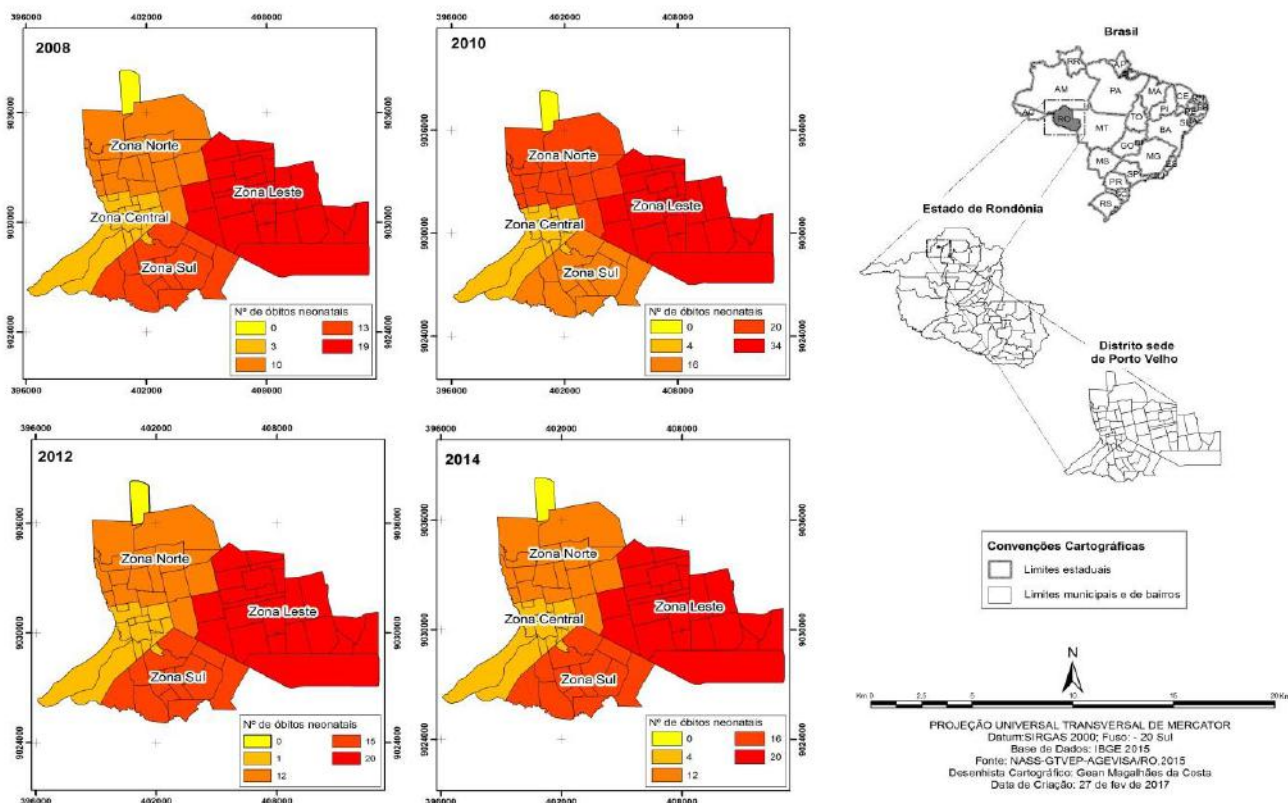


Fig.3: Distribuição espacial dos óbitos neonatal, por ano, segundo bairro de residência da mãe.

In this context, prenatal actions should be offered and carried out under the Basic-AB Attention in Family Health Strategy - ESF. This strategy is structured from the family health unit with multi-professional team, who is responsible for a population bound by it and develops promotion and preventive health care, treatment and rehabilitation of injuries. The city of Porto Velho currently has 19 primary care services, distributed in four zones (North, East, Central and South), 02 Basic Units without the Family Health Strategy and 17 Basic Units with the Family Health Strategy. Over this period, the city had 61 SF teams with a population coverage of 51% (SEMUSA, 2016). Among  $n = 432$  recorded deaths, the neighborhoods of the east side got the greatest records of births deaths alive with less than 7 days from preventable causes. The neighborhoods with higher incidence were aponia quarter (22), Socialist quarter (18), Mariana Neighborhood (16); Teixeira quarter (16) and Barrio San Francisco (15 Source: Santos et al, 2018.).

This aspect points to the need to enter the local territories and identify the details that lead to vulnerabilities that can

result in death in children less than year or even variations in the same territory.

From this, Figure 4 shows the geographical distribution in the city of Porto Velho of preventable neonatal deaths. 50.9% (220) of the total cases of deaths in the precocious neonatal period, were by preventable diseases that comprises the group.

In developing countries, more than nine million children die every year before birth and the first week of life as a result of complications during pregnancy. Many of these deaths are preventable. Overall, seven million women are affected by health problems related to pregnancy (YEGO et al., 2013).

In the northern region the impact is even greater by the lack primary health care service coverage and poor quality of the existing ones. According to the Quality Improvement Program of Primary Care (BRAZIL, 2017), the infrastructure of existing services and work processes are responsible for the low quality of care in this area, the discrediting of the front population to primary care model and the great looking to the medium and high complexity services.

Although not an objective of this study, the association made between the deaths in the precocious neonatal period and primary health care coverage area, showed that of the 59 neighborhoods with death records, only 18 (30.5%) are neighborhoods with coverage family health.

Souza and Melo (2013) state that one of the health care indicators that are linked to infant death is the coverage of the Family Health Strategy. This indicator is using as a variable in analyzes on the effects of AB on health conditions in the municipalities. In this respect it is possible to identify whether there was improvement in health indicators in relation to the degree of coverage.

The population coverage of family health teams was also used in other evaluations of the effectiveness of primary care in Brazil (Serra, 2004; PEIXOTO and ROCHA, 2008).

The findings lead us to reflect on the importance of family health coverage strategy and the impact that this cause in infant mortality. Taking into account that the practices developed by the SF teams are mostly focused on maternal and child health, it is clear that these indicators could be lower if there were more family health teams in the territories of the city's neighborhoods.

Neonatal mortality was high in this study, with an average of 83 deaths per 1,000 live births. In this group, the findings even more impressive when one realizes that in the precocious neonatal component (death less than 07 days), showed an increase of the coefficient of 6.4 in 2008 to 9.2 in 2015.

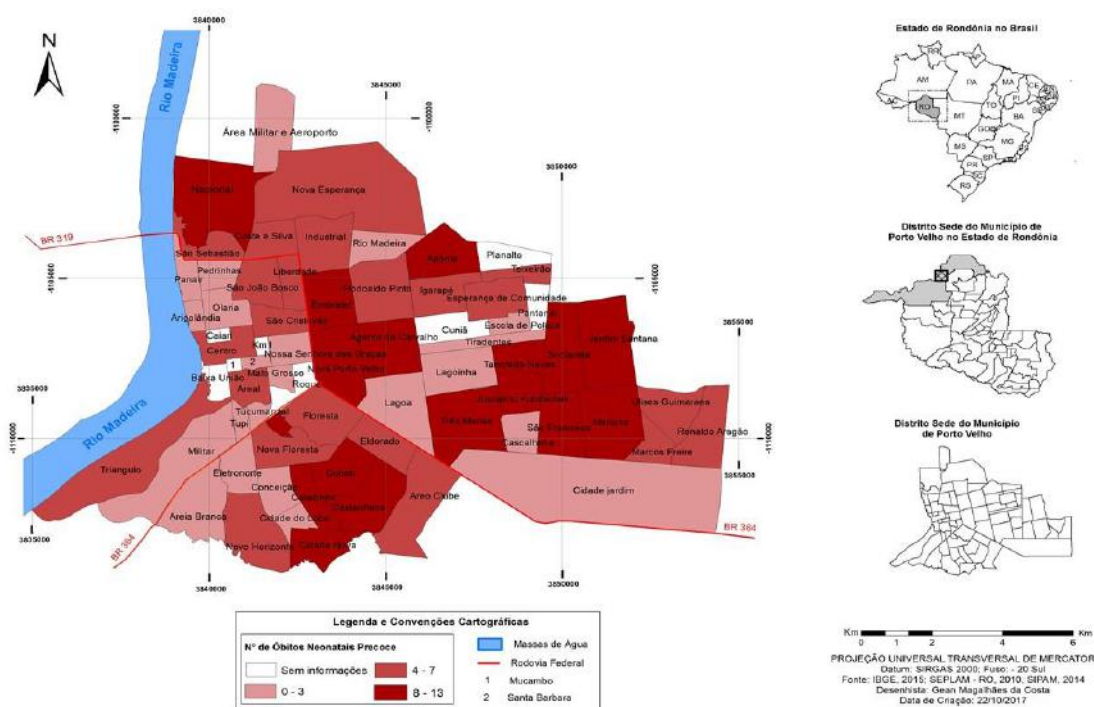


Fig.4: Spatial distribution of precocious neonatal deaths from preventable causes, according to the mother's residence. Source: Santos et al, 2018.

#### IV. CONCLUSION

The spatial distribution of infant deaths in the neonatal component enabled the identification of epidemiological patterns where most of the deaths occurred in this group

live births to mothers living in neighborhoods in the eastern part of the city of Porto Velho.

The results presented in this thesis indicate the need for improvement in the quality of information available on the

SIM for both neonatal deaths as precocious neonatal, and no major discrepancies between the dead and live births in the context of death in the perinatal period.

No entanto, a proporção de ausência de informação em campos referentes à escolaridade materna e antecedentes obstétricos, por exemplo, bem como a discordância e variabilidade para o campo duração da gestação, evidenciam a necessidade de sensibilização e capacitação continuada de toda equipe envolvida no fluxo da DO, desde seu preenchimento nas unidades assistências de saúde até a entrada dos dados no sistema de informação da secretaria de saúde, bem como dos gestores.

Another point to be discussed is the need for constant strengthening of infant mortality prevention committee and fetal development, especially regarding the death investigation, given the opportunity to enter or change information in the revised system. Despite the completeness of almost 96% found in the "underlying cause of death" between the perinatal deaths, the reliability evaluation or validation of the information contained in this field is not included in this thesis, therefore, additional studies to examine this information can help SIM qualification as a reliable tool for assessing perinatal deaths.

Since the precocious neonatal deaths occur in the 1st week of life, it is suggested the need to restructure the Stork municipal network, with investment in care for pregnant women and newborns. In addition, the network coverage expansion of maternal and child care, redefinition of geographical and population criteria to facilitate the access of pregnant women, mothers and newborns to this local network will contribute to the improvement of indicators.

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# Simulation Mechanism with 2 Degrees of Freedom

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**Abstract** — This article discusses the historical analysis of the development of simulators applied to aviation. From the development with the application of the first necessity, at the beginning of the 20th century, to the nowadays technology. Today the technology is used in several fields, justifying the increasing business investment destined to the sector, such as training, recycling, development and entertainment. Its advantage, compared to the real model, is the lower cost and greater security. Some simulator mechanisms were studied in order to select one that meets practical usage demands, and, in the end, a mechanism design is presented, aiming at the future construction and study of the different systems of a simulator in practice.

**Keywords** — Aircraft, Simulators, Design, 2DoF.

## I. INTRODUCTION

The advent of aviation brought the need to introduce practical and theoretical concepts for the future pilots. At first, those theoretical knowledges were developed in classrooms, with the complement of the practical part realized in real structures, susceptible to the risks and with high expenses.

The development of simulators, in order to replicate the actual conditions, came to supply this market demand. Capable of simulating not only everyday situations but also the most dangerous ones, avoiding the inherent risk and reducing costs.

Over the years the simulators have had their functions expanded and improved, movements have been linked, insertion of images and sensations, all in view of increased realism of the simulator.

And, even if it was developed with professional bias, today we have simulators on the market to meet the diverse ranges, from research and development to future aircraft, to the training and recycling of pilots and crew and even for the entertainment industry, being used for leisure.

The **Fig.1:** Current simulators with cab replication shows the appearance of current simulators, where it is replicated to the aircraft cockpit.[1]



*Fig.1: Current simulators with cab replication*

Thus, this article is divided into 8 chapters, which will be presented, after a brief introduction, a history on flight



simulators, aircraft main movements, types of systems and platforms, and a project, aiming to develop future drafting work of a complete simulator with all operating systems, with lower costs and safety.

## II. HISTORY OF SIMULATORS

Simulators are systems capable of simulating the behavior of some situation. Reproducing from physical sensations, to the output response, without the need for total element construction. Some aspects, however, require external components, such as those that respond by movement and perform speed sensations, or screens that copy visual stimuli.

In the specific field, aeronautical simulators are used since the first models for the training of pilots, however infidel the real conditions, as shown **Fig.2**, below. One of the first mechanisms developed was the Billing type, created in England in 1910, which was an airplane fixed on a universal joint, attached to the ground, and used for students to replicate the necessary movements and maintain balance in flight.[2]



Fig.2: Antoinette type simulator

Until the First World War, advances were restricted to mechanical components, which sought to replicate more flight situations, without the need for external factors, or help from other individuals. With the simulator, developed by Ruggles, as shown in **Fig.3**, which consisted of a ring-mounted seat that allowed the total rotation of the student on the three axes, besides vertical movement, produced in response to the user's movement through electric motors, this structure already allowed the simulation of aerial combat situations.[2],[5]

During World War II, the computer simulation had its great leap, both with the American Navy, with the *Mark I*, as with the army, with the *ENIAC*, using the computers, which were large and slow, of the time for simulation of missile launches.[3]

Simulators with visual systems date back to the late 1950s, where they used the cinema projection system, or closed-circuit television, with images recorded from a real

airplane. Even special instruments were used at the time in order to map the land, but the approach was not very practical and rather limited.[4]

Until the 1970s the production of simulators was extremely expensive, limited to large corporations and universities. The simulators of the time were limited not only by technology, but also by the workforce. Those responsible for develop, operate and maintain should possess thorough knowledge, which further becoming more expensive the project.[3]

Finally, in the 1970s, CGI (*Computer-Generated Imagery*) system began to replace the recorded images, but still in a very simplified and limited way by the processing of the computers of the time. Due to military necessity, which required more complex simulations, such as high-speed flights, attack situations and agile maneuvers, the CGI was further stimulated.[4]



Fig.3: Ruggles Advisor Simulator

In the 1990s, with the reduction of the equipment costs, increasing the processing capacity and simplifying the tools used in the development, the use of the simulators became more intense, being used as an efficient means to elaborate the projects, animations and research.[4]

The future will tend to raise the levels of complexity of the simulation, being even more flexible to deal with varied situations and not presenting problems to the user's decision, which would render their main function unfeasible: to replace, in the most realistic way, the real system.[3] The **Fig.4** presents a modern simulator, possessing total freedom of movement and visual system totally immersive.[6]





Fig.4: Modern simulator, with total freedom of movement

### III. AIRCRAFT MOVEMENTS

Any aircraft will rotate around its center of gravity on a flight and may therefore define the orientation of the aircraft by the amount of rotation along its three main axes, the Fig.5: Aircraft Rotation Movements below shows the movements of the aircraft.[7]

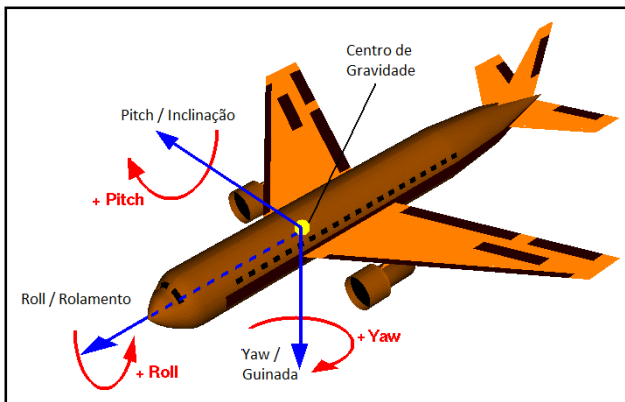


Fig.5: Aircraft Rotation Movements

The main movements are:[7]

- **Pitch:** is the movement around the transverse axis, which moves up, or down the aircraft;
- **Roll:** is the rotational movement around the longitudinal axis of the engine;
- **Yaw:** is the rotation movement around the vertical axis.

### IV. CLASSIFICATION FOR USE

The simulators are used in several segments, such as the design of new aircraft construction, civil and military training and, more recently, for the entertainment industry. The classification of the simulators is made considering: the subject, or the object to be analyzed; the simulation itself; or pilot-focused.[8]

- **Research and Development:** the simulators are used to determine the real perception of the reality that the system passes, seeking the improvement of the same. Branch that provides innovations to the area to search for the faithful representation of reality.

- **Engineering use:** the use in this field involves the development, or improvement, of an aircraft, using the simulator to analyze the behavior of the design phase from the idea to the production.
- **Use for training:** simulators used in training and retraining of pilots and teams.

## 1. SIMULATOR SYSTEMS

It is the various items that can compose a simulation mechanism, the greater the complexity, the greater the cost and the greater the reproduction of real conditions found.

### 1.1. Audio-visual system

A fundamental part for the user interaction with the simulator, composed of one or more image sources, sound system and flight replication software. Fig.6 presents the interface of one of the most used software developed by Microsoft.

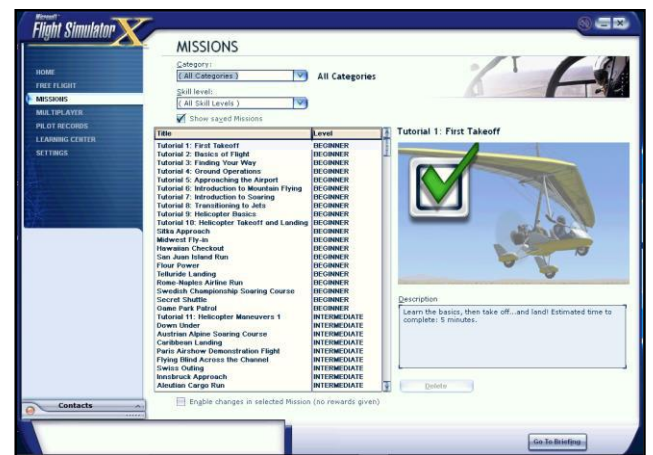


Fig.6: Flight Simulator-X Interface

### 1.2. Interface Systems

Performs the communication between the visual system and platform controllers. There are several programs that stand out in this functionality, the most used are Link2FS and ArdSim. Fig.7, below, presents the Link2FS settings screen.

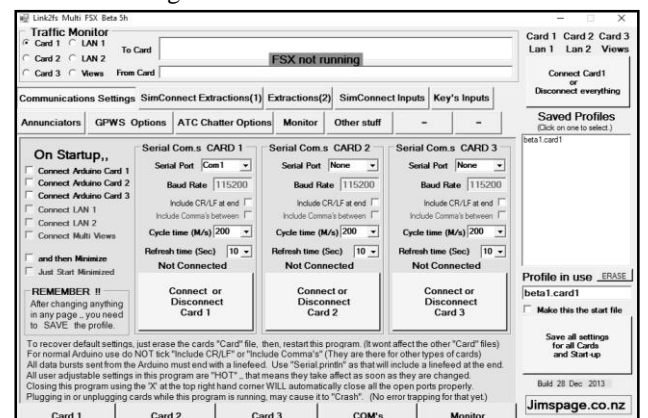


Fig.7: Link2FS Configuration Panel

### 1.3. Activation System

They are responsible for promoting the movement of the mechanism, responding to the user's command and replicating it.

### 1.4. Control system

They realize, through sensors and controllers, the movement of the activation system, in accordance with the command given by the user.

### 1.5. Structural System

They are the components that must withstand the design efforts, from applied loads, to the torque of the movement.

## 2. MECHANICAL SYSTEM

Some of the platforms on the market are presented in the topics below.

### 2.1 DIY Mini-Motion Platform

**Fig.8** shows the first model evaluated. It has 3 degrees of freedom: with pitch, roll and vertical translation.[9]

Mechanism consisting of a movable part, supported by a joint positioned in the center of gravity.

The translatory movement, obtained through the telescopic support, allows 85mm of total displacement, while the pivoting movements allow an angle variation between  $\pm 9^\circ$  for the pitch of  $\pm 13^\circ$  for the roll.[9]

This platform has its project totally available for construction, accessible through the internet.[9] However, details of ergonomics and reduction of expenditures with materials are the disadvantages seen in the mechanism.

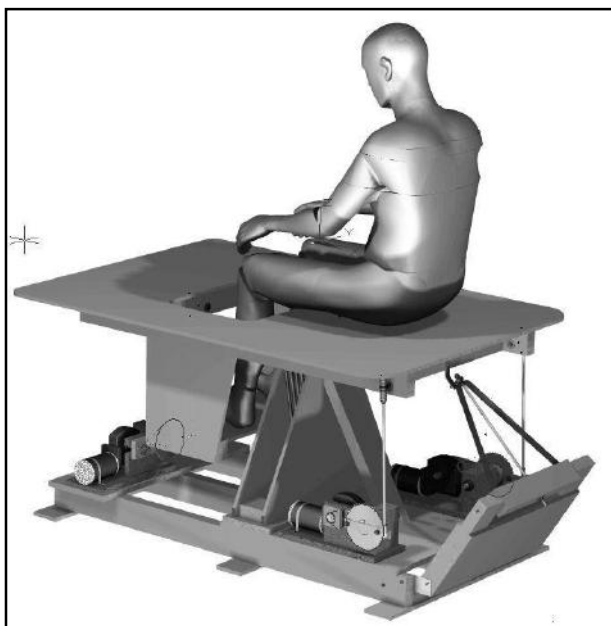


Fig.8: Simulation platform with 3DoF

### 1.6. Camps Party Platform

The simulator, shown in **Fig.9**: *Model in X*, presented in the CPBr5, presents the model seen in the Brazilian technological event, called the Campus Party edition number 5. This platform has 2DoF, making the movement of *pitch* and *roll*, with complete freedom of rotation with  $360^\circ$  turns in both cases. The load is supported by the shafts, which also transmit the torque from the drive.[10]

The major drawback of this simulator is the necessity that the components are fixed in structure and can be subjected to vibrations mechanism.[10]



Fig.9: Model in X, presented in the CPBr5

## 3. DEVELOPED MODEL

Considering the elaboration of a platform with cost-benefit and safety and the analysis of some existing models, a model was proposed, in order to be used later in a mechanism with the other systems.

The model of **Fig.10**, was designed in SolidWorks in order to lower expenses with materials and maintaining the freedom for the simulation.

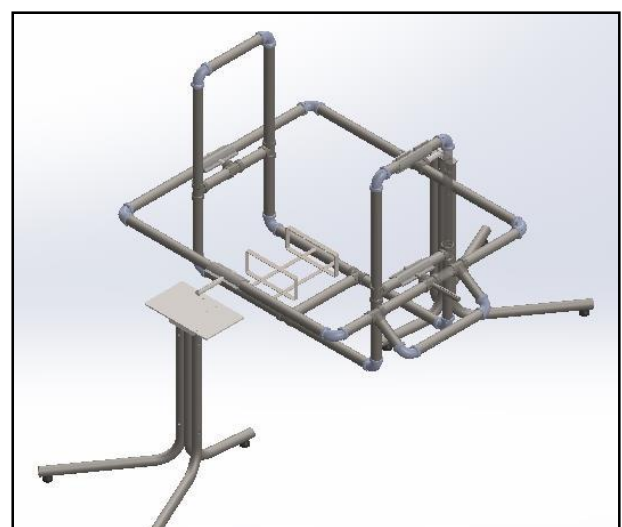


Fig.10: Platform with rings proposed

Based on a commercial ASTM A-36 steel frame, 2" and schedule 80. This choice was due to the structural

aspect, visual and ease of assembly of these components from their own connections, which would be connected through welding, or threaded.

National manufacturers' catalogs were used, in the case selected Comforja, both for dimensioning the tubes, from measures already established in the initial design, and for the dimensioning of the connections used.

It was used the standards ANSI B 36.10 for tubing thickness and external diameters and ANSI B 16.9 for the connections.[11]

There are 3 main parts, divided into:

- Support: promoting the support of the mechanism, with two tripods;
- External Ring: generates the rotation movement, around the axis, and simulates the pitch movement of the mechanism;
- Internal ring: generates the rotation, around the axis, and simulates the roll movement of the engine. It also supports the user and the audiovisual system.

The movements were limited mechanically  $\pm 40^\circ$  for *pitch* and *roll* as a safety measure and would already serve several real flight situations.

With a total of 3.5m wide, 2m long and 2 meters high. And it was designed for a user up to 1.80m in height and 150kg in mass.

It has the advantage, comparing that to the model of **Fig.9: Model in X, presented in the CPBr5** the fact of having its load carrier divided in 2 shafts, dividing efforts, in addition to a lower risk of tipping.

## V. CONCLUSION

The overall objective of the article was reached, where the platform, which will serve as the base of the simulator, was.

The mechanism was based on previous studies of other simulators, with the intention of producing one that is cheaper, safer and provides physical sensations in response to a visual system.

The further work should include the choices for the other constituent systems (visual, drive, control and interface), and numerical analysis to validate the effects of the loads imposed on the structural system.

## VI. ACKNOWLEDGEMENTS

The authors are very grateful to the PUC/MG (Pontifícia Universidade Católica de Minas Gerais), CNPQ (Conselho Nacional de Desenvolvimento Científico e Tecnológico), CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) and FAPEMIG (Fundação de Amparo à Pesquisa do Estado de Minas Gerais).

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<https://doi.org/10.1016/j.trc.2014.02.011>



# Productiveness Evaluation of a Machine Tool Manual Setup Compared with Automated CNC Machine

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**Abstract**— *The automatic tool change of machine tools affects the productive efficiency in several ways such as starving time reduction, increase/decrease of production rate as well reliability and reduce the process related costs of manufacturing. Based on that background an analysis of experimental scenarios of manual tool change versus automatic tool change was made in order to compare and evaluate its related production rate.*

**Keywords**— *Automation, CNC, machine tool, productiveness, tool change.*

## I. INTRODUCTION

Short for “computer numerical control,” CNC machining is a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. The process can be used to control a range of complex machinery, from grinders and lathes to mills and routers. With CNC machining, three-dimensional cutting tasks can be accomplished in a single set of prompts. CNC machines have been facing various applications where the automation is required. It can produce simple parts or complex parts through machining center computer integrated. Although the manufacturing processes require flexibility and complexity several attributes are achieved such as flexibility, accuracy, repeatability and consequently quality [1].

The improvements of machine tools in manufacturing processes had been developed to the purpose of increase productiveness without loss of quality and equipment downtime reduction due to human interface in the process. Setup time reduction have been used by manufacturers as a solution to increase productivity and reduce the related transformation costs. Nevertheless the setup time reduction is relevant due to three simple principles: (1) faster technologies of tool change reduce the probability of human error; (2) how lower is the setup time the production behavior becomes more dynamic; and (3) increase of machining saturation of the equipment [2]. Automatic tool change (ATC) integrated to the machining centers enables the reduction of non-productive time and allows tools availability to complex parts machining [3]. The purpose of this article is to evaluate the production rate considering the usage of the ATC concept by the comparison with manual tool change.

## II. THEORETICAL FRAMEWORK

Tool change time represents the total time to perform the operations independently if manual, semi-automatic or automatic. Some examples of operations are the approach, adjust, corrections and offsets. Therefore the manual tool change time calculation is made by the sum of time operation tasks that do not generate chip [4]. Automatic tool change is defined as the minimum interval required

to change tasks during the machining process that means the non-productive manufacturing time [5].

The machining cycle time is represented by the following equation.

$$T = C + T_{\text{machining}} \quad (1)$$

C = Tool change time

$T_{\text{machining}}$  = Machining time

The machining cycle time (1) is composed by the tool change (non-productive manufacturing time) and the machining cycle (productive time with chip removal). Considering the tool change time the sum of the individuals tasks up to the kth under the non-productive time, brings to the following equation.

$$C = \sum_{i=1}^k t_i \quad (2)$$

Nevertheless the range of chip removal time depends on the machining mechanism [6].

$$T_{\text{turning}} = \frac{L}{n f} \quad (3)$$

$T_{\text{turning}}$ : turning cutting process time (min)

L: part length (mm)

f: feed rate (mm/min)

n: revolutions per minute

$$T_{\text{drilling}} = \frac{L_d i}{n f_r} \quad (4)$$

$T_{\text{drilling}}$ : drilling cutting process time (min)

$L_d$ : hole depth (mm)

i: number of holes

n: revolutions per minute

$f_r$ : feed rate (mm/rev)

$$T_{\text{milling}} = \frac{L_d}{v_f} \quad (5)$$

$T_{\text{milling}}$ : milling cutting process time (min)

L: part length (mm)

$v_f$ : table feed rate (mm/min)

An appropriate way to estimate the productiveness rate among different kinds of machining is through hourly rate where the machining cycle is evaluated in one hour (60 minutes). Considering  $C_a$  automatic change,  $C_m$  manual change,  $T_a$  machining cycle time for automatic change,  $T_m$  machining cycle time for manual change and  $T$  as machining time, that is equivalent to all considerations, brings to the following analysis.

$$T_m = C_m + T \quad (6)$$

$$T_a = C_a + T \quad (7)$$

$$T_m - C_m = T_a - C_a \quad (8)$$

$$T_m - T_a = C_m - C_a \quad (9)$$

Based on the machining cycle time is possible to establish the productiveness ratio  $\sigma$  in parts per hour under the perspective of tool change.

$$\delta = C_m - C_a \quad (10)$$

$$\sigma = \frac{60 \frac{1}{T_m}}{60 \frac{1}{T_a}} = \frac{T_a}{T_m} \quad (11)$$

The combination of equations (9) and (10) generates to the following equation.

$$\sigma = \frac{T_a}{T_m} = \frac{T_a}{C_m - C_a + T_a} = \frac{T_a}{\delta + T_a} \quad (12)$$

### III. METHODOLOGY

The first step of methodology was simulate the tool change through a programmable device and then apply the theory mentioned before and its impact in the manufacturing productiveness.

In order to simulate the application of CNC machine to the quick tool change automation the LEGO NXT 9797 kit and an educational programmable robot were used to reproduce the environment studied.

To compare the tool change technology it was used a tool plan of a CNC tool with a tool change and machining time settle-up to drilling of  $\varnothing 8$  mm with drill change to  $\varnothing 10$  mm both in single step.

The following bill of materials were used during the experiment:

- 01 commercial aluminum hub with 100 mm edge;
- 02 HSS steel drill bits  $\varnothing 10$  mm and  $\varnothing 8$  mm;
- 01 drilling machine with 60 mm maximum drilling depth;

Parameters:

- 03 different operators;
- 02 holes and one drill change per operator;
- 03 measurements per operator, totaling 18 holes and 09 drill changes;
- Pre-drill hole with  $\varnothing 8$  mm exchange for  $\varnothing 10$  mm drill;
- Rotation at 1100 rpm;
- 02 chronometer.

**IV. RESULTS**

The following tables presents the each sequence measurements per operator.

Tab. 1. Operator #1 measurements

Seq.	Operator #1		
	$\sum_{i=1}^k t_i$	$\frac{L_{di}}{n f_r}$	$\sum_{i=1}^k t_i + \frac{L_{di}}{n f_r}$
1 <sup>a</sup>	0,750 min	0,833 min	1,583 min
2 <sup>a</sup>	0,700 min	0,700 min	1,400 min
3 <sup>a</sup>	0,766 min	0,616 min	1,382 min

Tab. 2. Operator #2 measurements

Seq.	Operator #2		
	$\sum_{i=1}^k t_i$	$\frac{L_{di}}{n f_r}$	$\sum_{i=1}^k t_i + \frac{L_{di}}{n f_r}$
1 <sup>a</sup>	0,566 min	0,400 min	0,966 min
2 <sup>a</sup>	0,500 min	0,283 min	0,783 min
3 <sup>a</sup>	0,616 min	0,366 min	0,983 min

Tab. 3. Operator #3 measurements

Seq.	Operator #3		
	$\sum_{i=1}^k t_i$	$\frac{L_{di}}{n f_r}$	$\sum_{i=1}^k t_i + \frac{L_{di}}{n f_r}$
1 <sup>a</sup>	0,750 min	0,316 min	1,066 min
2 <sup>a</sup>	0,600 min	0,300 min	0,900 min
3 <sup>a</sup>	0,683 min	0,250 min	0,933 min

The following table 4 describes the machining parameters of FAMAR CNC machine model SUB 160 2G 3 axis interpolated.

Tab. 4. Machining parameters of FAMAR CNC machine

Axis coord.	Machining description	Tool code	Tool material	Starving (min)
702, 703	drill Ø8	T2	MD	0,143
280, 281	drill Ø10	T2	MD	0,075
<b>Total time (min)</b>				0,218

The data collected applied in the equation (12) established the productiveness ratio between the manual tool change

with automatic tool change. These data are plotted in the following figure 1.

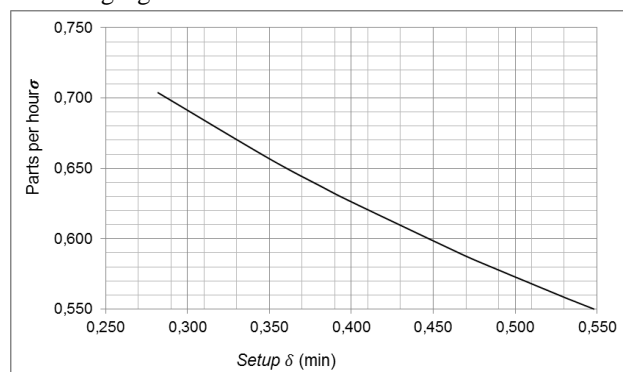


Fig. 1. Ratio between parts per hour ( $\sigma$ ) with setup time ( $\delta$ )

**V. CONCLUSION**

The ratio  $\sigma$  express the productiveness in terms of parts per hour under the manual setup perspective. It connects the manual setup with automatic setup in a way to extract the ratio between both environments there is a direct and proportional ratio between manual setup times with the need for automation of setup is verified by the results presented.

By the curve behavior interpretation the increase of difference between manual and automatic setup time results in decrease of hourly productiveness rate. Thus based on the math presented in this paper it is possible to estimate productiveness margin for both systems.

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# Analysis of Elastic Recovery in The Process of Bending Sheets of Duplex Steel SAF 2205 via Experimental Method and Numerical Simulation

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**Abstract**—The mechanical conformation is widely used in metal materials manufacture, being the bending process one of the most applied in the metal-mechanical industry. The material behavior analysis is important in this kind of process, since fabrication problems can compromise the final performance of bent components. During the bending process of metal sheets, the sheet undergoes a geometric variation after the withdrawal of the load. This effect, as known as elastic recovery, can be harmful when it is needed to fit two components with low tolerances. The comparative between elastic recovery problem analyses in folded sheets by numerical simulation and the experimental method seeks to anticipate possible inconveniences and additional costs during the try out tests. The numerical results are compared with the experimental laboratory tests. The contact and the interaction between the tool components and the sample boundary conditions are evaluated. Thereby, we consider the aspects necessary for modeling the elastic recovery in agreement with the experimental test, obtaining a very close result between the two methods.

**Keywords**— Bending, Elastic Recovery, SAF 2205, Numerical Simulation.

## I. INTRODUCTION

The bending forming process of sheet metal is one of the most applied in the metalworking industry. A large part of objects manufactured from sheet metal applies some kind of bending process (Sales, 2013). The elastic recovery consists of dimensional and geometric changes in the material. Those changes happens due to the withdrawal of the mechanical stresses necessary to perform the plastic

deformation. This phenomenon depends of several factors, such as friction, lubrication conditions and operation geometric characteristics. However, aspects related to the material structural characteristics, such as the micro structural arrangement of the sample in terms of constituents and phases, grain size, possibility of possible phase transformations during the stamping cycle itself, among others, also seem to influence the results, since in the plastic deformation occurs the hardening of the material, providing increase of resistance (Sales, 2013). Fig. 1 illustrates the main parameters associated with a single process: the bend radius  $R$ , is generally expressed in multiples of the thickness, the bend angle  $\alpha$ , the fold width  $b$  and the thickness of the sheet  $t$ .

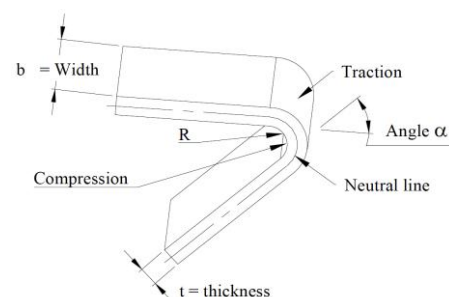


Fig. 1: Main parameters in sheet bending

The elastic recovery and the tooling involved in the manufacture of bending parts are important concern in the final dimension components design. They directly influence in productivity and costs. The increasing demand of automotive industry, which requires the increasing in use of steels with high mechanical strength, has led to an increase in the use of advanced high strength steel (AHSS)



as working material (Schaeffer, 2004). The increase in the material flow stress decreases its formability and increases the elastic recovery. For this paper were performed tests of SAF 2205 material as received and after a heat treatment at 1050°C (Martins and Forti, 2008, pp. 162-166). The elastic recovery effect is one of the main factors that determines the final shape of the product, if it is not properly controlled it can affect the accuracy of the product. The present work evaluates the comparative elastic recovery of the experimental process using the mathematical modeling ABAQUS/CAE 2017 software of stainless steel SAF 2205 in V bending.

Duplex stainless steels are characterized by the presence of ferritic-austenitic biphasic structure (hence also referred to as austenitic). This leading to good combination of the properties of homonymous stainless steels, such as good corrosion resistance and toughness and high mechanical strength (Sales, 2013). These alloys currently represent an important class of materials and have been widely used in several sectors some example are the chemical, petrochemical and nuclear industries (Michalska and Sozanska, 2006, pp. 355-362).

In terms of chemical composition, duplex stainless steels have chromium and nickel contents ranging from 17% to 30% and from 3% to 13%, respectively, as presented in Table 1 (Krauss, 2005). It is important to emphasize that the steel SAF 2205 or UNS 31803 (0.03% C maximum, 21.00% -23.00% Cr, 4.50% -6.50% Ni, 2.50% -3.50% Mo; 0.10% -0.22% N) is the most used duplex stainless steel in industry nowadays, corresponding for about 80% of the world production of austenoferritic stainless steels.

Table.1 – Chemical composition of the material used and SAF 2205 technical specification, Wt %

Element	C	Cr	Ni	Mo	Mn	Si
Material used	0,026	22,67	5,32	3,02	1,85	0,37
Technical specif.	0,03	21 23	4,50 6,50	2,50 3,50	--	--

Despite the advantages when compared to other groups of stainless steels, a number of technical limitations are observed in austenitic steels, especially in relation with thermal cycles or thermo mechanical processing during manufacturing operations. These limitations are associated to the possibility of development of secondary phases, which would lead to the loss of properties, such as reduction in corrosion resistance and toughness (Fargas, Anglada and Mateo, 2009, pp. 1770-1782). The compounds presented in these secondary phases are carbides, nitrides and intermetallic compounds.

The technological clarifications due to scientific foundations in the bending process area are relatively new. Bending is an operation where a metal is folded, during this process the outer surface is drawn and the inner surface is compressed. These tensions increase from a neutral internal line, reaching the maximum values for traction in the outer layers and the maximum value for compression in the inner layer (Moro and Auras, 2006, pp. 24-27).

Once the bending effort has ceased the part of the section that has been subjected to tensions below the proportionality limit tends to recovery to the initial position, this phenomenon is called elastic recovery (Moro and Auras, 2006, pp. 24-27). Some material sections are submitted to tensions below the proportionality limit because it has stayed in the elastic region.

In the material deformation zone only the elastically region is capable to recovery. This phenomenon is very common in the bending process, it happens when the energy is redistributed for the entire piece through the internal balance, which generally causes a distortion in the material geometry, specified in the project. Therefore, the final shape of the piece do not depends only from the geometry of the die / punch assembly but also from the amount of elastic energy accumulate. Quantifying this portion of energy is a difficult task because it is influenced by many factors, including the adopted material model. On the other hand, an accurate prediction of the elastic recovery helps to size the tooling still in the design phase avoiding the trial out step and also error during the manufacture and final assembly of folded components (Sales, 2013). Several methods have been proposed to quantify or evaluate the elastic recovery of metals in sheet bending. A common method of elastic recovery intensity analysis is the determination of the K index. In this method is used the angles before and after the elastic recovery  $\alpha_i$  and  $\alpha_f$  or the radius  $R_i$  and  $R_f$ , according to Equation 1 (Dieter, 1981). Other techniques consider the relationship between the radius before and after the relief of the bending force. Among these methods, some also involve information on the characteristics of the material, such as modulus of elasticity, hardening exponent and Poison's coefficient, among others (Dieter, 1981). The mentioned approaches can be observed in Equations 2 to 4.

$$K = \frac{\alpha_f}{\alpha_i} = \frac{R_i + t/2}{R_f + t/2} \quad (1)$$

$$\frac{R_f}{R_i} = \frac{180 - \alpha_f}{180 - \alpha_i} \quad (2)$$

$$\frac{R_i}{R_f} = 4 \left( \frac{R_i L_E}{E t} \right)^3 - 3 \left( \frac{R_i L_E}{E t} \right) + 1 \quad (3)$$

Where  $E$  is the modulus of elasticity of the material determined by the tensile test.

$$\frac{R_i}{R_f} = 1 - \frac{3k(1-\nu^2)}{(2+n)0,75^{(1+n)/2}} \left( \frac{2R_i}{t} \right)^{(1-n)} + \left[ \left( \frac{2R_i}{t} \right) \left( \frac{k}{E} \right)^{1/(1-n)} \right]^3 \times \left[ \frac{3(1-\nu^2)^{(3+n)}}{(2+n)0,75^{(1+n)/2}(1-\nu+\nu^2)^{(2+n)/2}} - \frac{(1-\nu^2)^3}{(1-\nu+\nu^2)^{1,5}} \right] \quad (4)$$

Where  $k$  is the coefficient of resistance,  $n$  is the harsh exponent and  $\nu$  is the Poisson coefficient.

In general, the occurrence of spring back effect in metallic materials can be only controlled or minimized, since its complete elimination is considered extremely difficult (Abdullah at al, 2012, pp. 195-205). In order to minimize this phenomenon usually it works with a radius of curvature smaller than the planed one, so after the stress relief the elastic recovery inputs the final radius and it will be similar to the radius previously planned (Dieter, 1981). Once that the magnitude of the elastic recovery is known, the sheet can also be bent at large angles than required. In addition to the techniques mentioned, which may need to perform many tests, since they are empirical, there are other methods described in the literature. Some of these procedures are the application of high compressive forces, performing stretch and bend process at the same time and performing bend operations at elevated temperatures, since the slump in the yield stress leads to a reduction in the elastic recovery (Tekiner, 2004, pp.109-117).

## II. EXPERIMENTAL PROCEDURE

The V bending matrix tests were performed in a hydraulic press using the tool developed at a  $90^\circ$  angle  $\alpha$ , the opening of the bending cavity was 20mm and all tests were extended until the contact of the specimens with the surface internal of the V regions of the matrix. Subsequently, the force is interrupted, the specimen is withdrawn and the angle  $\alpha'$  is measured with the aid of a degree transfer. The punctures rays ranged from 2 to 10mm with intervals of 2 mm. Each specimen measuring #1.9 x 19 x 49mm (Sales, 2013).

The specimens were taken from SAF 2205 sheets as received after a heat treatment at  $1050^\circ\text{C}$  (SAF 2205TT), with a 60 minute soak time and cooled in the air, in order to remove eventual characteristics printed by previously mechanical process. It is important to point out that this process was performed without promoting the development of intermetallic compounds (especially in the case of duplex stainless steel). The schematic drawing of the tooling and sheet is shown in Fig. 2.

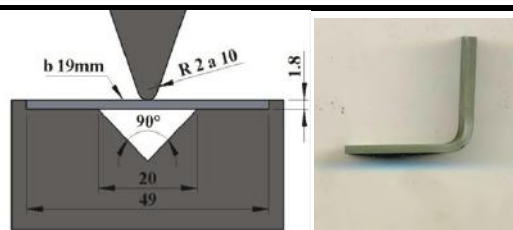


Fig. 2: Schematic drawing of the tools for bending of V-sheets and part sheet.

The analysis by mathematical modeling had used the same tooling profile with punch / sheet / matrix interaction with friction coefficient of 0.2. The punch and matrix were considered completely rigid. The deformation in full were attributed to the sheet. The elastic and plastic deformation parameters were defined in tensile tests and performed in the material as received (SAF 2205) and after suffer heat treatment (SAF 2205TT), according to table 2.

Table 2: Mechanical Properties of Duplex Steel SAF 2205 obtained from the tensile tests

Material	Elastic Module	Elastic Limit	Tensile strength	Strain $\epsilon$	Coefficient Poisson
SAF 2205	175GPa	620MPa	806MPa	25%	0,29
SAF 2205 TT	170GPa	525MPa	754MPa	38,5%	0,29

For the contact between components, the contact algorithm was applied. It was chosen suitable parameters with a large refinement mesh in this contact region. In Fig. 3 is shown the mesh of the expanded matrix / sheet / punch assembly with its symmetry planes. The matrix and punch materials are considered rigid.

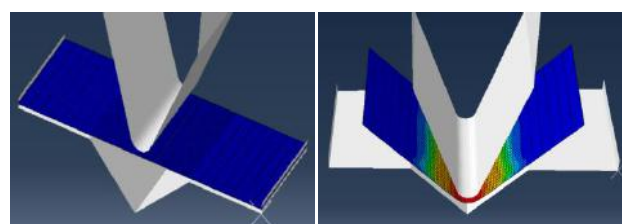


Fig. 3: Shell mesh for the finite element modeling.

In the modeling of the bending process a displacement in the punch is imposed. Thus, when the applied loading is removed the sheet assumes the punch and matrix geometry without happens the thinning of the thickness. After apply the loading, the stresses initially load are removed, leaving the sheet geometry with the shape of the new deformation. After this step the boundary conditions are applied to allow the recovery. The sheet material is considered completely elastic.

The initial displacement and recovery steps are repeated for all punch radius settings (2, 4, 6, 8 and 10mm), changing the properties of the materials according to the tensile curves of the two specimens evaluated (as received and after the heat treatment at 1050°C).

### III. RESULTS AND DISCUSSION

The outer bending surface of all parts was analyzed taking in consider the test conditions and the two states of the SAF 2205 material, as received and after the heat treatment (SAF 2205TT). According to the technique conducted, no cracks or other irregularities were observed resulting from the bending process. In terms of the materials characteristics, the material as received is the one with higher chance of cracking, since it still be influenced by the effects of previous mechanical operations (for example, hardening). In terms of the bending conditions, smaller bending radius represents the situation considered more critical, because they concentrate the greater tension in a smaller area, reaching values close to the tensile strength limit of the material.

Fig. 4 shows the distribution of the Von Mises equivalent stress on the sheet as received for the punch with radius R10 mm. This case corresponds to the end of loading and it can be noted that only the central region is in contact with the punch. It presents high stress levels reaching 759MPa, confirming the reason for no cracking on the external surface, since the values do not exceeded the material resistance limit. The major difficulty in this step was to ensure the convergence of the simulation due to the contact between the parties.

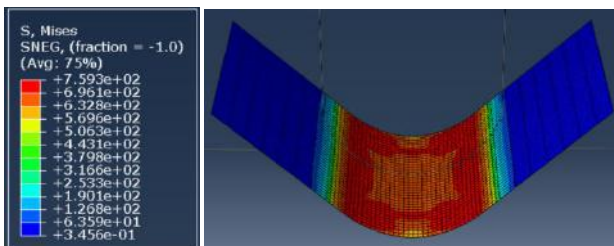


Fig.4: Sheet mesh R10 totally loaded.

After the displacement has been made, the punch return and the geometry of the sheet was evaluated by measuring the difference of angle  $\alpha$  ( $90^\circ$ ) with  $\alpha'$ . Fig. 5 corresponds to this new model and presents the distribution of the equivalent stress after the elastic recovery. In this case, there was a redistribution of the stress and their maximum values decreased to 432 MPa.

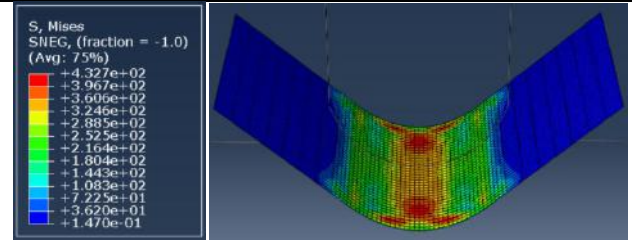


Fig.4: Sheet mesh R10 without loading.

For this specific simulation the value of variation of  $\alpha$  after the withdrawal of the load was 346 minutes showing the action of the elastic recovery in the bending process. All results are described in Table 3.

Table.3: Differences between experimental and simulated angles in the elastic recovery of SAF 2205 and SAF 2205TT

Radio (mm)	$\Delta (\alpha-\alpha')$ min Simulation	$\Delta (\alpha-\alpha')$ min Experim.	$\Delta (\alpha-\alpha')$ min Simulação TT	$\Delta (\alpha-\alpha')$ min Experim.TT
2	309	340	254	235
4	315	345	270	240
6	320	367	306	267
8	330	392	320	302
10	346	420	324	337

Table 3 shows the values filled according to the bending radius for each condition of the analyzed material. It was verified that the increase in the bending radius raised the elastic recovery angle for both materials. The elastic recovery phenomenon became clearer for the SAF 2205 material as received in both situations, numerical and experimental tests. The differences between the numerical and experimental simulation increased as the bending radius raised from 9% to 18% in the 2 and 10 respectively, as shown in Fig. 6 for the SAF 2205 material.

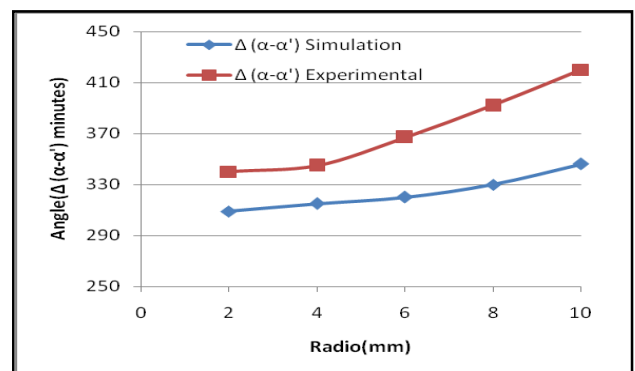


Fig.6: Radius x elastic recovery SAF 2205.

Similar to the previous data, the SAF 2205TT steel maintained the same tendency to increase the elastic recovery as the bending radius was increased. However, it presents a total inversion between the numerical

simulation and the experimental test, showing the numerical simulation values higher than the SAF 2205, except for the 10mm radius. The elastic recovery differences in the SAF 2205TT steel were much lower when we compared both procedures, the fluctuations was between 4% and 12%, shown in Fig. 7.

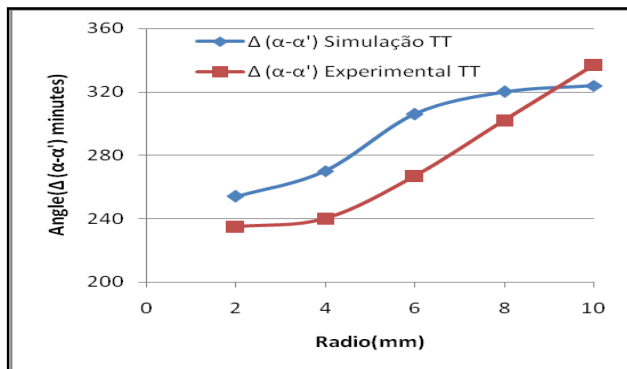


Fig.7: Radius x recovery elastic for SAF 2205TT.

The influence of the bending parameters on the elastic recovery phenomenon is an expected fact. This influence is constantly investigate for different materials and situations. The thickness of the sheet, bending radius, bending angle and width of the aperture of the matrix are indicated as the main geometric operation characteristics that can affect the results (Sales, 2013). Considering the approach of the present study, almost all the results obtained are in agreement with the literature, since it was observed that the increase in the puncture radius promotes an increase in the elastic recovery. Similar observations were presented in previous studies (Tekaslan, Seker and Osdemir, 2006, pp. 251-258).

In relation to the characteristics of the material to be formed, the flow limit and the modulus of elasticity are generally mentioned as the most significant parameters that affect the phenomenon of elastic recovery in bending (Tekiner, 2004, pp.109-117). The work suggests that a decrease in yield stress would lead to a reduction in the spring back effect (Tekiner, 2004, pp.109-117). On the other hand, smaller values of elasticity modulus would induce an increase in elastic recovery (Dieter, 1981). So the results presented in Figs. 6 and 7 are in agreement with previous studies. The parallel between the data obtained for the material as received with the one presented by the thermally treated material, associated, with lower flow limits, shows that the decrease in tension cited led to a reduction in elastic recovery. The data recorded from the material as received is affected by the hardening due to the previous plastic deformation during the sheet manufacturing process, so it will exhibit a higher flow limits (Table 2),

#### IV. CONCLUSION

In general, the numerical approach developed for both test conditions for the SAF 2205 steel were satisfactory, since they obtained results consistent with the experimental process and the reference literature. The elastic recovery phenomenon increased with the puncture radius and with the variation of the material properties.

The differences between numerical simulation and experimental testing were acceptable, with an average floating of 8%. This difference demonstrates that this method can be used as a reliability and cost reduction in the design of bending tools, since much of the time spent on try outs can be reduced with the bend angle correction been determined using the numerical simulation.

The same procedure can be applied in case where geometries are more complex, when an analytical solution or high cost in the experimental test makes impossible perform try out tests.

#### ACKNOWLEDGEMENTS

The authors gratefully thanks CEFET-MG and PUC-MG for assistance in the publication of this paper.

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# Conjectures of Mathematical Logic and Educational Games for Basic Education Based on the Guidelines of NCP, NCG and NBC

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**Abstract**— *Current technological advances allow us to create, adapt or simply use numerous resources to achieve improvements in teaching-learning. The purpose of this article is to show the result of an analysis of the current normative documents and recommendations for national education in Brazil (National Curricular Guidelines - National Curricular Parameters and National Common Curricular Base), primary and secondary education, regarding the contents recommended in mathematical logic, complementing with the analysis of a pedagogical political project of the fundamental education of a public school, to verify the existence of this content, in it. From this analysis and reflection on the importance of educational games in teaching, the article proposes the development of an educational game especially to assist in teaching the functionalities on the symbols of logic. It highlights the contribution of this game to the teaching-learning of these rules and symbols and, finally, concludes by showing the importance of this activity in the educational process.*

**Keywords**— *Logic. Teaching in Logic. Educational Games.*

## I. INTRODUCTION

The purpose of this article is to present the results of an analysis of National Curricular Parameters (NCP), National Curricular Guidelines (NCG) and National Curricular Basis (NCB), in primary and secondary education, regarding the recommendations of contents for mathematical logic. It was also analyzed a political pedagogical project of the fundamental education of a public school, as to presence of mathematical logic contents, which had as reference for its elaboration, the National Education Documents mentioned above. The Federal Constitution of 1988, in its article 210,

establishes that "minimum contents for primary education should be established, so as to guarantee basic homogeneity education and respect for cultural, artistic, national and regional values." This is ratified in the National Education Guidelines and Bases Law (law 9.394/96) and later official documents, such as the National Curricular Parameters (NCP) and the National Curricular Guidelines (CNG). CNG are mandatory standards, set by the National Education Council (NEC), which guide the curricular planning of schools and education systems. They address early childhood education, primary education, secondary education and teacher training. NCP are only curricular references (recommendations).

The Curricular National Base (CNB), in preparation since 2015, finally emerged in December 2017, in compliance with article 210 of the Federal Constitution of 1988. The document deals with early childhood education (kindergarten and pre-school) and elementary education (1st to 9th year). The NEC will discuss in another moment the curricular base of high school. CNB will now be the national benchmark for schools to develop their pedagogical projects. The Base does not exclude the official documents mentioned above. From the analysis of the contents, we want to base the importance of educational games in the teaching of mathematical logic and to elaborate a project of an educational game specially for teaching the rules and symbols of mathematical logic. It will not be approached the argument of the mathematical logic, as far as the rules and concepts of the premises and conclusions of a logical mathematical argumentation, the work will be focused only in the functionality of the symbols of the mathematical logic, contemplating an interdisciplinarity between the disciplines

of Arithmetic, Statistics and Mathematical logic. (MEC, 2018).

The importance of educational games in primary and secondary education. Our experience as teachers allows us to conclude that educational games play a fundamental role in the student's development in the following areas: social interaction, cognitive, political and cultural development. Students who, because of shyness or other reason, do not interact with the teacher or classmates, find in games the opportunity to break down these barriers, develop their skills, become more participative, and even formators of opinions and ideas in the classroom educational and social interaction.

Curricular Parameters (CP), National Curricular Guidelines (NCG) and National Curricular Basis (NCB), in primary and secondary education, regarding the recommendations of contents of mathematical logic. It was also analyzed a political pedagogical project of the fundamental education of a public school, as to the presence of contents of the mathematical logic, which had as reference for its elaboration, the National Education Documents mentioned above. The Federal Constitution of 1988, in its article 210, establishes that "minimum contents for primary education should be established, so as to guarantee basic education and respect for cultural, artistic, national and regional values." This is ratified in the National Education Guidelines and Bases Law (law 9.394/96) and later official documents, such as the National Curricular Parameters (NCP) and the National Curricular Guidelines (NCG). NCG are mandatory standards, set by the National Education Council (NEC), which guide the curricular planning of schools and education systems. They address early childhood education, primary education, secondary education and teacher training. NCP are only curricular references (recommendations).

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mathematical argumentation, the work will be focused only in the functionality of the symbols of the mathematical logic, contemplating an interdisciplinarity between the disciplines of Arithmetic, Statistics and Mathematical logic. (MEC, 2018)

This is especially recommended for high school NCP in relation to games in the educational environment. In our research we find in the descriptions of the NCP high school the following text: "Games and child play are very valuable elements in the process of knowledge appropriation. They allow the development of competences in the field of communication, interpersonal relations, leadership and teamwork, using the relationship between cooperation and competition in a formative context.

The game offers the stimulus and environment conducive to the students' spontaneous creative development and allows the teacher to broaden their knowledge of active teaching techniques, developing personal and professional capacities to stimulate in students the ability to communicate and express themselves by showing them new way, playful and enjoyable and participatory, to relate to the school content, leading to a greater appropriation of the knowledge involved. Using games as a pedagogical tool is not restricted to working with ready games, in which rules and procedures are already determined; but mainly, to stimulate the creation by the students of games related to the themes discussed in the context of the classroom. Content suitable enough to create games with students is the content related to the thematic unit."(BRASIL, 2000)

*Table.1: Existence of mathematical logic content in elementary education*

NCB	NCP	NCG
It does not cite directly mathematical logic. It cites in a very generic way the computational technology.	It does not cite directly mathematical logic. It cites in a very generic way the computational technology.	It does not cite directly mathematical logic. It cites in a very generic way the computational technology.

Source: MEC, 2018.

Analysis of the recommendations and obligatoriness regarding the existence of mathematical logic content, for elementary and secondary education. According to Table 1, the comparison of the existence of the content of mathematical logic in the national education documents is presented and in Table 2 the contents of mathematical logic for High School.

Table.2: Existence of mathematical logic content in high school

NCG	NCP	High school PPC in a public school
It does not cite directly mathematical logic. It cites in a very generic way the computational technology.	Mathematics validates and presents its knowledge, as well as fostering the development of deductive logical thinking and the more structured aspects of mathematical language. To assert that something is "true" in Mathematics usually means to be the result of a logical deduction, that is, to prove an affirmation (theorem) one must show that it is a logical consequence of other previously proved propositions.	It does not cite directly mathematical logic. It cites in a very generic way the computational technology, it has as base for the teaching the contents of the didactic books, that also are not specific, as far as the content of the mathematical logic.
	Informing and informing oneself, communicating, expressing oneself, arguing logically, accepting or rejecting arguments, expressing preferences, pointing out contradictions, making proper use of different nomenclatures, different codes and different means of communication are general competences that make part of the resources of all the disciplines, and that, therefore, they must develop in the learning of each one of them.	

Source: MEC, 2018.

## II. THE PROPOSAL (GAME IN TEACHING THE FUNCTIONALITIES OF THE SYMBOLS OF MATHEMATICAL LOGIC)

The proposal is the design and development of an educational game, to aid in the teaching of the functionalities of the symbols of the logic of mathematics and indirectly in the teaching of statistics.

The fundamental element, in spoken or written language, is the simple proposition formed by a name and a predicate. So when we say "Mars is a planet" we have a proposition, where "Mars" is a name or designation and "is a planet" is the predicate or attribute. Every proposition has one of two values, "false" or "true," there being no other, which is called the principle of the excluded third. From simple propositions we can form others, using the connectives "and", "or", "if ... then", "if and only if" and or exclusive, represented by the symbols,  $\wedge$ ,  $\vee$ ,  $\rightarrow$ ,  $\leftrightarrow$ ,  $\vee$ , respectively. We can also use the modifier "no" (not true), represented by the symbol  $\neg$ , for the creation of new propositions (ALENCAR FILHO, 2002).

The game works with the symbols of mathematical logic

$\wedge$  (e),  $\vee$  (or),  $\rightarrow$  (if ... then)  $\leftrightarrow$  (if and only if),  $\neg$  (no) and  $\vee$  (or exclusive). It has the following functionality: for the symbol  $\wedge$ , called conjunction, the result of an operation is true, only if the two values assigned to the variables are true, in other cases the result will be false. For the symbol  $\vee$ , called disjunction, the result of an operation will be false only if the two values assigned to the variables are false, in other cases the result will be true. For the symbol  $\rightarrow$ , called conditional, the result of an operation will be false, only if the second value is false; in other cases the result will be true. For the symbol  $\leftrightarrow$ , denominated biconditional, the result of an operation will be true, only if the two values assigned to the variables are false or true, in other cases the result will be false. For the symbol  $\vee$ , called *or unique*, the result of an operation is true only if the two values assigned to the variables P and Q are different, if these values are equal, the result will be false. Figures 1 and 2, below, show the configuration of the values of the variables and results, according to the logical connective.

Variable	Variable	Conjunction	Disjunction	Conditional	Biconditional	Exclusive Disjunction
P	Q	$P \wedge Q$	$P \vee Q$	$P \rightarrow Q$	$P \leftrightarrow Q$	$P \vee Q$
V	V	V	V	V	V	F
V	F	F	V	F	F	V
F	V	F	V	V	F	V
F	F	F	F	V	V	F

Fig.1: Configuration of variable values and results.



Variable	Negation
P	$\neg P$
V	F
F	V

Fig.2: The modifier for values of variables (negation).

The game consists of presenting the mathematical logic symbols for the player's choice and can be played by one or two players and a mediator. The Functionality of the game. After the player chooses a (connective) symbol, it is presented to the variables (P and Q) with the values of V (true) or F (false), so that he decides what the answer is, for the situation presented. After the answer, you are presented again with the variables (P and Q), now with some of the possible changes of their values (V or F), and so on, until the player chooses to stop at the end of the game when it is presented the performance summary (duration, number of hits, number of errors per symbol chosen and overall).

Conjunction (AND) ( $\wedge$ )			Disjunction (OR) ( $\vee$ )		
P	Q	R	P	Q	R
V	V	?	V	V	?
V	F	?	V	F	?
F	V	?	F	V	?
F	F	?	F	F	?

Fig.3: If the choice was conjunction (AND) or disjunction (OR).

Example: If the choice was the conjunction, mediator would present the options to the player to answer V (true) or F (false), according to Figure 3.

### III. RESULTS AND DISCUSSION

The contribution of this game to teaching and learning is to enable the student to develop logical reasoning, from learning the rules of the symbols of mathematical logic, so that the student will know the logical functionality, and when he has to learn mathematical logic in its fullness, rules, concepts and applicability, will already be familiar with the functionality of the symbols of logic, facilitating the acquisition of knowledge consistently and productively. This game can be applied to students in the 6th grade of elementary school onwards, with estimated time of one hour-class, for explanations of the rules of functionality.

Materials needed to apply the game are: a sheet of paper, a pen, a clock and a mediator or whiteboard, a brush and a clock. The time needed for who determines is the player or the players: it can be one minute, two minutes and so on. At the end, the mediator shows the game summary and makes the statistical calculations (duration of the game, number of

errors, number of correct answers), and can use the following parameters: to find the index of errors, for example, make the quotient of the number of errors by the number of operations played, to find the ratio of hits divides the amount of hits by the amount of operations played and to find the average response time of each player's operation, divides the player's used time by the amount of operations. The implementation of this game requires a programming language and a database to store the information of the game and the players. In the implementation, the statistical summary calculations would also be demonstrated.

The game was applied to a group of 25 (twenty-five) elementary students and 28 (twenty-eight) high school students, the achievement result in the understanding of mathematical logic was excellent, it was noticed that students understood the dynamics of the game, although there was some difficulty in understanding and memorizing the meaning of some symbols ("if ... then" and "if only") in the class of primary school students, but after the application of three exercises, the difficulties of understanding the rules of functionality and concepts of values, were overcome and the average achievement was 75% of correct answers with high school students and an average of 70% of correct answers, with elementary students. Overall the result was very good, considering that the subject is little explored in the textbooks currently adopted.

### IV. FINAL CONSIDERATIONS

From the researches, on educational games, proposed in the NCP, and on-site verification, we noticed that the practice of using educational games is little used by teachers, and that this practice should be more applied in classrooms, helping the teacher in working with students who present difficulties in learning. The classes would become much more dynamic, the acquisition of knowledge would have better rates of achievement and the student would feel much better able to learn what he is studying. There is a need for better preparation of education managers to motivate and assist teachers in the preparation and elaboration of intuitive and deductive games as aids in the acquisition of student knowledge. From the time that teachers start to use educational games more in classrooms without departing from the proposed objectives for the subjects, the level of learning will certainly be better and other educational indices may also improve. Often the student becomes a quitter because he feels unable to learn.

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# Practical Based Learning (PBL) for Academic, Technological and Scientific Education in Engineering Courses - Case Study

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**Abstract**— *The increase in the number of students evaded has alerted different segments of society and the public sector to the need to update the guidelines of engineering courses as well as innovation in teaching engineering. In this sense, the objective is to report on the challenges of engineering education in Brazil and the methodological strategies that have been adopted for the modernization of the curricula of engineering courses and consequent reduction of the indicators of avoidance and withdrawal. In addition, involving the use of the 43 academic academics of the University of Cruz Alta (Unicruz) who studied the discipline of Research Methodology in the second semester of 2017 through the Problem Based Learning (PBL) strategy as an innovative strategy education. Finally, in addition to the production of a technical material produced throughout the course, it was observed that there were only 2 students in 1 failed exam, demonstrating that teaching by PBL has high effectiveness for academic achievement in the discipline of research methodology.*

**Keywords**— *Agronomic Engineering, Civil Engineering, Environmental and Sanitary Engineering, Production Engineering, Research Methodology.*

## I. INTRODUCTION

The quality of education at different levels of schooling has been the object of analysis and studies in different parts of Brazil and the world in the attempt to understand the dynamics, the challenges and propose technically and economically viable solutions considering the different elements that make up the relations and [1;2]. In this scenario, a series of analysts, scholars and researchers have

emerged who, considering the national policies for education in Brazil in the different spheres, seek to outline the profile and needs of the different agents of education, considering the social, economic and, more recently, as strategies to establish pedagogical practices in a more effective, economically viable, and socially acceptable way in order to form politically aware citizens and, at the same time, to form active agents of transformation in their social context in what concerns the improvement and guarantee of the quality of life of the citizen subject [3;4;5;6;7;8].

In any case, the elements of social interaction that establishes teacher-student relations in higher education have undergone profound transformations, requiring a new look at the dynamics of higher education in the face of the technological and behavioral advances that have become more pronounced since the advent of was digital [4;6;8]. In this scenario, the understanding of didactics as a resultant competence of the psycho-intellectuals-emotional attributes inherent to the teacher in the establishment of the dialogue and transmission of knowledge in the academic-teacher relationship had to be re-discussed and contextualized to the contemporary demands resulting from the profound social and technological transformations that is determining the new dynamics in higher education [1;2;4;5]. In this context, the aim of this study is to present a brief report on the challenges of engineering education in Brazil and the methodological strategies that have been adopted for the modernization of engineering curricula at the University of Cruz Alta - Rio Grande do Sul. discipline of Research Methodology for undergraduates of the engineering course for the adoption

of Problem Based Learning (PBL) as an innovative teaching strategy.

## II. METHODOLOGICAL PROCEDURE

Based on the proposed objective, this case report is characterized as a descriptive research. In order to evaluate the learning efficiency of the discipline of scientific methodology applied to engineering courses, it was considered the income throughout the discipline in face-to-face activities, distance activities, presentation of scientific technical topics in disciplinary meetings, preparation of a technical study project to the work axes of agronomic engineering courses, environmental and sanitary engineering, civil engineering and production engineering. The period of study coverage occurred between 2014 and 2017, involving 430 academics in the engineering courses of the University of Cruz Alta. For the evaluation of undergraduates' technical project presentations, professors from other applied disciplines of the engineering courses were invited at the end of each semester. In each class had enrolled around 30 to 40 undergraduates for each Professor responsible for teach class pertinent contents to the scope of the Research Methodology.

In order to guarantee only the evaluation of the pedagogical strategy based on PBL, we compared the academic performance of undergraduates submitted to this didactic methodology, were compared with the academic performance of graduating from years prior to the application of this pedagogical strategy. Evacuation indicators were also considered among the classes as a way of evaluating the acceptance of undergraduates with the pedagogical strategies characteristic of PBL.

## III. RESULTS

According to Campos and collaborators (2015), active learning using problem-based teaching methodology (PBL) is configured with a promising alternative in the development of the teaching / learning process for engineering content [9]. In this methodology it is necessary that the student must learn to solve problems of his professional area within an interdisciplinary vision, which in turn favors the ability to develop skills and abilities and teamwork. The difference of this methodology in comparison to the methodology traditionally adopted in most of the higher education institutions in Brazil is due to the fact that the student is the main responsible for his / her own knowledge, stimulating to incite to the pro-activity of the academic [9;10-14].

In this sense, the case report involved 430 engineering undergraduates from the University of Cruz Alta (Unicruz) who studied the Methodology of Research Classes among year of 2014 up to 2017. This group was submitted to the pedagogical strategy based on PBL as an innovative

strategy of teaching the from the second two-month period by the formation of 90 teams in which the academics elaborated a review of the technical literature of nine topics of interest of the professional formation of the engineer having as reference the techniques and concepts of research methodology seen in the first two months of classes and deepened in the course of group reviews. In addition, it was agreed that the manuscripts would be evaluated by teachers of the engineering courses, subjecting them to the need to prepare for the oral presentation.

In addition to the involvement of academics, it was verified through the evaluation report sent by the Permanent Evaluation Committee (CPA) that 83.87% of the academics said they were very satisfied with the methodology adopted in the discipline. In addition, academics pointed out in the report offered by the CPA that they preferred the PBL-based method adopted during the 2nd quarter, that the traditional and passive teaching-learning model adopted during the first two months. The main results of these changes should be highlighted the results obtained and the high frequency after the adoption of the PBL and, at the same time, there was a reduction of 82.5% in the number of absences between the 1st and 2nd bimester and better utilization in multiple-choice tests, in which the average between the two-month period rose from  $6.55 \pm 3.15$  to  $7.95 \pm 1.43$ , respectively. In addition, the academics prepare a presentation and manuscript that had been submitted to the I Prointec - Show of Integrative and Technological Projects of Engineering as part of the evaluation of the discipline. Finally, in addition to the production of a technical material produced throughout the course, it was observed that there were only 20 students in exam 10 failed.

When compared to indicators of avoidance and repatriation related to the classical pedagogical approach, based only on the observation of the content taught by the teacher, the writing of evasion was verified in 84.5%. While the number of disapproved in the discipline was 92.5%. In this sense, it is possible to affirm that the pedagogical strategy based on learning by previously defined projects (PBL), allowed the greater involvement of the academics and, consequently, greater use in conceptual terms and, mainly, in the reduction of academic avoidance in the discipline.

## IV. DISCUSSION

According to Thomas Tredgold (1788-1829) he defines engineering as "the art of directing the great sources of energy of nature for the use and convenience of man" [14]. In this way, engineering courses are characterized by their high content of disciplines related to physics, mathematics and chemistry that demand a high degree of abstraction, associative and correlation capacities for the understanding



of natural phenomena and reproduction in a technical and optimized way for generation of a good and understanding of the phenomena that involve a chain of production [5;13].

At the same time, there has been an increase in vacancies in engineering courses in distance and hybrid education throughout the country, as well as in the number of students who have escaped, making higher education institutions, the Ministry of Education (MEC) and National Confederation of Industries (CNI) warned about the limited number of engineering academics and the need for engineers as a strategic professional in promoting economic, industrial and social growth in the country. The Brazilian Engineering Education Association (ABENGE), in association with the Business Innovation Movement of the National Confederation of Industry (MEI / CNI) and the Federal Council of Engineering and Agronomy (CREA - Confea), presented in January 2018 to the National Council of Education (CNE), a proposal for guidelines for engineering courses containing a series of notes on engineering curricula for the twenty-first century, going through the need for constant updating and methodological innovations for engineering teaching considering the social and technological advances that have been modifying the academic-teaching relations and that guarantees the technical and leadership formation for the conduction of the Brazilian productive sector [14].

The practice in teaching in higher education requires constant updating by the teacher and the institution and patience and high motivational skills and conflict management [1;3;5;7].

Conflict management is due to the fact that new students enter full of expectations and with almost no emotional resilience to situations of frustration characterized by difficulties of following the content inherent to the teaching-learning process of more complex contents, a debatable educational base due to the structure of education received at previous levels and the lack of persistence in staying motivated and assimilating the new contents because they demand an effort and disposition for the study that is not necessary for the proper formation, and not only the information of a given content [1;3;4;11]. Consequently, the lack of maturity and difficulties commonly faced throughout university life has led academics, mainly engineering academics, to give up or abandon their courses [5;12].

In this context, the adoption of methodological strategies adapted to the demands of the engineering courses becomes indispensable for the formation and maintenance of the academic of engineering during the 5 years of academic life. In this way, the courses of continuous training, extension, lato sensu and stricto sensu are the channels for the constant updating of the teacher to meet expectations, to solve and to circumvent academic

conflicts as part of the strategy to reduce evasion, abandonment and better utilization in order to be able to use the knowledge and skills of the future engineer [11;12;13].

## V. CONCLUSION

Finally, the teaching practice as a capacity for transfer and construction of knowledge in a regulated, motivated and technically oriented way that allows the technical and scientific training appropriate to the professional contexts in which the student, future professional, will find in the day-to-day job market. As far as engineering academics are concerned, it has been verified that in addition to a good average demand for pedagogical complementation of chemistry, physics and mathematics in the initial semesters, it is also the responsibility of the teacher and institution to constantly monitor the deficiencies of academics, constant updating of management strategies people to cope with the different generations who seek and reach higher education and continuing education of the teacher in order to remedy the deficiencies of the academic ones as the technical content is ministered from techniques and pedagogical tools like the PBL in the context of the discipline of Research Methodology for Unicruz engineering academics. With regard to public policies and curricular guidelines, there is a movement to update engineering curricula in the face of technological advances and that is more adapted to current and future generations of digital native academics.

## ACKNOWLEDGEMENTS

The authors are grateful to the managers of the University of Cruz Alta for technical and financial support for the development of this study.

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# Design and Development of a Magnus Hydrokinetic Rotor

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**Abstract**— *The energy matrix diversification has become noticed in the latest years. Energy conversion of the free flow in rivers and canals into electrical energy has been a good complementation for the conventional generation. The first application of hydrokinetic turbines, commercially, were in Mississippi's river (Minnesota, USA), in 2008. The usage of Magnus effect in hydrokinetic turbines occurred in an innovative manner. In this project, rotational cylinders actuate as blades of an axial hydrokinetic rotor, converting kinetic energy of the flow into potency in the rotor axle. This effect was initially observed in 1853 by Henrich Magnus and, since then, few researches were carried out to its application in hydraulic generation of energy. Therefore, tests in reduced-scale prototype and numerical simulations were made for the development and executive design of a hydrokinetic rotor. At the end of this study, a hydro generator with 62% hydraulic efficiency, considering the Betz Limit, was constructed.*

**Keywords**— *Magnus Effect; Energy Generation; Numerical Simulation.*

## I. INTRODUCTION

Magnus effect was discovered in 1853 by the German physicist Heinrich Gustav Magnus, from University of Berlin (Reid, 1997). This phenomenon can be observed when axisymmetric bodies start rotating in a flowage. Thus, following the no-slip condition, one layer of the fluid is displaced in the same rotational direction of the body. This movement in the rotational direction is transferred to the slightly posterior layers, what changes the pressure distribution next to the body, generating lift.

In 1920 the first notable application of the Magnus effect was carried out, by Anton Flettner, for Buckau's propulsion, a ship whose masts were rotational cylinders of 13 meters height and 2.7 meters diameter, with a rotational speed of up to 125 rpm. The masts were spun by electric motors, generating a resultant propulsion force that made Buckau capable to cross Atlantic Ocean in 1926 (Prandtl, 1925; Vieira, 1961).

In 2010 Magnus effect was employed in E-Ship1. This ship is used for the transportation of aero generators blades, and the effect had provided a reduction in fuel consumption of 30 to 40% (Wobben, 2010). An advantage of Magnus effect is that, depending on the work conditions, much larger lift forces are attainable when compared to those developed by conventional profiles with the same dimensions (Vieira, 1961).

The application of Magnus effect in hydraulic turbines hasn't been much studied yet, or, at least, not much disclosed. There's few literature about this theme – there is more literature about its application in aerogenerators (US 20070046029 A1, 2007), maritime propellers (Bergeson & Kent Greenwald, 1985), tennis (Goodwill, Chin, & Haake, 2004), golf and baseball (Nagami, Higuchi, Nakata, Yanai, & Kanosue, 2016) ball's deflection and its behavior on flowpast a rotating cylinder (Badr, Coutanceau, Dennis, & Mnard, 1990; Karabelas, 2010). Therefore, in this study established through the companies ELETROSUL and Institutos LACTEC, it was developed a contextualized approach about how this phenomenon manifests in water, identifying a potential application in the commercial electrical energy generation perspective.

Since its origin, hydrodynamic was very connected to direct investigation, experimentation, standing out the usage of aerodynamics tunnels as methods of trialling different wing's profiles. The main goals in theoretical and experimental studies were always to obtain the highest lift-drag ratio (Huang, Cheng, Chen, & Hsu, 2011; Tokumaru & Dimotakis, 1991; Vieira, 1961; Yen, San, & Chuang, 2008; Zhang, Wang, Lu, & Mi, 2005). For instance, Karabela (Karabelas, Koumroglou, Argyropoulos, & Markatos, 2012) studied the influence of the cylinder rotating speed on lift and drag coefficients, finding that the best aspect ratio, defined as the ratio between the circumferential velocity of the cylinder and the free-stream velocity, is 2.

Different diameters cylinders were employed in this study, which allowed the designation of the best aspect ratio, ratio of length to radius, in view of a future application. The

experimental results are compared to the theoretical obtained through the use of the equations based on the Kutta-Joukowski theorem.

Subsequently to the theoretical and the cylinders' studies, separately, tests were performed in a reduced-scale model, as well as in numeric simulations to establish the best geometric arrangement of the device.

## II. MATERIALS AND METHODS

Usually, the main goals of the aerodynamic profile's studies are the enlargement of the lift coefficient and the reduction of the drag coefficient. The choice of one model of profile, between various existent types, is normally done using a curve that relates lift coefficient (CL) with the drag coefficient (CD) and varying the angle of attack (Mannini, Marra, Pigolotti, & Bartoli, 2017; Robertson, Wedding, Peterka, & Cermak, 1977), which can be defined as the inclination of the profile in relation to the flow direction. Naturally, a cylindrical profile doesn't have an angle of attack that can be modified, as in a wing profile, being the lift of the cylindrical profile usually obtained as a consequence of a rotation that is inferred to the cylinder and changes his circulation.

Therefore, based on the Kutta-Joukowski theorem, the lift per unit of length (L) of a cylinder can be determined by the equation (1) (Lugones, 2011):

$$L = \rho_{\infty} \cdot V_{\infty} \cdot \Gamma \quad (1)$$

Where,

$L \rightarrow$  lift force per unit of length [N/m];

$\rho_{\infty} \rightarrow$  specific weight of the fluid of the free flow [kg/m<sup>3</sup>];

$V_{\infty} \rightarrow$  speed of the free flow [m/s];

$\Gamma \rightarrow$  circulation [m<sup>2</sup>/s].

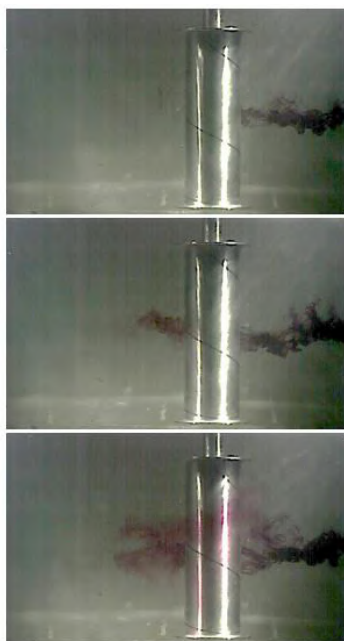


Fig. 1: Photo sequence of flowage's visualization by dye injection

The circulation is a scalar quantity associated to the vorticity. Fig. 1 presents an image sequence of the experiment discussed in this work, wherein can be verified, through the dye injection method, the circulation of the fluid around the rotational cylinder.

Mathematically, the circulation is given by (2) (Anderson, 1991):

$$\Gamma = \oint \vec{v} \cdot d\vec{s} \quad (2)$$

With,

$\vec{v} \rightarrow$  speed along a streamline [m/s];

$d\vec{s} \rightarrow$  infinitesimal length of a streamline [m].

Thus, in (1), integrating from 0 to  $2\pi$ , the equation (3) of the circulation around the cylinder (Munson, Young, & Okiishi, 2004) is obtained:

$$\Gamma = 2 \cdot \pi \cdot \omega \cdot r^2 \quad (3)$$

With,

$\omega \rightarrow$  angular speed [rad/s];

$r \rightarrow$  cylinder radius [m].

Hence, replacing equation (3) in (2), the lift force of the cylinder per unit of length can be obtained.

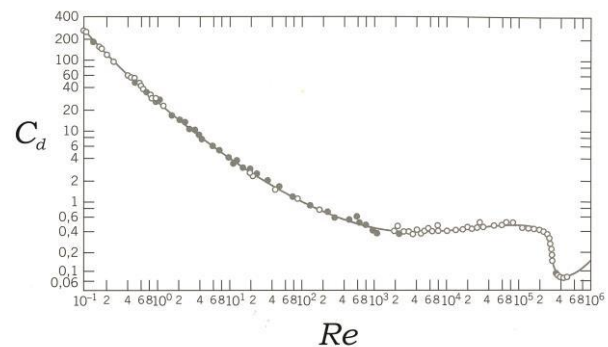


Fig. 2: Drag coefficient, as a function of Reynolds number, for a smooth cylinder (Anderson, 1991)

The drag on a body that moves through a certain liquid can be comprehended as a quantity of restriction force to its free movement, which increases along with the relative speed between the body and the fluid.

The D'Alembert Paradox (D'Alembert, 1768) establishes that the drag on a cylinder placed in the interior of an ideal fluid (not viscous) is null, due to the balance of forces established as a result of the flow uniformity along the symmetry that exists between the two parts of the cylinder. However, the results obtained experimentally oppose the Paradox, once any real fluid have viscosity which will originate, due to the existent shear forces between the fluid particles, drag forces on the cylinder.



In such manner, the drag force on a cylinder is obtained, classically, by means of the equation (4), using an experimental coefficient educed from the curve presented in Fig. 2.

$$F_a = \frac{1}{2} \cdot \rho \cdot A \cdot V^2 \cdot C_d \quad (4)$$

With,

$F_a$  → drag force [N]

$\rho$  → fluid specific weight [kg/m<sup>3</sup>];

$A$  → area [m<sup>2</sup>];

$V$  → relative speed between the fluid and the body [m/s];

$C_d$  → drag coefficient;

$Re$  → Reynolds number;

$\mu$  → dynamic viscosity [Pa.s];

$D$  → cylinder diameter [m].

The drag coefficient ( $C_d$ ) is obtained from an experimental curve that sets up a correlation between the coefficient values and the Reynolds number.

### III. EXPERIMENTAL DEVELOPMENT

The experimental development was based on the construction of an arrangement for the measurement of the perpendicular forces, drag and Magnus (lift), which actuate on the rotational cylinder. The experiment was performed in a canal whose flow rate was able to be controlled. The forces measurement arrangement, utilized on the trial, was fixed on the systems base, as in Fig. 3.

Therefore it became possible to measure the active forces on each one of the six cylinders employed, whose characteristics are shown in Table 1.

The nomenclature was defined as (C) for cylinder and subsequently the number, which represents the increasing order of the diameter. The (R) presented in C3R represents the knurled surface of the cylinder, whose goal was to evaluate the influence of the roughness on the Magnus effect as well as on the drag.

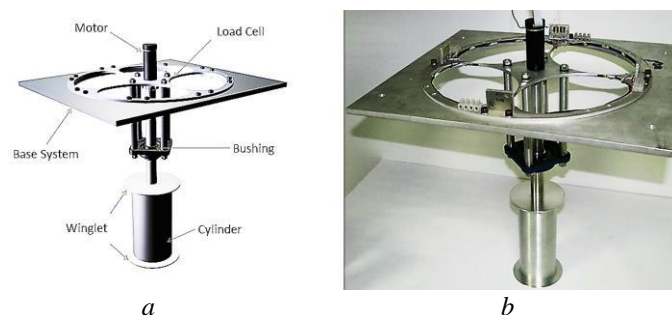


Fig. 3: Measurement arrangement.

(a) Schematic image, (b) Photograph of the constructed load cell.

Table 1: Data table of the studied cylinders

Nomenclature	Length (mm)	Diameter (mm)	Aspect ratio
C1	200	33.20	12.05
C2		48.95	8.17
C3		63.55	6.29
C3R		63.55	6.29
C4		76.90	5.20
C5		100.70	3.97

Thus, two cylinders with same diameter were built, one with a smooth surface and the other with a knurled surface.

$$a = l/r \quad (5)$$

Where:

$a$  → aspect ratio (dimensionless);

$l$  → cylinder length;

The tests were carried out varying the following parameters:

- 1) cylinders' angular speed;
- 2) diameter;
- 3) water flow velocity;
- 4) roughness.

According to the equation (6), as smaller the cylinder radius is, greater should be the angular speed in order that, in a flow of constant speed, the specific rotation is remained constant.

$$\alpha = \frac{\omega \cdot r}{V_\infty} \quad (6)$$

Where,

$\alpha$  → specific rotation [dimensionless].

Thus, the experimental procedure was comprehended as the establishment of the canal's water level in 300 mm and, in condition of no flow, the definition of the force measurement system ground zero, eliminating other variables as thrust. After resetting the load cell with no water flow, the next step was to open the input valve and establish the adequate flow rate to reach a stipulated velocity, first of 0.2 m/s and then, similarly, of 0.4 m/s.

Previously to the test's beginning, with the cylinder in stationary condition, a sample of Magnus and drag forces' values was recorded. Afterwards, the measurement system was reset once more, though this time in presence of flow, in order to establish the ground zero on Magnus force and, also, a measured value of drag. This measured value of drag force, obtained in presence of flow and without rotation, was added up to each case obtained subsequently, with rotation. That was made because, before obtaining the measurement for each rotation, the system was reset,

suppressing the portion of drag existent without rotation. Nevertheless, the values of residual Magnus force existent, obtained in presence of flow and without rotation, were discounted in each case, maintaining so the coherence of measurement's purpose.

After the experiment in the tests channel, several warheads geometries were simulated with the software Star CCM+. The aim was to define which model presents the lowest drag. With the constructive parameters determined, the hydro generator was designed and built.

#### IV. RESULTS AND DISCUSSIONS

Fig. 4a presents values of Magnus and drag forces for each cylinder, with a flow velocity of 0.2 m/s and distinct rotating speeds. It's important to notice that the curves presented in the figures are the tendency of a cloud of points collected from the measurement system. It could be observed that C1, besides inserting a great vibration to the system, can also provide low values of forces, for both Magnus and drag, what requested a refined treatment of this data, keeping, however, a random error inserted in its final results. Otherwise, the same wasn't found in the other cylinders. Therefore, it was verified that the usage of a cylinder with a larger diameter solved the vibration's problem.

Fig. 4b shows the Magnus and drag forces values, for each cylinder in flow velocity of 0.4 m/s and different rotation speeds. Analysing this figure, a difference in the forces applied on the cylinders is noticeable when compared to the forces plotted in Fig. 4a. It's clear that this alteration occurs due to the increase of the flow velocity, which means: Magnus and drag forces are functions of the flow speed.

It's noticed, in Fig. 4a, that Magnus force have a slight increase in C3R when compared to C3, but this behavior changes for 0.4 m/s flow, conform presents Fig. 4b.

On account of the greater coherence of data for larger flow velocity, from this point forward more emphasis will be given to the data collected with 0.4 m/s of velocity in the canal.

The specific rotation gives an idea of relative speed between the tangential velocity, in the cylinder external surface, and the velocity of free flow. This correlation suggests a pressure difference between the two counter faces of the cylinder, perpendiculars to the flow. Thus, that would be the origin of Magnus force, whose maximum value should be the same for two identical diameter cylinders in the same rotation or specific rotation. Particular comparison was made for cylinders C3 and C3R, of equal diameter, which differentiate just by the fact that

the C3R have a knurled surface, which, in turn, propitiates a greater rugosity in comparison to C3. The curves plotted in Fig. 5 present the values of CL and CD, as a function of the specific rotation, for the two cylinders.

Fig. 5 shows that C3R have a maximum lift force value with a specific rotation of 6 (720 rpm), dissimilar to cylinder C3, in which the lift force appears around 5 (610 rpm). To obtain an equal lift value, the cylinder C3 needs a lower rotation and, there so, presents a smaller consumption in comparison to C3R, which clarifies that, in this experiment, rugosity diminished the system efficiency.

It should be highlighted that, as well as a wing have tendencies that repeat in scale, the cylinders have very near tendencies. That is, it also repeats in scale. Thus, all cylinders present similar behavior which varies, in most part of the time, only in module. This fact is evidenced by the data obtained from the different cylinders and, even more, by C3R's behavior, which is slightly different in consequence of its dissimilar rugosity. C3R would be the one cylinder, in the present study, that doesn't vary its behavior only in scale. This tendency is more evident when CL and CD are analyzed, which are presented in Fig. 6 as a function of the specific rotation, for a 0.4 m/s velocity.

One more time, it is evident the difference between the C3R and the others. Through the analysis of the graphics in Fig. 6 - except for C3R - the specific rotation expected for the maximum CL stayed very close to five, whereas for C3R it was around six.

Other carried out analysis was the evaluation of the resultant between Magnus and drag forces, supposing that both are actuating in the same direction with opposite orientation. In this case, it is observed that the Magnus and drag forces are perpendicular to each other and were subtracted, just as a form of assess which cylinder presents better relation between these two forces.

From the comprehensive indicators of Table 2 and Table 3, the operational rotation speed, for a greater resultant force per cylinder, doesn't coincide with the maximum Magnus force, remaining in all cases at a slightly lower rotation.

In Table 2 and Table 3, for a criterion analysis, adopting the cylinder four (C4) as example, it's verified that in maximum Magnus force, which occurs in this case at 540 rpm, the resultant between Magnus and drag had a modulus of around 0.34 kgf. However, the highest difference between Magnus and drag doesn't occur coincidentally with the maximal rotation, presenting a 440 rpm value to achieve the maximum resultant force.

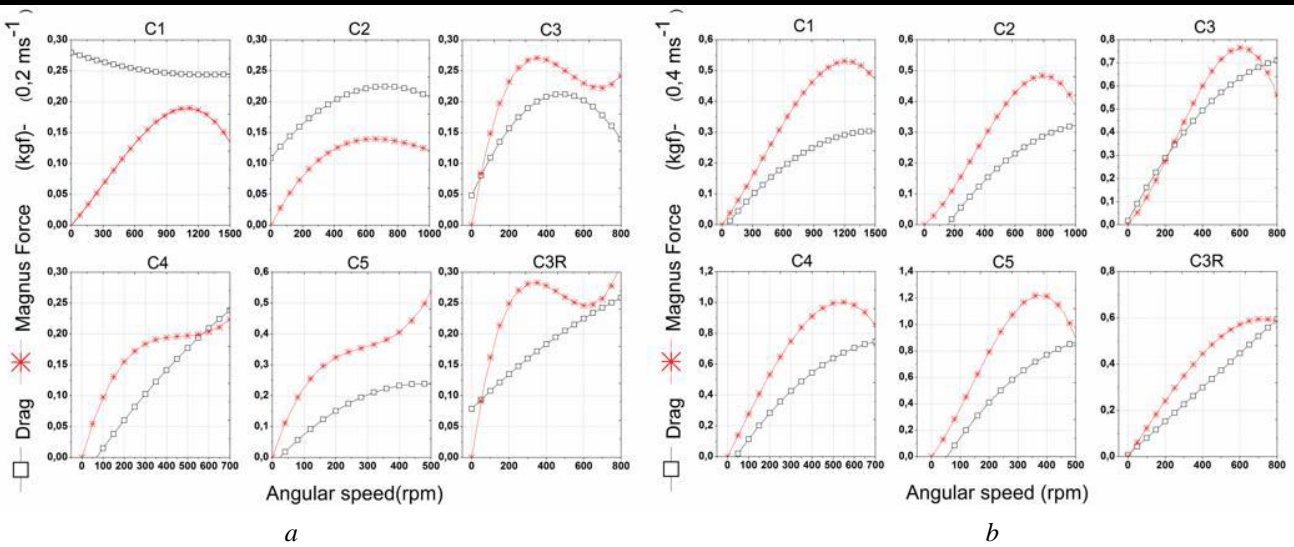


Fig. 4: Graphics of drag and Magnus forces for different flow velocities.  
 (a) Measured for 0.2 m/s, (b) Measured for 0.4 m/s.

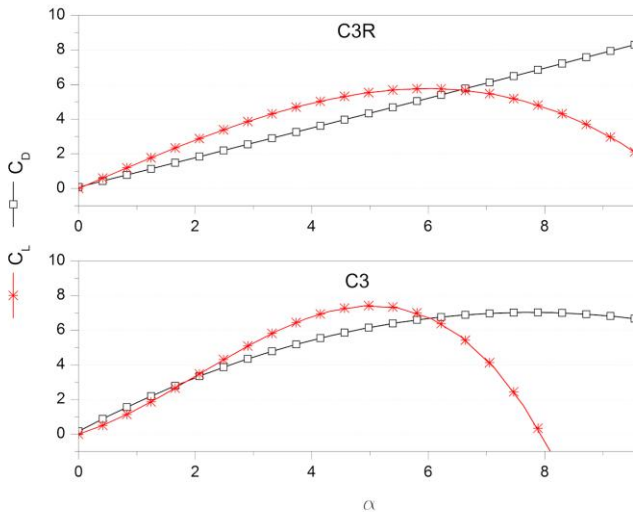


Fig. 5: Variation of  $C_L$  and  $C_D$  under different specific rotations, for C3 and C3R.

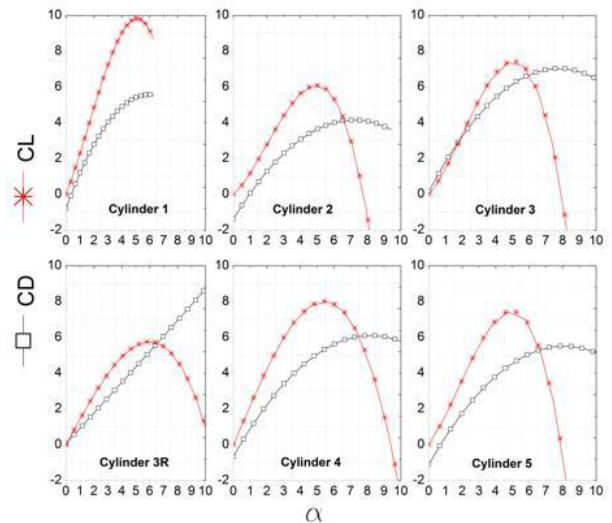


Fig. 6: Coefficients  $C_L$  and  $C_D$  in a flow velocity of 0.4 m/s.

Table 2: Difference between maximum lift and Drag forces

Nomenclature	Rotational speed (rpm)	Difference $F_{Lmax} - F_D$ (kgf)
C1	1220	0.24
C2	790	0.20
C3	610	0.13
C3R	720	0.06
C4	540	0.34
C5	380	0.48

Table 3: Maximum difference between lift and Drag forces

Nomenclature	Rotational speed (rpm)	Difference $F_L - F_D$ (kgf)
C1	1150	0.25
C2	700	0.21
C3	530	0.15
C3R	460	0.15
C4	440	0.37
C5	330	0.52

Fig. 7 presents the consumption's variation of the electric motors, employed to rotate the cylinders, as a function of the specific rotation. In this study, consumption enlarged as the aspect ratio diminishes. The values obtained for C1, slenderer, clearly can't be considered, mainly due to imbalance and vibrations that occurred during the measurement. Particular attention should be given, one more time, to the C3R whose consumption overcame C4's, according to Fig. 7.

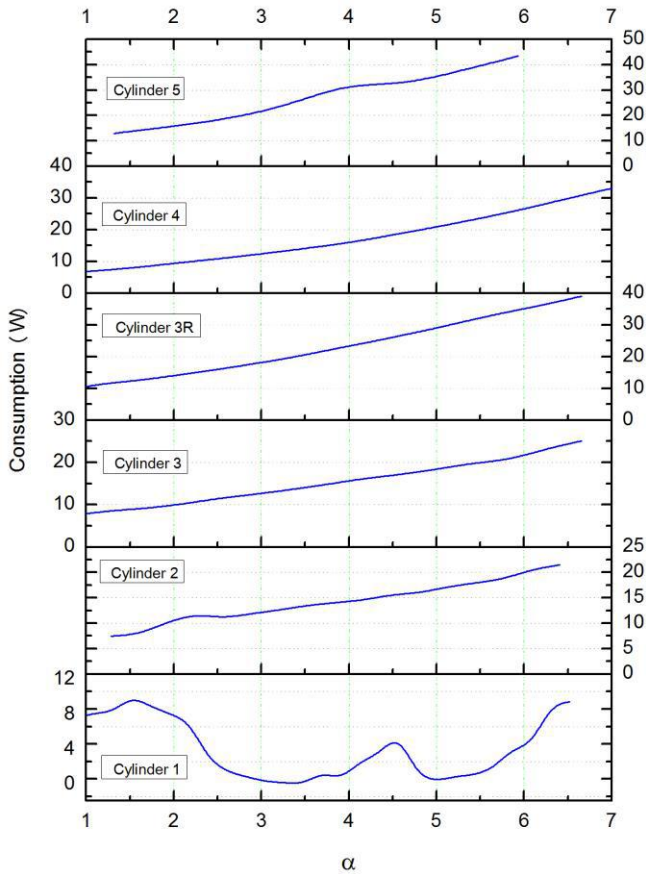
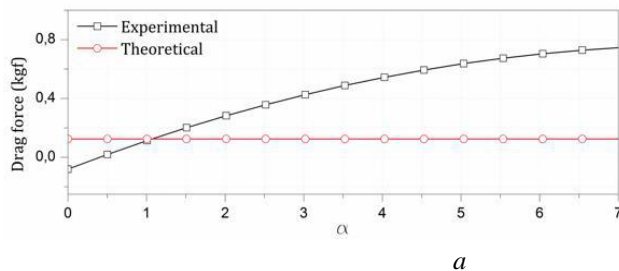


Fig. 7: Instantaneous consumption as a function of specific rotation, with a 0.4 m/s flow.

There so, for a more complete analysis that could, finally, point the most suitable aspect ratio in the current study, the following parameters were related in the same curve:

- a) The maximal resultant force ( $F_M - F_D$ ) that leads to the highest resultant torque pro cylinder;



- b) The consumption in the rotation that maximizes the resultant force;
- c) The rotation wherewith the maximum resultant forces are obtained;

Fig. 8 presents this curve, which reveals the relation between the three cited parameters.

Through the analysis of the curve in Fig. 8, it's plausible to admit that the greatest aspect ratio is obtained with C4. The C4, in relation to C5, operate almost in the same rotation, presenting a resultant force that is, in modulus, 32% lower. Moreover, C4 is more efficient than C5 because it consumes about 38% less. In sum, regarding the comparison with the others cylinders, the C4, in relation to: C5 – Consumes 38% less and have a 32% smaller resultant; C3R – Consumes less and the resultant is bigger; C3 - Consumes slightly more and the resultant is bigger; C2 - Consumes slightly more and the resultant is bigger.

Fig. 8 reveals a practically linear increase in consumption between the cylinders C2, C3 and C4. The same does not occur with the C5, what suggests that the increase stops being linear after a given cylinder diameter. Another relevant point is C3R's consumption, which tends to rise along with greater rugosity. Speed has an approximately quadratic diminishment with the cylinder diameter's growth, while the force's maximal difference initially decreases, reaching a minimum with the C3.

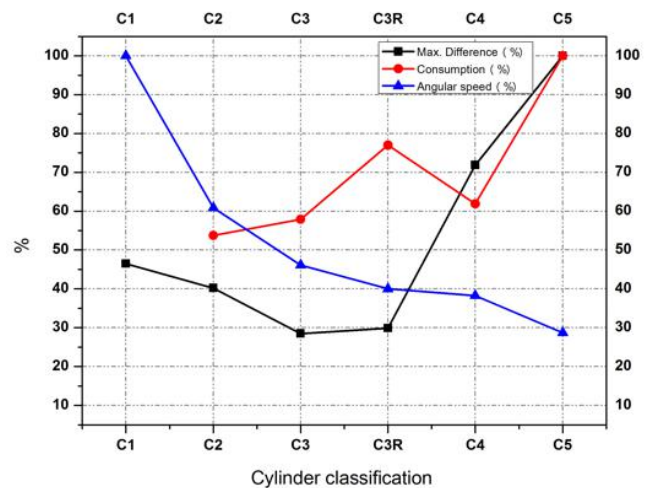


Fig. 8: Relation between consumption and Magnus-Dragefficiency.

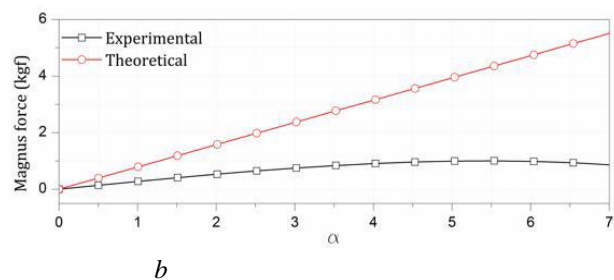


Fig. 9: Differentiation between theoretical and experimental forces: (a) for drag force. (b) for Magnus force.



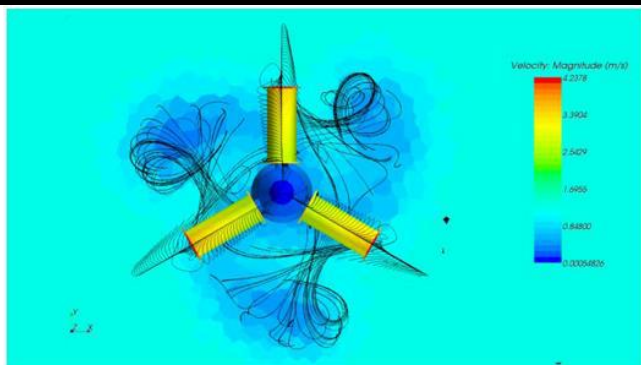


Fig. 10: Simulation of a complete rotor.

The theoretical results had shown significant differences in comparison with the experimentally achieved. According to Fig. 9a, there's a clear difference between the Magnus force, foreseen by theory, and the experimentally obtained for the C4's case, defined as the one with the suitable aspect ratio in the studies.



Fig. 11: Picture of the complete machine, set up over the canal.

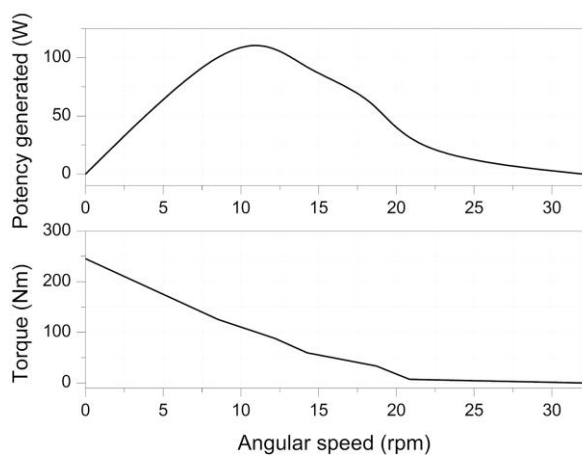


Fig. 12: Potency and torque of the machine.

Likewise, in Fig. 9b is verified the difference between theoretical and experimental drag force. This difference occurred, basically, because the classic theory of drag force, for a cylinder immersed in a fluid, doesn't consider the influence of its rotation.

At the start, the rotation of the cylinders was followed by a given vibration, which inserts an uncertainty to the measurement system. This, in turn, could justify the negative beginning of the drag force, as shown in Fig. 9b. The cylinder that exhibited the greatest performance, the one with the aspect ratio 5.2 (C4), was constructed.

The simulations of the complete rotor, illustrated in Fig. 10, enabled the determination of the end-plate diameter and the ogive geometry.

There so, a hydro generator was built, based on the obtained parameters. To measure the torque of the machine, a Prony brake dynamometer was employed. Fig. 11 shows the machine set up over the canal.

In the same axle of the brake, an encoder was installed, in order to measure the machine's angular speed ( $\omega$ ). Fig. 12 presents the potency and torque obtained.

## V. CONCLUSIONS

The performed trials intended to compare the aspect ratios of the cylinders. Based on these tests, the best aspect ratio could be selected according to the maximal Magnus resultant force criteria. Thus, between the tested aspect ratios, it's verified that the cylinder with the superior efficiency, by the adopted criteria, was the one with 5.2. It is important to emphasize that this aspect ratio will be used in the construction of a machine for electricity micro-generation, fact that motivated the trials performance.

The Magnus Effect has potential for applications in hydro kinetic machines. However, this technology hasn't attained its development apex yet. As an example there's the employment, not tested yet, of a diffuser which, according with recent studies, could increase the  $C_p$  (potency coefficient) in 43% (Brasil Júnior, 2007).

On the other hand, in the current conditions, there is a potential application for this technology, requiring, for its establishment, the specification of a suitable surrounding.

## ACKNOWLEDGMENTS

The Institutos LACTEC extends thanks to the Institutions:

- ELETROSUL Centrais Elétricas S.A.
- Agência Nacional de Energia Elétrica - ANEEL.

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# Perspective of Environmental Services and Management in the Amazon Region, Pará-Brazil

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**Abstract**—At the moment the Brazilian Amazon development, especially in the areas of the Northeast of Pará (NE/PA) and Metropolitan Region of Belém (RMB), demands public policies that provide attractive economic means in environmentally sustainable systems for rural societies. Thus, the objective is to make a descriptive analysis to subsidize the adaptation of a program of public policy for technical assistance and Environmental Services Provision (PSA), called the Socio-environmental Rural Family Production Program (PROAMBIENTE). In order to reach this intervention, it will be necessary to comply with a number of steps, which are mainly related to the elaboration of the Development Plan (PD), the Socio-Environmental Certification Standards (PCSA), Individual Diagnosis (DI) and Utilization Plan (PU) and the construction of Community Agreements (AC). In order to do so, future studies on the implementation of the program and its implications through the variables that will be generated will be essential, verifying those that are most influential in land use and landscape change, identifying the variables of change, in order to generate information capable of qualifying the application of integrative policies in NE / PA and RMB.

**Keywords**—Amazon, environment, public policy, sustainability.

## I. INTRODUCTION

In the Amazon, the environmental issue is related to discussions about the ways in which development programs and policies are implemented for rural societies, especially for quilombolas, indigenous peoples, settlers, extractivists, peri-urban farmers, riparian and others. These discussions take place in a context in which it is agreed

that the policies and programs aimed at family production in the Amazon should develop mechanisms and formulate instruments to promote sustainable practices for socioeconomic reproduction for this public [2, 3]. Thus, the current scenario of rural development in the Amazon requires a federal public policy, state and municipal public policy that provides mechanisms and economic instruments that make attractive investments in the sustainable systems of agricultural, extractive and environmental production [1, 2].

The purpose of this article is to make a descriptive analysis to support an adaptation of the methodology for the reality of the rural societies of NE / PA and RMB, based on a public policy program of technical assistance and provision of environmental services, the Socio environmental Development Program Rural Family Production (PROAMBIENTE) that was implemented in the Amazon biome between 2003 and 2013, which predicted, from its productive actions, the provision of six types of environmental services: (a) avoided deforestation, (b) carbon sequestration, (c) conservation of water, (d) conservation of soils, (e) preservation and conservation of biodiversity, and (f) reduction of fire risk.

## II. METHODOLOGY

Surveys have been made in the existing database (final proposal, articles, minutes, various documents, among others.) of PROAMBIENTE as well as a bibliographical survey, by scientific articles, master dissertations and doctoral theses in available databases, as well as a survey of environmental legislation. Then, the qualitative analysis and interpretation of results were made. We analyzed the interviews with the selected groups, combined with the

information from the database to analyze possible changes in the management and delivery of environmental services in the RMB and NE / PA.

### III. RESULTS AND DISCUSSIONS

The PROAMBIENTE Program that was the fruit of many discussions of the Federations of Agricultural Workers (FETAGs) of the Legal Amazon; of the Confederation of Agricultural Workers (CONTAG); of the Amazon Working Group (GTA); of the National Council of Rubber Tappers (CNS); of the National Movement of Artisanal Fishermen (MONAPE); the Coordination of Indigenous Organizations of the Brazilian Amazon (COIAB) and the technical cooperation of the Federation of Organs for Social and Educational Assistance (FASE) and the Amazon Environmental Research Institute (IPAM) on the need to overcome the dichotomy between rural production and environmental conservation, main theme of the Amazon Cry of 2000<sup>1</sup>[2, 3, 4]. The program focused on environmental services, defined as: "... the quality of life offered to society by qualitative changes in production systems". As for the value of the environmental service, the program itself identified it within the principles of valuation of the ecological economy, which was initially calculated as equivalent to half a minimum wage per month, based on the cost of eliminating the use of fire in production systems, recover the Legal Reserve Area (ARL) and maintain the Permanent Preservation Areas (APP) called the opportunity cost which is: "[...] the additional cost to reduce the risks and environmental impacts of production systems that are not internalized in the final price of the product to the consumer market [...]" Due to the various debates and discussions about the program to be adapted in the NE / PA and RMB with the entities that work in the region, especially in the

<sup>1</sup>It was and until today is a mass movement and political manifestation of small farmers, peasants, family farmers, rubber tappers, riparians, coconut breakers and other groups representing the rural sector. Created in 1991 in the State of Pará, it spread to the Amazonian states where it facilitated the beginning of a democratization process of rural credit, through the institution of the FNO-Special. In 1994, the Cry of the Amazon was assumed as a form of struggle by the peoples of the countryside of other states, assuming the current form entitled "Grito da Terra Brasil", which every year, usually in May, promotes mobilizations in all Units of the Federation and a large demonstration in Brasilia to claim the improvement and expansion of public policies aimed at the countryside [2, 3]

municipality of Ananindeua, where these discussions should culminate with the creation of the NE / PA Council and RMB with UFPA-Campus Ananindeua ahead of it, a collegiate body that will be responsible for making decisions within the regions, respecting the resolutions of the local councils of the municipalities involved. The NE / PA and RMB Council will be directly dialoguing with the municipal representatives and will often meet and respect the decisions and actions to be implemented within the regions.

It will be the Council's responsibility to discuss the actions, monitor and monitor the activities of the local technical assistance. It also aims to ensure the social control of the program and ensure the participation of representative organizations of rural societies, local public authorities and governmental and non-governmental entities in the three spheres of the federation (municipal, state and federal) and all entities involved in the implementation of the program [2, 3, 4].

The Council will be of decisive character and will be formed by a collegiate which will present majoritarian powers representative of the rural societies, among them: Trade Unions of the Workers and Rural Workers (STTR); associations and other trends present in the municipalities of Ananindeua, Marituba, Santa Bárbara, Benevides, Santa Isabel and others in NE / PA; as municipal secretaries of Agriculture and Environment; an Eastern Amazon Embrapa; the National Institute of Colonization and Agrarian Reform (INCRA); Federal University of Pará (UFPA) and other entities that work in the region.

#### 3.1. Methodological assay to the Rural Society of the Region

In order to implement this methodological test in NE / PA-RMB, it will be necessary to comply with some steps that refer to the process of construction of this dialogue intervention with rural societies, which mainly include elaboration of the *Development Plan* (PD)<sup>2</sup>, *Socioenvironmental Certification Standards* (PCSA)<sup>3</sup>, *Individual Diagnosis* (DI)<sup>4</sup>, *Family Unit Utilization Plan*(PU)<sup>5</sup> and the construction of *Community Agreements* (CA)<sup>6</sup>

<sup>2</sup> It is the study that will portray the socio-economic and environmental reality of NE / PA-RMB;

<sup>3</sup> It is the set of rules and laws that must be respected by families and community groups of rural societies to provide environmental services and after remuneration;

<sup>4</sup> It aims to raise and study information on socioeconomic and environmental reality and subsidize the construction of PU of each family;

<sup>5</sup> It is the integrated planning of the family unit, being a reference for the family to determine what are and how will be the changes in land use;

<sup>6</sup> It is the document agreed in each community group regarding the concepts and values of natural resources, as



The construction of this methodology will have as one of the main purposes, the format of a database through statistical software – Windows Tab(TabWin) and Statistical Package for the Social Sciences (SPSS) to subsidize information for future research and strategic actions for the strengthening of rural societies to be registered by the Council, supported by both the local authorities and future partnerships established during the construction of the program. In addition to subsidizing the elaboration of the PUs in line with the strategic actions put in the PD to improve the management of the RN in the region.

### 3.2. Construction of the Development Plan (PD) and the Socio-Environmental Certification Standard (PCSA)

The PD will be divided into two parts: firstly a diagnosis itself, will be done using Rapid and/or Participative Rural Diagnostic (DRP) techniques with the objective of portraying the socioeconomic and environmental reality of the regions through the information to be updated about the different groups of rural societies, production systems, infrastructure, environment, commercialization and, also, from the point of view of local organizations and external institutions that operate in the regions [4].

The second part refers to the elaboration of the actions directed at the rural societies of the regions through the techniques of Strategic Planning (PE), which basically determines the actions by objectives and will aim to contemplate the main strategies of rural societies to overcome obstacles to their own development and management of the RN, besides the directives and more urgent actions of the PD.

For the construction of PD and PCSA, the "*landscape reading map*<sup>7</sup>" method will be used with the adoption of geoprocessing technology where it will be able to cover the set of acquisition, storage, retrieval, manipulation, analysis and distribution of spatially referenced data in the areas of municipalities indicated by the RMB and NE / PA Council as priorities for the implementation of the program.

It is noteworthy that in the "*landscape reading*" to be carried out during the construction of the PD and PCSA, where current mapping technologies such as conventional

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well as being the basis for certification and remuneration of environmental services.

<sup>7</sup>Technique that consists of traversing the previously defined zones in order to know the particularities of the region, the NB, among others. It also subsidizes the debate of the groups according to the characteristics, tendencies, differences, similarities, etc. It allows to identify structures within the same geographic space, such as schools, roads, health post, etc., and provide a systemic view for the group under discussion during the PU and PCSA workshops.

topography, aerial photographs and satellite imagery will be used, Global Positioning System by Satellite (GPS), Geographic Information Systems (SIGs), as well as other forms of data acquisition and rapid and precise information processing, covering wide aspects, making thematic maps possible and delimiting and quantifying areas such as: APP, ARL, areas of agriculture, pasture, fruit growing, forestry, forestry and other activities, as well as degraded areas, areas subject to floods and potential water resources, eroded or erosion areas, extension of roads and fences, configuration of the land structure, as well as the different forms of use of the RN.

It should be noted that the PCSA is a set of principles, indicators and criteria that, if fulfilled, will give the beneficiaries the right to receive through a social and environmental fund, the Payment for Environmental Services (PSA), whose principles express general concepts to be followed by the families of rural societies. These criteria transform the concepts and principles that constitute guidelines for the work of households and the indicators turn the criteria into practical questions that can be applied during the field audit.

The news, in relation to other processes in progress in the various localities, is the component of the provision environmental services to society. In other words, family groups of rural societies belonging to the RMB will propose to perform environmental functions, in addition to traditional food and fiber production, as an additional source of external resources to support their own endogenous development process.

It is worth mentioning that it is planned to implement a Socio-Environmental Certification System (SCSA), where the certification process will be divided into two stages. In the first, families certify each other (participatory certification), in scope of the ACs signed. In the second step, a certifying (independent) institution will be contracted to conduct field audits to confirm the information provided by the community. For rural societies to be certified, two preconditions are required: that the family has developed the PU and that its community group has constituted a CA.

### 3.3. Construction of the Usage Plan (PU) and the Community Agreement (CA)

Regarding the PU will be elaborated by the families with the support of the local technical team. PU is the integrated family planning. It is also the basis for technical credit and PSA projects, for the term of conduct adjustment (TAC)<sup>8</sup> and for the Environmental Licensing (LA) of the *family unit*[2, 3, 4]. According to the methodology to be used in

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<sup>8</sup> The TAC is signed between the farmer and the competent environmental agency, identifying the location of the existing ARL and the projection and recomposition plan of the APPs that need to be recomposed.

the elaboration of the PUs, each family will be stimulated to design the current use of the newborns and the desire of the families in relation to the future use of their *family unit*, in sheet of paper, which will already serve as a base for the community to see the planning of the family unit and its possible change of land use.

For Vasconcelos[4] the PU is a general planning of the *family unit*, based on the family members' operational capacity, for a period of 15 years, containing short, medium and long term actions.

It is worth mentioning that the ID will be the basis for the construction of the PU. These two methodologies, even though they are correlated, will be constructed at different moments, but with the same PD method used in DRP, with DI and PU being adapted for each situation. The CAs have the objective of promoting the certification of environmental services to the families that will participate in the program and, specifically, to ensure that the PCSA is respected. In addition to ensuring that families are fulfilling PUs.

Considering that one of the objectives of CAs is to ensure that families are fulfilling the *plans*, it is important that a family knows the PUs of other families. Therefore, a redemption of the *plans* will be made. Thus, each family should present their PU from the maps, current and future, that will be elaborated. This socialization will be facilitated by the local technical team, presenting the main common points of conversion in the PU of each community group. As for the verification methodology, a mixed certification system is foreseen, that is, they will propose a first stage of participatory certification that will culminate in the drafting of group *agreements* and a second stage of conventional certification that will be finalized with certification audits. After one year of implementation, the community subgroup shall review its *agreement* and indicate its compliance and non-compliance. Next, entities registered by the program and accredited by the National Institute of Metrology (INMETRO) will perform certification audits to verify the *agreements*. As it will not be possible to conduct audits in 100% of families, each year, around 10% of the subgroups should be audited, closing 100% of the audit over 10 years. On the other hand, that subgroup that is not audited, will be worth what the agreement says.

Each subgroup of the program should meet and establish its *agreement*, which will indicate the collective commitments for the fulfillment of the PU and the PCSA. The ACs will be established based on the commitments defined in the PCSA itself (reduction of fire use, reduction of poison use, reduction of deforestation, etc.). For example, the subgroup may define collective strategies to prevent the occurrence of accidental fire (through mobilization of many people, firebreak, etc.).

The program now being implemented is characterized by the functioning of integrated flows to the benefit of rural societies in the regions: (a) shared management between organized civil society, federal, state and municipal governments through the functioning of the Council with the UFPA- *Campus Ananindeua* leading, in the regional scope, through the functioning of the Councils, secretariats and entities attending to a historical flag of the social movement of social control of the public policy; (b) territorial management through the formation of family groups of rural societies, to establish a collective process of environmental awareness and significant production of primary products and environmental services; (c) participatory design and implementation of the PD (aspects outside family units, such as processing, marketing and commercialization of production, infrastructure works and other structural demands) and PUs (aspects within family units and communities, such as management objectives, spatial and temporal distribution of production, input and labor input flows, and exit of primary products and environmental services); (d) ACs that provide the information base to designate PSA and non-PSA family groups, and finally; (e) advisory by local institutions elected by the community members themselves.

#### IV. CONCLUSION

In the search for a new perspective, the program to be adapted for the family units of rural societies of NE / PA-RMB constitutes a technical-pedagogical exercise of a public policy with participative methodologies, socioeconomic changes and proposing the qualification in the management of the RN with a view to the future PSA. Thus, the program must act from the beginning of its implementation through an innovative local advisory that will seek to support the rural NE / PA-RMB societies in the process of providing environmental services, with the objective of reversing socioeconomic conditions and negative impacts on the environment caused by the interventions of past public policies, especially those with disorganized explorations of RN.

The dialogue intervention in NE / PA-RMB will present a great challenge for UFPA-Ananindeua Campus in the teaching-research and extension axis. Because the socioeconomic status of families and the changes in the type of land use and RN management in the family units that will occur due to this intervention, especially those triggered by PU and AC tools, will be a great opportunity to verify their effect.

In this sense, it is accepted that future studies will be essential about the implementation of the program in NE / PA-RMB and its implications through the variables that will be generated through the PUs and ACs in order to point out those that will most influence in the land use, and

at the same time will identify the potential variables of changes in the type of future land use, in order to generate information capable of qualifying the application of integrative policies (for example, local advisory and credit for PSA), modifying the socioeconomic reality and environmental aspects of the NE / PA-RMB rural societies and which will serve as a basis for intervention in other regions of the State of Pará.

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# Power Flow Calculations by Deterministic Methods and Artificial Intelligence Method

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**Abstract**— In this paper, we will present different methods for Power Flow Calculations. First, we will describe the deterministic methods; which are Gauss-Seidel (GS) and Newton-Raphson (NR) methods, in addition to that, we will use also a Newton based method Fast Decoupled Load Flow (FDLF). Second, we have the Artificial intelligence method Neural Network (NN). Matlab programs were developed for solving Power Flow problem using GS and NR methods and regarding the ANN, we established and trained artificial neural networks models for computing voltage magnitudes and voltage phase angles. We used these methods to solve the Power Flow problem of the Institute of Electrical and Electronics Engineers (IEEE) 14 bus system. The results that we obtained were presented in graphs at the end of the paper.

**Keywords**— Artificial Neural Networks, Fast-Decoupled Load Flow, Gauss-Seidel, Newton-Raphson, Power Flow.

## I. INTRODUCTION

Power Flow Analysis is an essential step at any electrical network analysis. Indeed, it allows us to calculate the quantities of a network under a steady state operation, namely the voltage magnitudes and voltage phase angles at any point of the network. From these, it is possible to calculate the currents in the transport lines, the transited active and reactive powers and the power losses caused during the transport of electrical energy. This analysis is very important to study, to plan and to exploit an electrical network.

The equations of Power Flow are non-linear, which require using numerical methods for solving this type of equations. In our paper, we will use Gauss-Seidel (GS) and Newton-Raphson (NR) iterative methods. Then, we have Artificial Intelligence Techniques such as Artificial Neural Networks (ANN), which we will apply to the Power Flow Analysis (PFA).

The following sections of this paper will give a preview of the iterative methods GS and NR and the Artificial

Intelligence method ANN, then the solution proposed of PF problem for the Institute of Electrical and Electronics Engineers (IEEE) 14 bus system. At the end of the paper, we will make conclusions and perspectives.

## II. DETERMINISTIC METHODS

### 2.1 Method of Gauss-Seidel

The GAUSS-SEIDEL method is one of the simplest iterative methods used to solve the problem of power flow or generally for the resolution of a very large set of nonlinear algebraic equations. At the beginning, initial values are assumed, with this values we get the first approximation, we continue with iterations until the solution converges and that is happen when the changes between a variable and its previous value is very small:

$$\Delta x_i = x_i^k - x_i^{k-1} < \varepsilon \quad (1)$$

k is the number of iteration and  $\varepsilon$  is a small value.

To speed up the convergence of the Gauss-Seidel method, we can use an acceleration factor. For example, the accelerated value of voltage at bus i and k+1 iteration is given by:

$$V_i^{(k+1)}(\text{accelerated}) = V_i^k + \alpha \Delta V_i \quad (2)$$

Where  $\alpha$  is the acceleration factor.

This factor is used to reduce the number of iterations and also to give a precise solution. A suitable value of  $\alpha$  for any system can be chosen by making tests on the power flow studies. A generally recommended value is  $\alpha=1.6$ . A wrong choice of this factor may affect the convergence of the method [1] [3].

We will apply the method of Gauss-Seidel with acceleration to solve Power Flow problem.

#### 2.1.1 Gauss-Seidel Algorithm

Step 1: Form the admittance matrix Ybus;

Step 2: Choose a tolerance value  $\varepsilon$ ;



Step 3: Assume the unknown values of the system; voltage magnitudes for load buses and voltage phase angles for load and generator buses;

Step 4: Start iteration;

Step 5: Compute reactive power for generator buses, compute bus voltages; for generator buses voltage magnitudes remains the same but voltage phase angles changes;

Step 6: Compute the changes in voltage magnitude value with the use of the acceleration factor  $(\Delta V_i = (V_i^{(k+1)} - V_i^k)/\alpha)$ ;

Step 7: Test if  $(\Delta V_i < \epsilon)$ , then stop the iteration, if not continue the iteration and repeat steps from 5 to 7.

Based on this algorithm we developed a Matlab program to solve PF problem with GSA method.

### 2.2 Method of Newton-Raphson

NR is the most efficient iterative method currently used for PFA. In this method, convergence is reliable and guaranteed. It's necessary to choose an assumed value near the solution to get the result very quickly if not, the method can take more time to converge [1].

The expressions of active and reactive powers at bus i:

$$P_i = |V_i| \sum_{p=1}^n |Y_{ip}| |V_p| \cos(\delta_i - \delta_p - \gamma_{ip}) \quad (3)$$

$$Q_i = |V_i| \sum_{p=1}^n |Y_{ip}| |V_p| \sin(\delta_i - \delta_p - \gamma_{ip}) \quad (4)$$

Pi: The calculated value of net active power entering bus i;

Qi: The calculated value of net reactive power entering bus i;

|Vi|: Voltage magnitude of bus 'i';

Yip: The parameters of line between the two buses i and p;

δi: Voltage phase angle of bus 'i';

δp: Voltage phase angle of bus 'p';

γip: The angle of the parameters of the line between the two buses 'i and p' in polar form.

We have: 
$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \Delta V \end{bmatrix} \quad (5) \text{ with: } J = \begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix}$$

ΔP: Active power mismatch;

ΔQ: Reactive power mismatch

Δδ: Voltage phase angle change;

ΔV: Voltage magnitude change;

J: Jacobian matrix.

#### 2.2.1 Newton-Raphson Algorithm

Step 1: Formulate the admittance matrix;

Step 2: Assume the unknown values of the system;

Step 3: Start iteration;

Step 4: Calculate the powers and determine the Mismatch;

Step 5: Formulate the Jacobian matrix;

Step 6: Define differences of unknown values Δδi and Δ|Vi|;

Step 7: Edit previous approximations of δi and |Vi|;

Step 8: Check if (Mismatch < ε); then stop the iteration, if not continue the iteration and repeat steps from 4 to 8.

Based on this algorithm we developed a Matlab program to solve PF problem using NR method.

Due to the complexity of calculations in the NR method, a lot of simplifications was been used, then, as a result we have the Fast Decoupled Load Flow (FDLF) technique.

#### 2.2.2 Method of Fast Decoupled Load Flow

It is a method based on the Newton-Raphson method. It use the decoupling that exists between the active power and the voltage phase angle, and the reactive power and voltage magnitude. This method enable us to fix the value of Jacobian during the iteration in order to avoid costly matrix decompositions. We have four hypotheses:

- The voltage magnitudes of buses are nearly equal to one per unit in a normal steady state operation;
- The susceptance is much bigger than the conductance, because the transmission lines are mostly reactive ( $B_{ij} \gg G_{ij}$ );
- The voltage phase angle's differences are small in a normal steady state operation;
- The reactive power consumed by the elements connected to this bus is always more than the injected reactive power at any bus when these elements are shorted to the ground ( $B_{ii}V_i^2 \gg Q_i$ ).

With this hypotheses, we get:

$$\frac{\partial P_i}{\partial V_i} \approx 0 \text{ and } \frac{\partial P_i}{\partial V_j} \approx 0 \Rightarrow J_2 \approx 0$$

And:

$$\frac{\partial Q_i}{\partial \delta_i} \approx 0 \text{ and } \frac{\partial Q_i}{\partial \delta_j} \approx 0 \Rightarrow J_3 \approx 0$$

Hence,

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & 0 \\ 0 & J_4 \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \Delta V \end{bmatrix} \quad (6)$$

And we will rewrite the elements of Jacobian matrix. We need to find partial derivatives:

$$\frac{\partial P_i}{\partial \delta_j} \approx -B_{ij}V_i^2; \quad j = i \quad (7)$$

$$\frac{\partial P_i}{\partial \delta_j} \approx -V_iV_jB_{ij}; \quad j \neq i \quad (8)$$

$$\frac{\partial Q_i}{\partial V_j} V_i \approx -B_{ij}V_i^2; \quad j = i \quad (9)$$

$$\frac{\partial Q_i}{\partial V_j} \approx -V_iB_{ij}; \quad j \neq i \quad (10)$$

Combining equations (6), (7) and (8) we get:

$$\Delta P_i = -V_i \sum_{j=1}^n V_j B_{ij} \Delta \delta_j \Rightarrow \frac{\Delta P_i}{V_i} = - \sum_{j=1}^n V_j B_{ij} \Delta \delta_j$$

As:  $V_i \approx 1.0 \text{ pu}$ , we get:  $\frac{\Delta P_i}{V_i} = - \sum_{j=1}^n B_{ij} \Delta \delta_j$

Or, 
$$\frac{\Delta P}{V} = [-B] \Delta \delta = [B'] \Delta \delta \quad (11)$$

Combining equations (6), (9) and (10) we get:

$$\Delta Q_i = -V_i \sum_{j=1}^n B_{ij} \Delta V_j \Rightarrow \frac{\Delta Q_i}{V_i} = - \sum_{j=1}^n B_{ij} \Delta V_j$$

Or,

$$\frac{\Delta Q}{V} = [B''] \Delta V \quad (12)$$

With:

ΔP: Active power mismatch;

$\Delta Q$ : Reactive power mismatch

$\Delta\delta$ : Voltage phase angle change;

$\Delta V$ : Voltage magnitude change;

$B'$ : Constant matrix for all buses except the slack bus, it have a dimension of  $(n-1) \times (n-1)$ ;

$B''$ : Constant matrix for load buses, it have a dimension of  $(m \times m)$ ;

$n$  is the number of system's buses and  $m$  is the number of load buses.

### 2.2.3 Algorithm Fast Decoupled Load Flow

Step 1: Form the admittance matrix  $Y_{bus}$  and deduce the constant matrix  $B'$  et  $B''$ ;

Step 2: Choose a tolerance value  $\epsilon$ ;

Step 3: Assume the unknown values of the system; voltage magnitudes for load buses and voltage phase angles for load and generator buses;

Step 4: Start iteration;

Step 5: Calculate the powers and determine the Mismatch;

Step 6: Define differences of unknown values  $\Delta\delta_i$  and  $\Delta|V_i|$ ;

Step 7: Edit previous approximations of  $\delta_i$  and  $|V_i|$ ;

Step 8: Check if  $(\text{Mismatch} < \epsilon)$ ; then stop the iteration, if not continue the iteration and repeat steps from 5 to 8.

Based on this algorithm we developed a Matlab program to solve PF problem using FDLF method.

## III. ARTIFICIAL INTELLIGENCE METHOD

### 3.1 Artificial Neural Networks

An Artificial Neural Network (ANN) is a computing system based on biological neural networks structure. It is capable of modeling nonlinear problems. It has a lot of advantages, especially, that it can learn from observing data sets. That is why, it can be used as an estimator. For solving problems using ANN, we have to train it by presenting a history of inputs-outputs data. In general, an ANN is composed of three layers; the first one is an input layer, the second one is a hidden layer and the last one is an output layer. However, we can use more than one hidden layer and that is what we will present in this paper [4] [5] [6] [7].

### 3.2 Artificial Neural Network Models

In our paper we used two models of ANNs, the first one for computing voltage magnitudes for load buses and the second one for computing voltage phase angles for generator and load buses. The first model is composed of one input layer, two hidden layers and one output layer and the second one is composed of one input layer, one hidden layer and one output layer. For the both models, we used as a network type "Feed Forward Backprop", for the training function "trainlm", for the performance function "mse" and regarding the transfer functions we used "tansig" for the hidden layers and "purelin" for the output layer.

Couples of active and reactive power (inputs) were generated and by using the NR method we compute the

voltage magnitudes and voltage phase angles (targets), to train our ANNs.

Mean Square Error (MSE) type performance function was used to test the ANNs models.

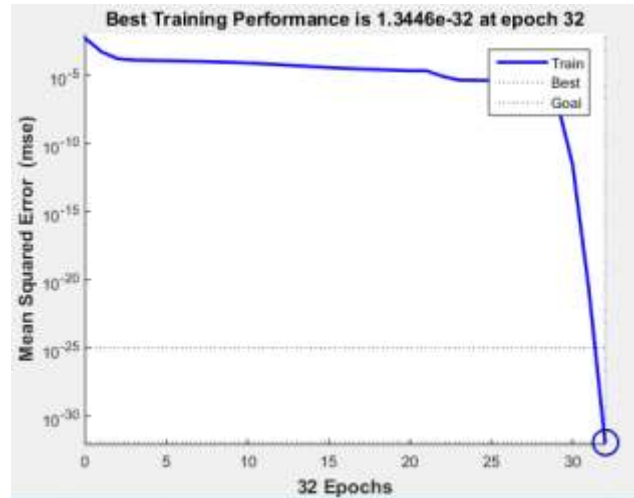


Fig.1: The performance of the ANN for voltage magnitudes.

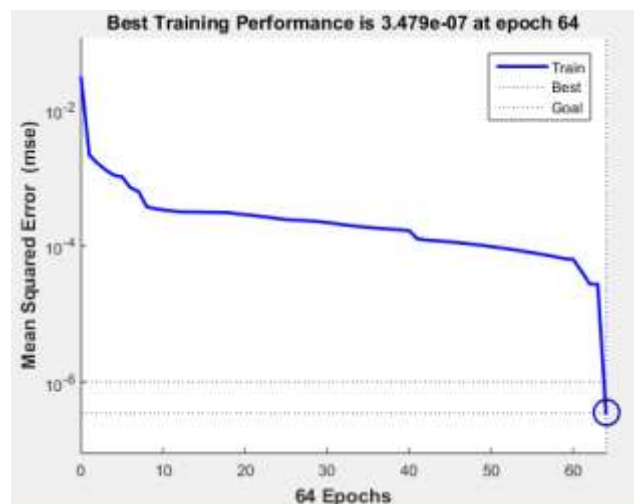


Fig.2: The performance of the ANN for voltage phase angles.

There are graphs of the MSE function representing the performance of the training of the ANN models. According to these graphs, the MSE was decreased at the end of the training phase to reach a value of  $1.3446e-32$  at epoch 32 for the voltage magnitude and  $3.479e-7$  at epoch 64 for the voltage phase angles. This means that these neural networks were well trained.

## IV. APPLICATION TO IEEE NETWORK

### 4.1 IEEE 14 bus system

The studies were carried out on the (IEEE) 14 bus system, bus 1 is a Slack bus, buses 2 and 3 are generators buses and the remaining ones are load buses.

Table.1: Values of input data in per unit (pu)

Bus number	Inputs data (power data in pu)	
	P	Q
1	2.3294	0.3121
2	0.1830	0.0295
3	0.9420	0.0971
4	0.4780	0.0390
5	0.0760	0.0160
6	0.1120	0.0612
7	0.0000	0.0000
8	0	0.1824
9	0.2950	0.1660
10	0.0900	0.0580
11	0.0350	0.0180
12	0.0610	0.0160
13	0.1350	0.0580
14	0.1490	0.0500

4.2 Results

The following table shows the results of voltage magnitudes by using GS method, NR methods and ANN.

Table.2: Voltage magnitudes in per unit (PU)

Bus number	Numerical Techniques and ANN for V in pu			
	NR	FDLF	GS	ANN
1	1.0600	1.0600	1.0600	-
2	1.0450	1.0450	1.0450	-
3	1.0100	1.0100	1.0100	-
4	1.0423	1.0423	1.0423	1.0438
5	1.0516	1.0516	1.0517	1.0530
6	1.0761	1.0761	1.0760	1.0796
7	1.0505	1.0505	1.0505	1.0549
8	1.0803	1.0803	1.0802	1.0846
9	1.0250	1.0250	1.0250	1.0461
10	1.0264	1.0264	1.0264	1.0320
11	1.0473	1.0473	1.0472	1.0519
12	1.0585	1.0585	1.0584	1.0623
13	1.0511	1.0511	1.0510	1.0551
14	1.0181	1.0181	1.0180	1.0233

The average error between NR and GS from bus 4 to bus 14 is 1.1818e-04;

And between NR and ANN from bus 4 to bus 14 is 5.40e-3.

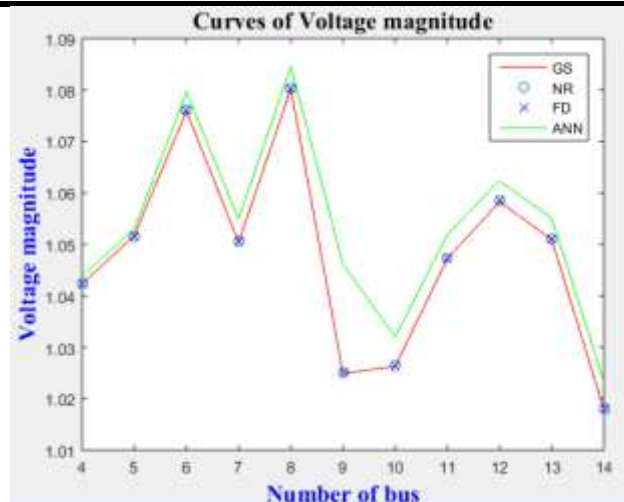


Fig. 3: Curves of voltage magnitudes.

This graph represents the voltage magnitude in each bus. The results obtained by iterative methods are almost mingled, also, the error between them and ANN is not big.

The following table shows the results of voltage phase angles by using GS method, NR methods and ANN.

Bus number	Voltage phase angles in radian (rad)			
	NR	FDLF	GS	ANN
1	0	0	0	-
2	-0.0859	-0.0859	-0.0857	-0.0852
3	-0.2181	-0.2181	-0.2176	-0.2176
4	-0.1836	-0.1836	-0.1831	-0.1855
5	-0.1605	-0.1605	-0.1601	-0.1609
6	-0.2574	-0.2574	-0.2567	-0.2564
7	-0.2334	-0.2334	-0.2326	-0.2340
8	-0.2334	-0.2334	-0.2326	-0.2335
9	-0.2606	-0.2606	-0.2599	-0.2448
10	-0.2649	-0.2649	-0.2641	-0.2646
11	-0.2631	-0.2631	-0.2623	-0.2632
12	-0.2720	-0.2720	-0.2713	-0.2715
13	-0.2722	-0.2722	-0.2715	-0.2712
14	-0.2837	-0.2837	-0.2829	-0.2827

The average error between NR and GS from bus 2 to bus 14 is 6.4615e-04;

And between NR and ANN from bus 2 to bus 14 is 1.8e-3.

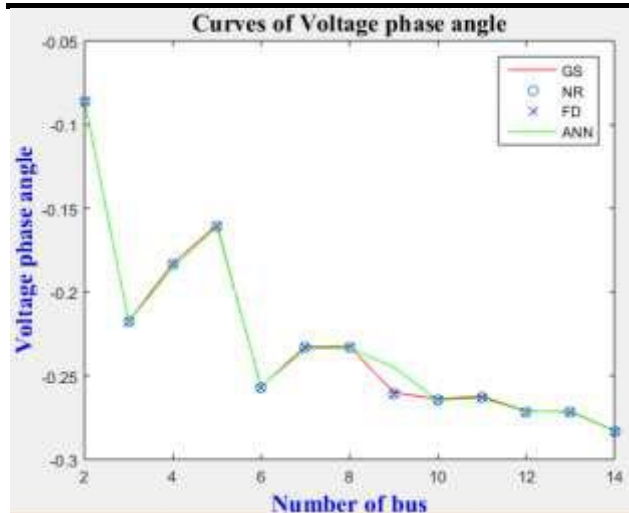


Fig. 4: Curves of voltage phase angles.

This is a graph that represents the voltage phase angles in each bus. We can notice, that the values obtained by the iterative methods and ANN are very close to each other, the error is very small between them.

## V. CONCLUSION

Due to the improvement of computer technologies, different methods were developed to solve power flow problem. In this paper we treated numerical methods and artificial intelligence method.

GS's method is simple and easy to program, it is suitable for small systems, but for large systems, NR's methods have proven their robustness in front of the GS method.

The development of the networks and the transition to smart grids lead researchers in this field to depend on the artificial intelligence methods. ANNs has proven its importance in solving power flow problem.

After comparing the results of voltage magnitudes and voltage phase angles, we found that the error between the numerical methods and ANNs was very small, however, the models of the ANNs have to be improved to get better results.

The next step would be to compute the transit currents, to check that they do not exceed the limit values and to evaluate the losses, in addition to that, we can work on the optimization of the power flow path.

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# Proximate Analysis of Seed Extracts and Methanol Content of Juice of Some Grape Varieties in Turkey

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**Abstract**— The present study describes the determination and comparison of antibacterial activity, total phenolic content in seeds of seven popular grape cultivars and methanol content of grape juice grown in Turkey. It's called Muskule, Gokuzum, Razaki, Akuzum, Eksi kara, Siyah pekmezlik and Buzgulu in Turkey. The antibacterial activity was evaluated by the microdilution method and the minimum inhibition concentrations of extracts from determined. The phenolic content was determined using spectrophotometer. Pollution from methyl alcohol, which is extremely harmful for human health was determined using GC. The minimum inhibitory concentration (MIC) values of grape extracts with antibacterial activity ranged from 0,312 to 5 µg/ml. The total phenolic content of grape seed of Ekşi kara was found to be about one-half times as mg GAE/g compare to Büzgülü. The highest methyl alcohol ratios are found in Ekşi kara among juice of grape varieties (12.01 g/µl).

**Keywords**—*Vitis vinifera* L.; Antibacterial activities; Total phenolic content; Methyl alcohol.

## I. INTRODUCTION

Grape production in our country is a very important fruit species. Seeds of grape varieties contain large amounts of phenolic compounds [1]. These compounds have many favourable effects on human health. For example, human inhibited low-density lipoprotein [2]. Risk of cancer are reduces [3]. The defatted seeds as a rich source of polyphenolic compounds have been largely studied by several research groups [4]. During the chewing, part of the phenolic compounds in grapes are transferred to the human body. Sources of antimicrobial compounds are grape seed extracts [1]. Also, it should be mentioned the importance of phenolics in determining some quality attributes and properties in fresh fruits and vegetables, like

the color, texture, taste and flavor. One of the principal roles that have been proposed as part of the actions of phenolics in man is that of an antioxidant [5]. In nature there are a large number of different types of antimicrobial compounds that play an important role in the natural defence of all kinds of living organisms [6]. There are high amount linoleic acid in seed of grape varieties [7]. Linoleic acid consumption may reduce the level of high density lipoprotein cholesterol, increasing the risk for coronary heart disease mortality, increased risk of diabetes, cardiovascular disease and pathophysiological mechanisms impairing insulin activity [8]. Methanol that formaldehyde, and formic acid turned into indicates a toxic effect in the body. Amounts of alcohols depends on grape variety, fermentation conditions, method of distillation and duration of extraction. Due to these compounds is high boiling points during distillation take place in the final product [9]. Studies are announced in alcoholic beverages containing methanol, can cause eye defects, skin cancer and deaths. Methyl alcohol is toxic effect from skin inhaled or absorbed from the gastrointestinal route. Methyl alcohol can cause acidosis, severe abdominal pain, disturbances of consciousness or visual disturbances [10]. For these reasons, grape consumerism is important to know the amount of methanol. Many species of *Vitis* were studied for especially volatile constituents. Some papers have been referred to volatile compounds in endemic grape samples [11]. Although similar studies on some grape seed cultivars in Turkey, a comparative study on methanol content of grape juice and antibacterial activities, phenolic content of seven popular grape seed cultivars in Turkey has not been reported up to now, according to our knowledge. The present study was carried out to determine and compare methanol content of grape juice and the antibacterial activities, phenolic content of them.

## II. MATERIAL AND METHODS

### Collection of material

The ripened grape samples were collected from seven different Turkish vineyard producers, Eksikara (black color table and dried grape), Akuzum (white color table grape), Buzgulu (red color table grape), Razaki (white color table grape), Muskule (white color table grape), Gokuzum (white color table and molasses grape) and Siyah pekmezlik (black color molasses grape), in 2011. Seven samples were collected from different grapevines for each cultivar. The seeds were excised from product and air-dried at room temperature under shaded conditions. It was stored at room temperature until analysis.

### Antibacterial Activities

Dried seed of grape varieties material was finely powdered using a laboratory mill. 10g of each sample was exhaustively extracted with 100 ml methanol:acetone:water at room temperature under stirring and the extracts were filtered through a Whatman filter. After evaporation of the solvent at 40°C in rotary evaporator, the residues were stored at 4°C until further analysis. The antibacterial activities of the seeds of grape varieties were assessed against four bacteria species: *Bacillus cereus* ATCC 1778, *staphylococcus aureus* MRSA ATCC 43300, *Klebsiella pneumoniae* ATCC 700603 ESBL (+) and *Pseudomonas aeruginosa* ATCC 15442. Ampisid was used as a positive control. All bacteria were grown in the same medium at 37°C for 22h [12]. Minimum inhibition concentration (MIC) values were determined using 56-well microtiter plates by dissolving the sample in DMSO. Suspensions of standard microorganisms were inoculated onto the microplates. The growth of the microorganisms was observed by using a microplate photometer (Thermo Scientific Multiskan). The MIC values were defined as the lowest concentrations of the seed of grape varieties extracts to inhibit the growth of microorganisms.

### Total phenolic content

The total phenolic contents of extracts were determined according to the Folin-Ciocalteu method, manually [13]. The extracts were prepared as follows: The seeds (5.0 g) were extracted with a mixture of methanol and water (80:20, v/v, 100 mL) for 18 hours on the 125 rpm rotary shaker. After filtering and evaporating to dryness in vacuo, the crude extracts were obtained. The 100 mL of extract (20 mg/mL) was oxidized with Folin-Ciocalteu reagent (0.2 mL), and the reaction mixture was neutralized with sodium carbonate (1mL, 15%). The absorbance was measured at 760 nm after 60 min on a spectrophotometer (Shimadzu UV-1601). Using gallic acid as standard, total phenolic content was expressed as µg GAE equivalent/g of extract.

### Methanol content

The methyl and ethyl alcohol were separated and analyzed by Shimadzu 15-A gas chromatograph (GC), equipped with dual flame ionisation detector and a 1.8 m × 3 mm internal diameter packed glass column containing GP Carbopack B60/80 coated with 5% Carbowax 20M. (Cat no: 11766) The injector and detector temperatures were 120 and 130 °C, respectively. Column temperature program was 80 °C where it was maintained for 7 min. Nitrogen at a flow rate of 0.8 ml/min was used as the carrier gas. Isopropyl alcohol was added as internal standard from each samples [14]. The methyl alcohol were identified by comparison of retention times with known external standard mixtures, quantified by a Shimadzu Class-VP software and the results expressed as percentage distribution of methyl alcohol. All the chemicals used for the gas chromatography analysis procedure were obtained from Supelco Inc. (Bellefonte, PA, U.S.A.). Each of the experiments was repeated three times.

## III. RESULTS AND DISCUSSION

The antibacterial activities of the seed extracts of seven grape varieties were evaluated by using the MIC values in a micro-dilution method. Minimum inhibitory concentrations (MIC) of seed extracts of grape varieties are presented in Table 1. The results show that seeds of seven grape varieties exhibited antibacterial activity. Our findings showed that the ethanol extract from *Vitis vinifera* L. seeds had interesting activity against both gram-negative and gram-positive bacteria.

*Bacillus* species, especially *B. cereus*, are responsible for foodborne diseases [15]. *B. cereus* was inhibited by two of the studied grape cultivars (Eksikara, Akuzum, Buzgulu, Razaki, Muskule, Gokuzum, Siyah pekmezlik (0.312, 0.675, 2.5, 2.5, 2.5, 1.25, 0.675, respectively) with 0.5 µg/ml concentration.

*Staphylococcus aureus* is the cause of many diseases, such as food poisoning, osteomyelitis, polyarthritis, endocarditis [16]. Five studied grape species exhibited a strong antibacterial effect on *S. aureus* and Eksikara had the highest activity on the bacteria with a 0.312 mg/ml concentration. Therefore, Eksikara may be used as an antibiotic for *S. aureus* infections.

*Klebsiella pneumoniae* is a kind of bacteria found in the upper respiratory tract microflora. *K. pneumoniae*, which is very important for human health of the upper respiratory tract infections, urinary tract infections and opportunistic pathogens involved in the formation of wound infections [17]. This bacteria belonging to the type of grapes gathered all of the other samples except for the sample showed the same MIC value.

*Pseudomonas aeruginosa*, is found most in soil and water. *P. aeruginosa*, respiratory and urinary tract in

patients with immune deficiency, opportunistic pathogen that burns and open wounds. At the same time in the blood can infections. Nosocomial infections, one tenth of the *P. aeruginosa* is due to. *P. aeruginosa* in situations where the dirty bathtubs and Jacuzzis, such as exposure to low water quality can lead to dermatitis. All examples against of this bacteria type showed the 2.5 µg/ml concentration a weak value of the MIC.

The seed extracts of grape varieties was found to have antibacterial action against four strains of bacteria. These varieties were Akuzum, Eksikara and Siyah pekmezlik. Due to values are very close the other varieties does not mean there is strong antibacterial. However, a lower concentration of ampisid (0.5 µg/ml) had a strong antibacterial effect on the bacteria.

According to study, antibacterial effects of seeds of grape varieties are different. Differences of antibacterial activities reported that resulted from the difference in methodology, chemical composition, type of microorganism and climatic conditions.

Gokturk et al., 2004 [18] also determined that the grape seed extracts had antibacterial activities against fourteen bacteria. Both the ethyl acetate:methanol:water (60:30:10) and Acetone:water:acetic acid (90:9.5:0.5) extracts of *Vitis vinifera* L. inhibited the growth of 13 bacteria and the MIC values of the acetate:methanol:water (60:30:10) extracts were determined as 30 µg/ml for *K. pneumoniae*, and 27.5 µg/ml for *P. aeruginosa*. According to the results, all examined *Vitis vinifera* L. varieties showed antibacterial activity the ethyl acetate:methanol:water (60:30:10) grape seed extract on growth of different bacteria [6]. However, our results demonstrated that some studied grape varieties were active against other bacteria (Table 1).

#### **Total phenolic content**

The phenolic contents are shown in Table 1. The total oil contents were ranged from 7.17 to 14.29%. The variation depends largely on the variety. As shown in the table, grape seeds are a moderate source of oil and protein. These findings were supported by Tangolar et al., 2009, [19]. The highest phenolic content was determined in seed of Eksikara (121.3 mg GAE/g), followed by Razaki (103.84 mg GAE/g), Siyah pekmezlik (90.16 mg GAE/g), Muşkule (81.23 mg GAE/g), Göküzüm (76.35 mg GAE/g), Akuzum (74.81 mg GAE/g) and Buzgulu (66.29 mg GAE/g). The results of similar studies for other cultivars follow; 50.66-58.91 mg GAE/g [20], 79.20-154.60 mg GAE/g [21], 11.17-24.43 mg GAE/g [22] and 25.03-48.03 mg GAE/g [23]. The phenolic content in seeds of Eksikara is relatively higher than those of the above-mentioned literature data. The results also revealed that total phenolic content of seed of Eksikara was found to be one-half times of that of Buzgulu. It is thought that the higher phenolic

contents from Eksikara and Razaki (the station with the milder climatic conditions) than those of Akuzum and Buzgulu (the harder climatic conditions) are result from different latitude.

#### **Table 1**

##### **Methanol content**

The alcohol compositions of varieties of the grape juice and are presented in Table 2. It was identified methyl and ethyl alcohol for the grape juice varieties and evaluated their compositions for species. The highest alcohol ratios are as follow; methyl alcohol; Eksikara, Razaki, Buzgulu, Göküzüm, Muşkule Akuzum, and Siyah pekmezlik, 12.01 g/µl, 8.7 g/µl, 3.21 g/µl, 2.72 g/µl, 1.02 g/µl, 0.21 g/µl and 0.03 g/µl, respectively. The highest ethyl alcohol ratios are as follow; 0.021 g/µl, 0.011 g/µl, 0.009 g/µl, 0.007 g/µl, 0.0001 g/µl, 0.0001 g/µl, 0.00 g/µl, same line, respectively. The results showed that methyl alcohol and ethyl alcohol level of varieties of the grape juice from Eksikara were higher than that of other grape cultivars. Similarly, Yilmaz and Toledo, 2006 [4] reported there are water, methanol, ethanol, acetone, and ethyl acetate in seeds of grape varieties.

#### **Table 2**

According to the analysis of juice of 35 grape varieties: average of methyl alcohol was 3.96 g/µl. It is not harmful. In our country, alcohol limit is 50 ml/dl [14]. This regard, the results is suitable Turkish Food Codex. Some researchers reported that there was a relationship between the chemical structures of the most abundant compounds in the tested products and the antimicrobial activity [24].

## **IV. CONCLUSION**

Consequently, the methanol content of grape juice and phenolic contents, antibacterial activities of seven cultivars were determined and compared. The results clearly indicate that there are differences in phenolic contents and antibacterial activities between them. These differences are thought to genetic features and different latitudes. In general, the present study revealed that *Vitis vinifera* L. extracts possess antibacterial activity against several tested microorganisms. Therefore, the extracts can be used as a source of natural antibiotics. According to the results, Eksikara, in terms of the phenolic content and antibacterial effect was found to be the best grape variety. But, methanol amount of this variety is the highest level. According to these results, seeds of grape varieties which is the highest antibacterial effect can be used as the type of wine.

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## TABLES

Table.1: Phenolic compound contents and minimum inhibitory concentrations (MIC) of extracts of seeds of grape varieties grown in Turkey

Grape Varieties	gram (+)		gram (-)		Phenolic comp. ( $\mu\text{g GAE/g}$ )
	<i>Bacillus cereus</i>	<i>Staphylococcus aureus</i>	<i>Klebsiella pnömanize</i>	<i>Pseudomonas aeruginosa</i>	
Eksikara	0,312 $\mu\text{g/ml}$	0,312 $\mu\text{g/ml}$	1,25 $\mu\text{g/ml}$	1,25 $\mu\text{g/ml}$	121.3
Akuzum	0,675 $\mu\text{g/ml}$	1,25 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	74.81
Buzgulu	2,5 $\mu\text{g/ml}$	1,25 $\mu\text{g/ml}$	5 $\mu\text{g/ml}$	5 $\mu\text{g/ml}$	66.29
Razaki	2,5 $\mu\text{g/ml}$	1,25 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	103.84
Muskule	2,5 $\mu\text{g/ml}$	0,675 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	5 $\mu\text{g/ml}$	81.23
Gokuzum	1,25 $\mu\text{g/ml}$	1,25 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	76.35
Siyah pekmezlik	0,675 $\mu\text{g/ml}$	1,25 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	2,5 $\mu\text{g/ml}$	90.16
Ampisid	0,5 $\mu\text{g/ml}$	1 $\mu\text{g/ml}$	64 $\mu\text{g/ml}$	128 $\mu\text{g/ml}$	

Table.2: Value of methyl and ethyl alcohol of juice of some grape varieties grown in Turkey

Sample(g/ $\mu\text{l}$ )	Methyl alcohol	Ethyl alcohol
Eksikara	12.01 $\pm$ 0.00	0.021
Akuzum	0.21 $\pm$ 0.00	0.011
Buzgulu	3.21 $\pm$ 0.00	0.009
Razaki	8.7 $\pm$ 0.00	0.007
Muškule	1.02 $\pm$ 0.00	0.0001
Gokuzum	2.72 $\pm$ 0.00	0.0001
SiyahPekmezlik	0.03 $\pm$ 0.00	0.00

# Soybean Breeding Aiming at increasing Productivity and Root-Knot Nematode Resistance

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**Abstract** - In Brazil, the root-knot nematode (*Pratylenchus brachyurus*) has gained importance, whatever because of the damage caused to soybean crops or because of its broad dispersion and incidences in producing areas. Therefore, this invention aimed at developing a new cultivar resistant to the major soybean diseases as well as to the root-knot nematode. As a result, we developed a soybean cultivar designated UFUS 8301. Generations were advanced by the single seed descent method. Value for Cultivation and Use assays were carried out during a 3-year period (2010/13). Distinctness, uniformity, and stability experiments were carried out during a 2-year period (2011/13). We used the reproduction factor (RF) statistics to assess damage and reproductive potentials of *P. Brachyurus*; analysis of variance tested differences between means. We accepted the null hypothesis there was no difference between UFUS 8301 and the parameter of resistance *Crotalaria spectabilis*. UFUS 8301 was found distinct from any other cultivar, homogeneous to the descriptors that had identified it and stable through generations. UFUS 8301 presented 19% oil and 39% protein on the seeds, and yield (3687.5 kg ha<sup>-1</sup>) above Brazilian national average.

**Keywords**—Brazilian Cerrado, Glycine max, *Pratylenchus brachyurus*, Soybean breeding.

## I. INTRODUCTION

Although Soybean [*Glycine max* (L.) Merr.] is grown primarily for grains production, its industrial uses range from feeding, production of yeasts and antibodies to manufacture of soaps and disinfectants. Concerning human consumption, this is used mainly as purified oil, in margarine, shortenings, cooking and salad oils. Besides, protein meals are dominated by soybean meal, which accounts for more than two-thirds of global protein meal production. The high-protein defatted and toasted soybean meal is used as a supplement in feed rations for livestock, such as poultry and swine, and recently also in aquaculture [1, 2].

Soybeans exports are dominated by Brazil and the United States, which together account for nearly 80% of global exports. Global soybean production has increased sharply in 2016, with the United States and Brazil registering record crops. Brazil is prospected to overtake the United States as the largest soybean producer, as more additional lands are made available, Brazilian production

is expected to grow at 2.6% per annum (p.a.) compared to Argentina (2.1% p.a.) and the United States (1.0% p.a.) [2].

Brazilian soybean-breeding programs have been able to increase agricultural diversification with new well-adapted crops, bringing new lucrative opportunities for farmers. The Ministry of Agriculture is responsible for both protection and registration of new cultivars. However, to be produced and marketed in the country, it is previously required to be included in the National Register of Cultivars, regardless of whether the new variety is protected or not.

Value for Cultivation and Use (VCU) and Distinctness, Uniformity, and Stability (DUS) tests are mandatory as part of the application process to register, protect and add a new soybean 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 assays must be carried out for a minimum two years to compare the performance of candidate varieties with varieties already on the National Register of Cultivars. Also, The DUS assays are performed to provide evidence that the candidate cultivar subject to protection is distinct from other(s) whose descriptors are well known, also is homogeneous within generations and stable to the same traits over successive generations.

In general, soybean genetic improvement is a process of production of the variability of desired traits intending selection of superior genotypes and seeds multiplication for commercial purposes. Several selection methods have been used to identify progenies who possess the most useful combination of wanted features. Most often, these include pedigree selection, by visual screening of the best-appearing families in each generation; single-seed descent, by advancing one seed or pod from each plant the next generation to develop homozygous lines; and bulk breeding, where a population is advanced in bulk until later generations with no artificial selection, when nearly homozygous lines are selected for yield assay [3].

In the soybean-breeding program at the Federal University of Uberlândia, to develop any new cultivar, we first define our goals according to problems and weaknesses of the current germplasm. In this context, the root nematode *Pratylenchus brachyurus* has gained importance in Brazil, whatever because of damage caused to soybean crops or for its broad dispersion and high incidence in producing areas, such as Cerrado.

A root-knot nematode survey in the north of Mato Grosso, in the 2016/2017 harvest and 2017-second crop, has pointed to the increasing of nematode populations numbers in all municipalities; all of 3328 samples

analyzed were found positive for *Pratylenchus* sp. presence [4]. *P. brachyurus*, like many other plant-parasitic nematodes, are microscopic worms that can be damaging to many crops. Across the world, many billions of dollars have been lost due to the damaging abilities of nematodes in cash crops [5]. In the Brazilian soybean fields, *P. brachyurus* has become increasingly common. Lima et al. [6] assessed *P. brachyurus* populations throughout Tocantins state in fields grown off-season and found this pathogen on 82% of samples, with densities ranging from 23 to 20,400 nematodes per 200 cm<sup>3</sup> soil, or 10 g root samples.

Therefore, our goal with this invention was developing a soybean cultivar able to meet producers need as resistance against major soybean diseases, including to the root-knot nematode, in addition to high oil and protein contents along with high grain yield. As a result, we developed a new cultivar designated UFUS 8301, which presents comparative advantages over others in high productivity and *P. brachyurus* resistance.

## II. MATERIALS AND METHODS

UFUS 8301 was derived from the crossing between IAC-8.2 x MG / BR 46 (Conquista) on the Capim Branco farm, located in Uberlândia, MG, Brazil; Latitude 18° 52' 94" S, Longitude 48° 20' 45" O, Altitude 835 m. Generations were advanced by the single seed descent (SSD) method. In this approach, each generation has only one single seed randomly selected from each plant, which is bulked to grow the next generation. In general, this procedure refers to planting a segregating population, harvesting a sample of one seed per plant, and using this one-seed sample to produce the next generation. Other methods as single-pod descent (SPD) and bulk methods (BM) produce redundant inbred lines that are descended from either the same F2 or F3 plant. However, single seed descent (SSD) has the advantage of minimizes the amount of genetic variability, although SSD method requires more time than SPD and BM [7].

Manual crosses produced hybrid seeds (F1). The F1s were grown on the field and allowed to self-pollinate to produce F2 seeds. One single seed from each F2 plant was collected and bulked to plant the F3 generation. F3 seeds were advanced by single seed descent (SSD) method until F6. Superior plants F6 were grown in the field, and the best lines were selected and assessed in progeny tests (F7). Progeny tests were carried out in a randomized block design, with three replications. Final yield assays were conducted 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 places in the Brazilian states Minas Gerais (MG), Goiás (GO) Mato Grosso (MT),

Bahia (BA), São Paulo (SP) and Piauí (PI) (Table 1).

Table.1: Breeding method, assays and selected features applied on developing of UFUS 8301.

<sup>a</sup> G/Y	Location	Method	Selected Features
F <sub>1</sub> 2003		Bi-parental crosses	Diseases resistance and grain yield
F <sub>2/3</sub> 2004		<sup>c</sup> SSD	
F <sub>4</sub> 2005		SSD	Diseases resistance
F <sub>5</sub> 2005	Capim Branco	SSD	
F <sub>6</sub> 2006	Farm MG	SSD	
F <sub>7</sub> 2006		Progeny-test	Diseases resistance and grain yield
F <sub>8</sub> 2007		Preliminary yield assay	
F <sub>9</sub> 2007/8		Intermediate yield assay	
F <sub>10/11</sub> 2008/10	MG, MT, BA GO	Final yield assay, <sup>b</sup> VCU	Diseases resistance and quantitative traits
F <sub>11/12</sub> 2010/13	MG, GO, MT, BA PI	VCU	

<sup>a</sup>G/Y = Generations/Year; <sup>b</sup>VCU = value for cultivation and use; <sup>c</sup>SSD = single seed descent.

## 2.1 Value for Cultivation and Use (VCU)

VCU trials were carried out during a 3-year period (2010/13), in a randomized blocks design with three replications. Plot sizes were equal to 5.0 m<sup>2</sup>. Experimental regions were labeled. The experiments in the Regions 302 (Ituverava, SP), 303 (Uberlândia, Urutaí, Itumbiara, Minas Gerais), 401 (Rondonópolis, Alto Taquari, Palmeiras de Goiás Goiás), 402 (Lucas Rio Verde, Sinop, Mato Grosso) and 403 (Porto Alegre do Norte, Mato Grosso) were carried out during 2011/12 and 2012/2013 growing seasons. Experiments in Regions 405 (Luís Eduardo Magalhães, Bahia) and 501 (Bom Jesus, Piauí) were carried out during 2008/2009 and 2009/10 growing seasons.

We have assessed 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. We computed the number of days from the emergence to maturation when 95% of pods were dried; and the vegetative cycle by the number of days from emergence to flowering (50% of flowering plants); maturity was reported in the first day on which 95% of the pods turned brown. We measured first pod insertion height from the soil level to the insertion of the first pod. We have assessed pod dehiscence using a scale ranging from 0 (no dehiscence) to 10 (complete dehiscence), and lodging resistance from 1 (no lodging) to 5 (all plants are prostrate) [8].

We assessed yielding per useful plots area to evaluate the productivity of cultivars and lineages; standardized to 13% of humidity and transformed into kilograms per hectare [9]. Oil and protein were assessed by NIR spectrophotometry and results were reported on an as is percentage basis.

Data obtained were assessed by analysis of variance considering 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;  $\mu$  = general mean;  $G_i$  = effect of the  $i$ -th genotype ( $i = 1, 2, \dots, g$ );  $B_j$  = effect of the  $j$ -th block ( $j = 1, 2, \dots, b$ );  $E_{ij}$  = experimental error.

The Scott-Knott test grouped means at 5% probability level. Experiments that had presented Coefficients of Variation higher than 20% were not computed in the yielding by region analysis.

We have assessed UFUS 8301 resistance, 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*.

## 2.2 *Pratylenchus brachyurus* resistance

We evaluated UFUS 8301 *P. brachyurus* resistance in a completely randomized design, with three replicates. The experiment was carried out from November 2013 to February 2014. A pure population of *P. brachyurus* inoculum was multiplied and maintained at greenhouse conditions in soybean plants. We have extracted *P. brachyurus* isolates from soybean roots through the method proposed by Coolen & D'Herde [10].

To assess damage and reproductive potentials of *P. brachyurus* populations, we have measured the reproduction factor (RF). This statistics has been widely used in nematological studies to define resistance and susceptibility of plants to nematodes. According to Taylor & Sasser [11], since the reproductive ability on a given



host is directly related to resistance nematode reproduction that can be used to measure root-knot nematode resistance. The FR is the ratio,  $R = \text{final nematode population}/\text{initial nematode population}$ , where  $R \leq 1$  indicates an inefficient host [12]. In our experiment, the RF was assessed 30, 60 and 90 days after inoculation. BRS MT Pintado was setting as the parameter of susceptibility, and *Crotalaria spectabilis* as the parameter of resistance. Santos et al. [13] have shown that the best moment for assessing the FR of soybean genotypes under greenhouse conditions range from 75 to 90 days afterward inoculation with *P. brachyurus*.

Analysis of variance (ANOVA) was used to test the differences between RF means. The null hypothesis stated there was no difference between the observed values and the expected value given by *C. spectabilis*, which is a poor-host *Pratylenchus* spp. The use of *C. spectabilis* in succession or rotation with soybean has been the most effective measure for the control of root-knot and root-lesion nematodes in infested areas [13, 14]. RF means were grouped by Scott-Knott at 5 % of probability level to find out the homogeneous groups, whenever the situation had led to a significant *F*-test [16].

### 2.3 Distinctness, uniformity and stability (DUS)

DUS experiments were carried for a 2-year period (2011/13) on the *Capim Branco* farm, latitude 18° 52' 94" S, longitude 48° 20' 45" O, Altitude 835 m, under conditions ensuring normal development of plants. For differentiation, characteristics contained in the official descriptor of the species/genus were used. As required by the Ministry of Agriculture and Food Supplies (MAPA) for completion of the detailed technical report, in each assay was included 300 plants, with three replicates. Distinguishability and stability were assessed in 20 plants. We evaluated the descriptors hypocotyl color, type of growth, pubescence color, flower color, pod color, the shape of the seed, integument color, and peroxidase reaction.

### III. RESULTS AND DISCUSSION

We found UFUS 8301 distinct from any other cultivar, homogeneous to the descriptors that had identified it, as well stable through successive generations. The number of atypical plants found in the DUS experiments was equal to 3. Conquista was found the most similar cultivar to UFUS 8301; therefore, it was used for differentiation purposes; traits that differentiate them both are described in Table 2.

Table.2: Most similar cultivar to UFUS 8301 and characteristics that differentiate them both.

Differentiating features	Features expression on MG / BR 46 Conquista	Features expression on UFUS 8301
Anthocyanin pigments	Present	Absent
Type of growth	Determinate	Determinate
Flower color	Purple	Wight
Pubescence	Brown	Light brown
Hilum color	Black	Medium brown
Plant size	Medium	Medium
<i>Pratylenchus brachyurus</i>	Susceptible	Resistant
<i>Meloidogyne incognita</i>	Resistant	Susceptible
<i>Meloidogyne javanica</i>	Resistant	Susceptible

UFUS 8301 presented determined growth and lodging resistance. Excessive vegetative growth might lead to lodging. Soybean lodging can reduce yield potential and increase harvest losses as lodged plants are more difficult to cut and gather into the combine [17]. Buzzello et al. [18] found a negative correlation between lodging and grain yield, and a positive correlation between plant height and lodging. UFUS 8301 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% [19].

Pereira Júnior et al. [20] described standard values of insertion of the first pod greater than 14 cm. However, according to Almeida et al. [21], the first pod insertion height should be higher than 10 cm because it is desirable to mechanical harvesting since that would avoid losses of uncollected pods due to its low insertion height. UFUS 8301 first pod height ranged from 10 to 11 cm (Table 3). Val et al. [22] assessed agronomic traits of 30 soybean genotypes in Jaboticabal, SP, 2012/2013 harvest, and observed first pod heights ranging from 5.40 to 20.73 cm; in particular, for Conquista, the most similar cultivar to UFUS 8301, that was equal to 13.07 cm.

Table.3: Average results of agronomic traits assessed in UFUS 8301.

<sup>a</sup> Reg	<sup>b</sup> DF	<sup>c</sup> DM	<sup>d</sup> PH	<sup>e</sup> FPH	100-seed weight (g)
302	45	129	71	10	14
401	45	122	70	10	14
402	46	118	70	11	14
403	44	119	69	11	14
405	45	120	65	10	15
501	42	121	67	10	14

<sup>a</sup> Experiments in Regions 302; 303; 401; 402; 403 were carried out in during 2011/12 and 2012/2013 growing seasons. Experiments in Regions 405 and 501 were carried out in during 2008/2009 and 2009/10 growing seasons. <sup>b</sup> NDF = Days to 50% flowering; <sup>c</sup> NDM = Days to maturity; <sup>d</sup> PH = Plant height at maturity (cm); <sup>e</sup> FPH = First pod height (cm).

Cordeiro Júnior et al. [23] studying the behavior of 30 soybean cultivars in Sao Paulo Northern, 2016/17 harvest, observed plant heights at maturity ranging from 47.92 to 88.75 cm. Arantes et al. [24] described features and use recommendations of soybeans indicated to the central region of Brazil; Conquista average plant height was reported to be equal to 80 cm. Another study performed in Jaboticabal, SP, 2012/2013 harvest, assessed agronomic traits assessed of 30 soybean genotypes, plant heights at maturity were reported ranging from 55.67 to 108.13 cm, Conquista average plant height was equal to 94.20 cm [22]. We found UFUS 8301 averages plant height ranging from 65 to 71 cm (Table 3).

As soybean is a photoperiod-sensitive and self-pollinated species, days to flowering and maturity, duration of flowering-to-maturity and plant height are crucial for soybean adaptability and yield [25]. The photoperiod influences soybean cultivars causing changes in behavior depending on the latitude, i.e., in Brazil, Arantes et al. [24] observed Conquista reaches maturity of about 130 days in Uberaba, MG (latitude 19 ° S); but in Sorriso, MT (latitude 15 ° S), it reached maturity at 110 days. UFUS 8301 has shown the life cycle of 118 to 129 days. Soybean flowering period is relatively extensive (ranging from 30 to 40 days) and overlaps with the formation of pods and seeds, which makes it resist short periods of drought during flowering [26]. Sudhanshu et al. [27] found that both days to 50% flowering and plant height have a direct effect on reducing seed yield. UFUS 8301 has shown 42 to 46 days to 50% flowering (Table 3).

Soybean yielding depends on numerous traits contributing to production, which might have their action linked. Therefore, the selection practiced on one

characteristic may simultaneously bring change in the other related feature. Path coefficient analysis has shown that seed yield/plant is a positive and significant association with biological yield, pods per plant and 100-seed weight, indicating that an intense selection for these characters will improve seed yield in soybean. Among these traits, 100 seed-weight exhibited the highest positive direct effect on seed yield [26]. The average weight of 100 seeds may vary depending on the sowing season and locality [24]; UFUS 8301 average 100-seed weight ranged from 15g to 14g (Table 3).

UFUS 8301 advantage to the producers was confirmed by comparing its productivity over other materials (Table 4). Besides, crop average national productivity estimated by the CONAB [28], from 2011 to 2013, recorded 2220.95 kg / ha<sup>1</sup>; the average productivity of UFUS 8301 in the same period was 3687.5 kg ha<sup>-1</sup> representing a productivity increase of 1.66 times.

Table.4: Production comparative results (kg ha<sup>-1</sup>) of UFUS 8301 and cultivars witness.

<sup>a</sup> Regions	302	303	401
<sup>b</sup> (CV %)	(12)	(13)	(12)
<i>UFUS 8301</i>	3700	3660	3660
<i>BRS 262</i>	3670	3550	3560
<i>M SOY</i>	3650	3590	3700
<i>Witnesses</i>			
<i>8001</i>	3650	3590	3700
<i>Emgopa</i>	3590	3630	3680
<i>316</i>			
<b>Regions</b>	401	402	403
<b>(CV %)</b>	(12)	(11)	(13)
<i>UFUS 8301</i>	3730	3700	3680
<i>BRSMG</i>	3650	3600	3760
<i>752S</i>			
<i>Witnesses</i>			
<i>Emgopa</i>	3700	3550	3540
<i>316</i>			
<i>MSoy 8001</i>	3750	3650	3670
<b>Regions</b>	405	501	
<b>(CV %)</b>	(11)	(12)	
<i>UFUS 8301</i>	3700	3670	-
<i>Sambaiba</i>	3670	3600	-
<i>Witnesses</i>			
<i>MSoy 8914</i>	3550	3656	-
<i>MSoy 8866</i>	3650	3650	-

<sup>a</sup> Experiments in Regions 302; 303; 401; 402; 403 were carried out in during 2011/12 and 2012/2013 growing seasons. Experiments in Regions 405 and 501 were carried out in during 2008/2009 and 2009/10 growing seasons. <sup>b</sup> CV = Coefficient of Variation.

Modern soybean is one of the world's most important crops mainly because of its high protein (40%) and oil (20%) content [29]. However, soybean oil and protein

content in the seeds are under polygenic genetic control, hence subject to environmental effects. We found 19% oil content and 39% protein content UFUS 8301 seeds (Table 5). In the study performed in 2010/2011 harvest, in the central region of Brazil, Conquista seeds were reported to hold 42.70 % protein, and 19.70 % oil content [24].

Table.5: Oil and protein contents percentage found contents in the seeds of UFUS 8301 and the cultivars witness.

<sup>a</sup> Reg	UFUS 8301		Witnesses					
			BRS 262		M Soy 8001		Emgopa 316	
	<sup>b</sup> O	<sup>c</sup> P	O	P	O	P	O	P
302	18	38	19	39	18	38	-	-
303	19	39	18	39	19	38	-	-
401	18	39	18	38	18	38	18	38
			BRSMG 752S		Emgopa 316		MSoy 8001	
401	18	39	18	38	18	38	-	-
402	19	38	18	39	19	38	18	39
403	18	39	19	39	18	39	19	39
			Sambaiba		MSoy 8914		MSoy 8866	
405	19	39	19	39	18	39	18	39
501	18	38	18	38	19	38	19	38

<sup>a</sup> Reg = Experiments in Regions 302; 303; 401; 402; 403 were carried out in during 2011/12 and 2012/2013 growing seasons. Experiments in Regions 405 and 501 were carried out in during 2008/2009 and 2009/10 growing seasons; <sup>b</sup> O = Oil; <sup>c</sup> P = Protein.

The diseases are among main factors limiting the increase of soybean yield. In recent years, many soybean diseases and plagues have already been reported for the crop; however, its incidence and severity depend on factors such as climate, cultivars, pathogen inoculum potential, soil structure and fertility, plant vigor, among others [30]. We found UFUS 8301 resistant to the virus VMCS (soybean mosaic virus), and to bacterium *X. axonopodis* pv. *glycines* (bacterial pustule) and *P. syringae* pv. *glycinea* (bacterial blight). Bacterial pustule and bacterial blight can occur in all soybean-producing regions. However, most of the cultivars in use are genetic resistance to these bacteria; therefore, nowadays, these are considered minor diseases problem [30]. Also, UFUS 8301 was resistant to *C. sojina* (frog-eye leaf spot) and *P. gregata*. In Brazil, some *C. sojina* breeds have already been detected; fortunately, most soybean cultivars in use are genetic resistance to these breeds. However *P. gregata*, the fungus that causes the disease known as brown stem

rot can be severe in soils with reduced fertility and when temperature and moisture are favorable for soybean seed development [30].

UFUS 8301 was also resistant to *D. phaseolorum* f. sp. *meridionalis* (stem canker) and *F. solani* (fusarium root rot). Stem canker is a fungus adapted to regions with higher temperature; all Brazilian soybean cultivars currently in use are resistant to this pathogen. The fusarium-root-rot damages vary and depend on the intensity of the inoculum and environmental conditions; however, the decline in yield in some soybean producing regions might be evident [30]. We also found UFUS 8301 moderate resistant to powdery mildew. The fungus *M. diffusa*, which is common in plants grown in greenhouses, causes this disease; however, the vast amount of spores formed on the leaf surface lately is easily disseminated by the wind, and this disease is gaining economic importance, leading to the need for chemical control in many soy-producing regions [30].

Regarding the root-knot nematodes *M. incognita* and *M. javanica*, UFUS 7401 have not shown resistance; however, it has proved to be unfavorable or poorly adapted to the *P. brachyurus* reproduction. There was no significant difference, by the Scott Knott test at 5% probability, between UFUS 8301 and *C. spectabilis* (Table 6).

Parameter of Resistance	Cultivars	RF
<i>Crotalaria spectabilis</i> FR = 1.14 b	UFUS Carajás	12.78 a
	UFUS Mineira	11.70 a
	UFUS 105	7.16 a
	Pintado	6.98 a
	UFUS Vila Rica	5.02 b
	BR 46 (Conquista)	3.70 b
	UFUS 119	3.68 b
	UFUS 32	3.56 b
	UFUS Guará	3.50 b
	UFUS 37	2.84 b
	UFUS 8301	2.56 b
	UFUS 7401	1.70 b
	UFUS 8401	1.54 b
	UFUS 6901	1.40 b
<sup>b</sup> CV (%)		25.80

<sup>a</sup>Averages followed by the same letter constitute a homogeneous group by the Scott Knott test at 5% probability; <sup>b</sup> CV = Coefficient of Variation.

There has been considerable progress in our knowledge of microorganisms and push-pull plants (e.g., *C. spectabilis*) that contribute to the biocontrol of nematodes [31]. According to Monteiro [32], despite *Crotalaria* species are generally unfavorable or poorly adapted to the

reproduction of *Pratylenchus* spp., some breeds can multiply or remain in these plants as these reactions vary as species and their populations in both plants, and parasites. Therefore, this might explain our *Crotalaria* RF results superior to one (Table 6).

#### IV. CONCLUSION

We developed a new soybean cultivar with high productivity and resistant to *P. brachyurus*; that aspects represent comparative advantages over others cultivars current in use in Brazil. UFUS 8301 has been included in the National Registry of Cultivars (RNC) under *P. brachyurus* resistant status, register number 33899. Seed production has begun in by the Federal University of Uberlândia (UFU), Uberlândia – MG 2014, in compliance with the regulations of MAPA. Recommended cropping from October 20 to December 10 in growing seasons in Minas Gerais, Mato Grosso, Bahia, Piauí, São Paulo and Goiás states. Ideal population density is 240 to 270 thousand plants per hectare. Suggested production systems are no-till and conventional tillage.

#### ACKNOWLEDGMENTS

Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG).

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# Experimental Planning Factorial: A brief Review

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**Abstract**— *The optimization of experimental relevance parameters can be considered one of the most critical steps in a scientific work according to the chosen model may contribute to a result that does not match the true great. Thus, it is of utmost importance to the observation of the effects of the variables and the interaction between them in a given system, and the multivariate optimization systems, based on factorial design of experiments, a useful and simple alternative, given the need to assess simultaneously the effect of a large number of variables and their interaction between them from a small number of trials. In this paper, we present concepts related to optimization of multivariate procedures with emphasis on experimental design systems experiments and their application in studies of various areas of knowledge, proving its efficiency in the analysis of multivariate systems. Inclusion criteria for articles were: original articles and research on factorial experimental design in common use in laboratories in different fields of research, including studies and pre-installation already installed and in Portuguese, English and Spanish.*

**Keywords**— *Factorial design, experimental planning, multivariate analysis, factorial experiment.*

## I. INTRODUCTION

Perhaps one of the most critical stages of a scientific work is related to the optimization methodology of experimental parameters of relevance. According to the methodology chosen is not always possible to evaluate the interaction between the variables and may contribute to a result that does not match the great or true. Then make use of methodologies factorial experimental designs that can analyze multiple variables at the same time to the same factor (CUNICO, 2008; PERALTA-ZAMORA, 2005).

Freund; Wilson; . Mohr, (2010a) and Dias-Mayer et al, (2017), points out that the methodological systems

planning of the experimental projects, the methods must be carefully analyzed, being sophisticated techniques with statistical experiments (ANDERSON; WHITCOMB, 2010), for the purpose of collection of data or evidence has the objective of contributing to an investigator to exercise knowledge about one or more questions about his work.

To better understand the processes that are being monitored in a particular research is of utmost importance to the observation of the effects of the variables and the interaction between them (NETO et al 2007; PEREIRA FILHO et al., 2002). In this sense, the optimization of multivariable systems have shown great momentum and is useful in various fields of knowledge, received attention in studies involving biotechnological processes (PERALTA-ZAMORA et al. 2005).

Moura et al (1999) mention about the advantages of employing a multivariate analysis on the recognition of genetic mismatch along allow identification of genetic variability sources, the size of each character analyzed for genetic divergence as well as the levels of P (phosphorus) more appropriate, in addition to the best combinations with greater chances of success for crosses.

In their study, the authors mentioned above, investigated the feasibility of multivariate analysis to identify sources of genetic variability among lines of sweet pepper, whereas nutritional efficiency R and the most appropriate doses, as well as the most appropriate feature of the plant to the selection process .

Silva et al (2016) was used in multivariate analyzes together exploratory study units known as clustering. A hierarchical method with main components to assess the associations between the production components and product doses Ribumin, a conditioner of soil, applied in corn cultivars. The purpose of the multivariate analysis technique for grouping is to gather

the sample units and groups so that there is homogeneity within the group and heterogeneity between them.

However, multivariate optimization systems, based on factorial design of experiments, have proven a useful and simple alternative given the need to simultaneously evaluate the effect of a large number of variables and the interaction between them from a small number of trials (PEREIRA FILHO et al 2002; PERALTA-ZAMORA et al 2005; CUNICO et al 2008).

Freund; Wilson; Mohr, (2010b) points out that in the factorial experiment is expected to examine the effect of two or more causes the same type of sampling unit. On a study laboratory factorial experiment can be utilized to analyze the differences in the yields of several varieties, as well as the different levels of function of a microorganism, for example. A model in each combination in all levels of factors are applied. It is experimental units. From this perspective, understand and project the statistical control of all experimental units of a sample leads to excellence of quality of processes of goods and services of the final product to be desired.

to get net score in results of surveys algorithms require data simultaneously applying several factors for each experimental unit in a biotechnology laboratory it is necessary to check its quality and veracity, using bases STATISTICS to validate the survey data to be indexed. Thus, the process of Experimental Planning Factor, it is an essential factor for the development of work in order to mitigate errors in front of tests to a job (FREUND; WILSON, MOHR, 2010b; LEARDI, 2013).

The Experimental Planning Factor It is one statistical tool that can be used to check the logic of the real synthesis method and establish whether it is necessary to revalidate the tests used to access the data provided in a search. A factorial experimental design defines the imposition to make changes in the data production of synthesis in order to establish control of processes such as monitoring and control of processes with the purpose of detecting possible upgrades in the development and processes of research tests. Additionally, it assists in taken preventive decisions, becoming thus intended action to eliminate the possible causes of an impending shift of an unwanted situation in order to prevent these causes can come actually to occur (ANDERSON; WHITCOMB, 2010; FREUND; WILSON, MOHR, 2010a, 2010b).

Anderson; Whitcomb (2010); Bishop; Petersen; Trayser, 1982; Day-Mayer et al. (2017) having a factorial experimental design is to have a tool that allows to investigate each sample tested during the research meeting the requirements of procedures and protocols used by the researcher, in which, prior to testing, if performed a bibliographic. The review should have a focus at

synthesis quality systems, to demonstrate that what is being producing or being analyzed has been previously validated even if the work is unpublished, demonstrate that to then have the final product quality. Research requires adequate statistical power, sufficient sample to detect scientifically sound effects (JAN & SHIEH, 2016).

### 1.1 Multivariate Analysis Tools

According Bracarense; Takahashi (2014) and Anderson; Whitcomb (2010) by joining one factorial design becomes important to its use as a part of a gradual improvement process to identify areas of stress that can be allocated effectively. Factorial Experiments are tools like ANOVA, DOE, factorial design 2k, 3k or Periodic Review product (RPP), among others factorial experimental designs that can evaluate possible unwanted situations that the experiment could suffer.

ANOVA can be used to estimate the main effect of each variable and the interactions between them. The main effect is the difference between the average response of a particular variable in a level and this average response at another level, collapsing on the levels of all other variables (COLLINS et al., 2014). The analysis of variance (ANOVA) is considered the best approach when it is desired to relate various means (BOAVENTURA et al., 2017).

But the design of experiments (DOE) provides a conceptual interface through research that disrupt a phenomenon in order to understand their behavior and it is a way to understand the process through the establishment of mathematical relationships from beginning to end of the process (POLITIS et al., 2017; BESSERIS, 2013). Such planning is also an indispensable apparatus in any scientific endeavor that requires information collected Validation (BESSERIS, 2013). Efficiency and effectiveness in designing, collecting and explain the experimental observations are essential in many areas, from engineering to management, providing a solid foundation as the main tactic of research in the physical sciences, health and social (DEJAEGHER & VAN DER HEYDEN 2011, KNIGHT et al., 2012, OBERG & VITEK, 2009).

DOE is a statistical method to establish which variables are important in the process and in what conditions these variables should work in order to optimize the process (ILZARBE et al., 2008). Its fundamental structure for implementation as well as its conversion project and interpretation of data were established by FISHER & BENNETT (1990).

More broadly, an experiment can be defined as a procedure in which a system or process purposeful changes are made to variables in order to come to evaluate the possible undergone changes due to the response

variable, as in order to analyze the changes their reasons. The design of an experiment is the process of planning and executing an experiment. The statistical experimental design point is defined as the set of instructions to assign observational or experimental treatments units (FREUND; WILSON; MOHR, 2010a, 2010b).

Any experiment planning first begins with the definition of objectives, subsequently determined how it

will measure performance and finally we list the controllable factors that can affect performance (KENETT; STEINBERG, 2014).

According Kenett and Steinberg (2014), for an experiment to be considered statistically designed, some issues require determination (Table 1).

Table.1: Issues to consider in an experiment planning.

Questions	
1	<i>Definition of the problem;</i> Description of the problem of language, as was the identification, who is responsible for product / process consideration.
2	<i>response variable;</i> What and how will be evaluated; how data will be collected.
3	<i>control factors;</i> What factors can be controlled by the analyst, or planning decisions.
4	<i>factor levels;</i> What are the levels of current factors and what are the reasonable alternatives.
5	<i>noise factors;</i> What factors can not be controlled during regular situations, but can be controlled in an experiment, and what factors simply can not be controlled, but can be observed and recorded.
6	<i>experimental matrix;</i> What are the main effects and interactions of interest. What is the total number of runs of the experiment. What is the power required detection against which alternatives. What are the experimental conditions.
7	<i>Number of repetitions of the experiment and order;</i> What is the maximum number of replications in each experimental run. In which order experiment will be conducted.
8	<i>Data analysis;</i> How will data be analyzed? Who will write the final report.
9	<i>Budget and project control;</i> Who is responsible for the project. What is the budget. How will the calendar. What resources are needed.

**Note.** Adapted from (KENNET; Steinberg, 2014).

The experimental design separates into two distinct phases: 1) screening phase (screening phase) and 2) modeling phase (phasemodeling) (BOX et al, 2005).. During the screening process, a group of variables receives a consideration stochastic based on their power levels shown from one or more response (MONTGOMERY, 2006). Only statistically dominant effects are introduced to the modeling phase. Screening can help make the information acquisition costs and more manageable knowledge (THOMKE, 1998).

For screening experiments, we consider the maximum possible variables (WANG, 2007) And once the

screening is completed the important factors are selected and studied through the use of more complete designs which include designs three factor levels and able to withstand the effects of quadratic growth or higher (POLITIS et al., 2017). However, in manufacturing processes it is necessary to explore some of the interactions between two factors taken into account for this, are chosen projects that are able to assess the interaction between these two factors. Being able to use the expertise in related fields and draw the experiment considering these interactions and leaving it to find the best design for the experiment (WANG, 2007).



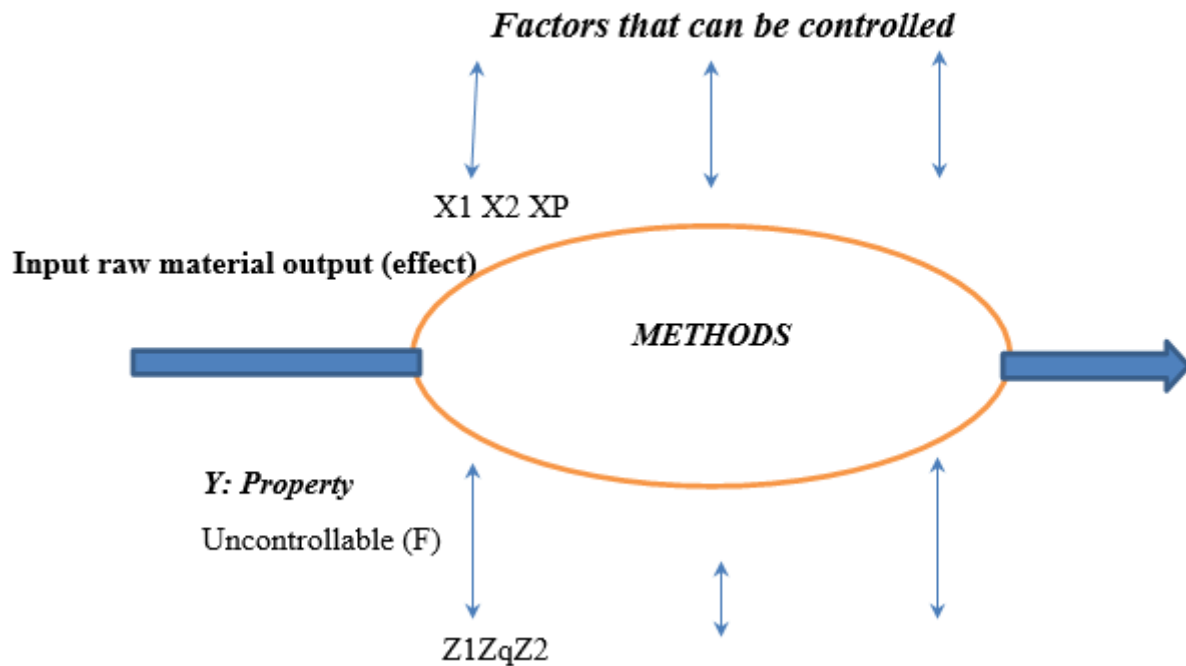


Fig.1: Source: Bertoline, (2012). Experimental flowchart. (Adapted by the authors, 2018).

It is necessary to consider some basic principles when planning an experiment in order to ensure that data is obtained in order to provide a correct analysis leading to valid conclusions regarding the problem under study, namely, the principle of repetition, the principle of casualization and local control principle (BORTOLINE, 2012).

This query or literature review possessed intended to check the registered specifications of experimental designs that may or may not be used of in a search, your goal is to present a theoretical and didactic knowledge of varieties of methods of a factorial design so you can help in the understanding and production of experimental design in order to optimize the work on an experimental scientific research.

## II. METHOD

To identify articles on the subject was held search in the databases PubMed, ScienceDirect, Scopus and Scielo. The factorial experimental designs have based on the study of the influence of each variable in response study, covering in its experimental field the effects of influence between the variables of the systems, and the search strategy consisted in the use of key words in English: 1. Factorial design, 2. Experimental planning, 3. Multivariate analysis and 4 factorial experiment. The

following filters have been added to search on ScienceDirect: only journals; title, abstract; key-words.

After consulting the databases and application of search strategy, studies repeated between different searches were identified. Inclusion criteria for articles were: original articles and research on factorial experimental design in common use in laboratories in different fields of research, including studies and pre-installation already installed and in Portuguese, English and Spanish.

The grouped articles were excluded in order: repeated irrelevant review, other publishing formats (notice, short communications, perspectives, letters), and other languages. In addition, manual searches were made in reference lists of review articles found with the predetermined keywords.

## III. RESULTS

After removal of the articles repeated between the different searches, the exclusion criteria were applied, as shown in Figure 2. Of the remaining 100 articles were retrieved 66 original research articles involving multivariate optimization in scientific papers in different areas of knowledge. Through manual search were recovered 2 more items. All articles related, after the exclusion criteria were related to the experimental design.

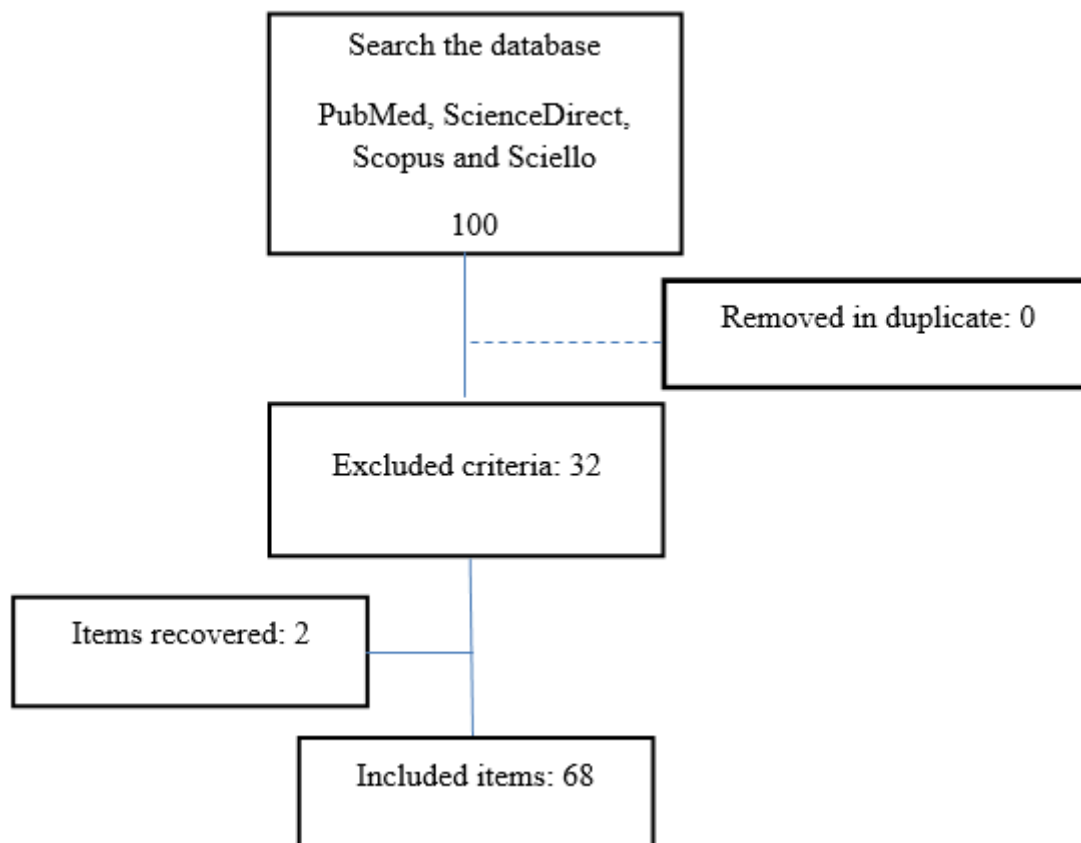


Fig.2: Flowchart of identification and selection of items. (Prepared by the authors, 2018).

### 3.1- FACTORIAL EXPERIMENTS

The factorial experiment is a statistical tool that presents itself as a planned experiment, allowing you to observe the effects that several factors tend on a result. The factors from a variety of reactions allows to evaluate both a multitude of factors in an experiment (ANDERSON; WHITCOMB, 2010; WEBSTER, 2006; FREUND; WILSON; MOHR, 2010a, 2010b).

Factorial designs have the advantage of allowing the presumption of the effects of interaction between the various factors in addition to providing greater accuracy to estimate the effects of individual factors (DEY, 2011).

According to (PATIENCE, 2013), tools and techniques to plan, execute, analyze and apply results of experimental or development programs range from basic shapes such as trial and error, to detailed statistical plans that start with the selection of projects to identify factors as variables. According to Patience (2013), the trial and error is present with the intuition of the researcher, namely his experience is effective when it begins to understand a problem. Patience (2013) states that despite the understanding, in most cases this strategy is inefficient compared to an experimental project, in which the factors are modified in defined increments at specific levels. Different, but with a didactic sense, LEITE LIMA et al., (2017) qualifies a variable according to its attributes.

The experimental factorial design is effective in the study of two or more factors (Jaynes et al., 2013). The main effect may be defined as the change in the response due to a change in the factor level. The effect of interaction between the factors understands that the difference of a factor is not the same at all levels of the other factors. The main set of effects and interaction effects are the factor effects (WU & HAMADA, 2009).

ANDERSON; WHITCOMB, (2010) and KAREL D. VOHNOUT (2003) state that a factorial design can be defined as full or fractional. A full factorial experiment is an action of the researcher to measure responses vThe holiday combinations of factor levels. In full factorial experiments, the effects of the intervention components, or variables are independent, which makes it possible to estimate separately the main effect and their higher order interactions (JAYNES et al., 2013).

In addition, the factorial experiment is able to efficiently estimate the main effects by the average of the other effects, the geometric growth of their samples while additional variables are added (ALLORE & MURPHY, 2008). The full factorial experiment can be the most efficient way to investigate a series of intervention components (COLLINS et al., 2009). In many cases, the main effects of five, six, or more factors can be studied with adequate power using the same sample

size would be needed for a single factor (COLLINS et al., 2009). Full factorial experiments are possible even with cluster randomization (DZIAK et al., 2012).

However, there is a disadvantage of the full factorial design. According LEITE Lima et al., (2017) and NAHUM-SHANI; DZIAK; COLLINS (2017) the disadvantage is that it related to increase in the number of experimental tests, as the factors or numbers expand. In this way ALASONATI et al., (2015) recommends reducing the maximum possible number of factors and the number of levels of each factor, otherwise the experimental design will be slightly manageable and very complex model. Using this reduction strategy in the number of variables it is possible a focus on key factors or variables (ANTONY, 2002).

When there is a large number of experimental factors you need to consider a fractional factorial design (Cochran & Cox, 1957). fractional factorial designs as well as offer many of the advantages of a full factorial design requires significantly smaller experimental conditions and is a variation of factorial designs, involving the use of a subset of the experimental conditions of a full factorial design, wisely chosen to preserve the main statistical properties (NAHUM-SHANI DZIAK Collins, 2017).

In a fractional factorial design only a fraction or a subset of the full factorial experiment is selected and used (Allore & MURPHY, 2008). The fractional factorial experiments have been abundantly used in various research areas (ZHOU, BALAKRISHNAN, & ZHANG, 2013).

The choice of which implement conditions has important consequences for the inference, this is done strategically, usually using software to allow an estimate of the effects of primary interest (DZIAK et al., 2012). The fraction is chosen by selecting one or more independent generators (FLEISS 1999) defining which variables are confounded with the main effects (COCHRAN and COX, 1957).

The confounded effects can not be estimated separately and distinguished from each other because the experimental levels of each matrix are identical in the experimental design (ALLORE & MURPHY, 2008). The interactions of more than two variables are considered harmlessly confused while the misconception about the main effects and two-way interactions need to be carefully considered (ALLORE & MURPHY, 2008). The procedure called blocking in factorial designs occurs when it is not possible to perform a large number of homogeneous plays together when this occurs the division into smaller executions is necessary, and is connected to confounding phenomenon (RAMAKRISHNAN, 2005).

To ensure that the effects of importance are not placed together is essential for the fractional factorial

design to be chosen a definition of relationship, which usually covers the choice of settings to ensure that only the words corresponding to factor the effects of higher order are included in relation (WOODS & LEWIS, 2017).

The resolution of a plan indicates the highest degree of interaction that is not confused with other interactions of the same order (COCHRAN & COX, 1957). This type of experiment can be useful when resources are limited or the numbers of experimental factors are larger, allowing the use of smaller numbers of tests (PATIENCE, 2013).

Furthermore, in clinical studies also using partial-factorial experiment. The partial factorial experiment is a study where the population is randomized. The study is a randomized controlled clinical trial use in medicine where certain variables that can be controlled, can seek to identify the relationship between these variables. The study seek to identify the relationship of the use of a drug and the improvement of patients. If you can control a determiner factor in at least a factor of interest and a subset of this population is randomized on one or more factors. The choice of how to restrict the random assignment has been determined by economic constraints, geographical or clinics (ALLORE & MURPHY, 2008).

Second STEWART (2005) and LEITE LIMA et al., (2017) the factorial design is basically to conduct a survey of factors of a given experiment to analyze and evaluate the effects they exert against each other and on the final product. Still LEITE LIMA et al., (2017) this final product is the number of tests performed.

### 3.2 - Factorial designs 2K

Several authors have considered the factorial design as an important statistical tool capable of generating precise and accurate results, and enable the evaluation of multivariate way systems, optimizing all the variables that were part of the experimental system COSTA et al. (2006). Its application can be verified (Table 2) and is used in various projects developed in different areas of knowledge.

In general, this type of design is represented by  $k$ , where  $b$  represents the number of levels chosen and  $k$  the number of variables or factors (CUNICO et al., 2008). The levels are commonly called "high" and "low" or "absent" and "present," represented as follows: "+" and "-", "0" and "1", respectively (BORTOLINE, 2012).

This model is able to demonstrate the outstanding advantages of factorial design in a series of single factor studies. A wide range of research problems associated with interactions, main effects, among others, can be examined in terms of a linear combination of the average effects. It emphasizes that the designated linear comparison is the hypothesis of interest and reveals essential information

that can not be obtained from only factor studies (JAN & SHIEH, 2016).

Factorial Experiments two levels have the advantage of the fact does not always refer to a quantitative parameter can be used for qualitative questions, but also have pitfalls. They have only an approximation within experimental range; It does not contain replicated information; and being performed in just two levels are not able to consider quadratic terms (BRERETON, 2018).

Because they are easy to use the factorial design of two levels are widely popular, moreover have simple calculations, but when the number of factors is

considerable number of experiments to be performed becomes large, the front that makes it necessary to use other types of experiments (BRERETON, 2018).

### 3.3 - WORKS OF RESULTS WITH PLANNING FACTOR

Several authors have considered the factorial design as an important statistical tool capable of generating precise and accurate results, and enable the evaluation of multivariate way systems, optimizing all the variables that were part of the experimental system COSTA et al. (2006). Its application can be verified (Table 2) and is used in various projects developed in different areas of knowledge.

Table.2: Methodology From factorial arrangement in multivariate analysis

Methodology	Reference
Randomized block design with factorial design	Moura et al. 2012
	Silva et al. 2016
	Lisboa et al. 2016
	Cajazeira et al. 2018
	Gobbi et al. 2008
Completely randomized design with factorial design	Silva et al. 2018
	Chagas et al. 2013
	Tomala et al. 2014
	Peralta-Zamora et al. 2005
	Fandín and Duran 2004
	Cossa and Sirqueira
	Santos et al. 2018
Full factorial design on two levels	Lima and Gouveia 2012
	Maretti, E. et al. (2016)
	Antony, J. (2002)
	Costa et al. 2006
	FREUND; WILSON; MOHR, 2010a
	Neto et al. 2007
	Webster, BJT (2006)
	Macagnan et al., 2017
	KATOVIC et al., 2001
	Jan, S. & Shieh, G., 2016
Fractional factorial two levels	Alasonati, E. et al. (2015)
	Zhou, Q. et al. (2013)
	Wang, PC (2007)
	Jaynes, J. et al., 2013
	Dziak, J. et al., 2012
Factor planning with central points	Besseris, G., 2013.
	Collins, L., et al., 2014
	Allore, H. & Murphy, T., 2008.
	Peloi et al. 2016
	Pereira Filho et al. 2002



Factorial design in three levels	Bonaventure, RS et al. (2017)
Full factorial design ( $2^k$ ), individual experiments ( $2k$ ), single factor ( $k + 1$ ) and Fractional factorial design	Collins, L., et al., 2009

Investigated the work, according to the table mentioned above it was established the importance of using this model in the evaluation of statistical experimental data

(Figure 3) to generate a precise answer and quality in various areas of knowledge, as described below.

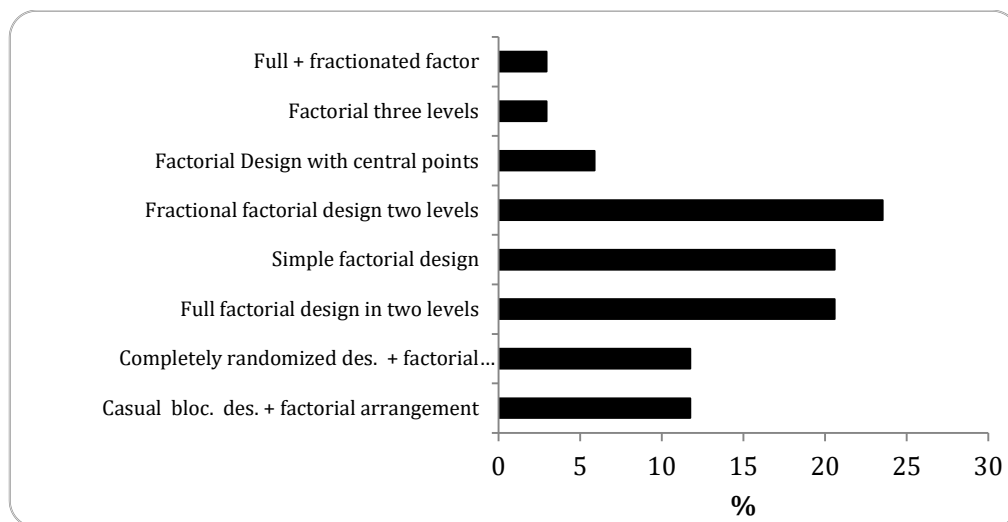


Fig.3: Use of factorial design in scientific papers.

To Cossa and Sirqueira (2009) factorial arrangement enabled him assess the multivariate way system and correlate all the variables related to the experimental system, they evaluate the use of tire compounds with polypropylene powder, in order to check the influence of input variables, represented by (Tire powder, dicumyl peroxide and bismaleimide) on the response variables, comprising (tensile, elongation and oil swell).

Similar, Cunico et al. (2008) found the practical application of experimental design in the statement of a study of relevant operational variables optimization, aimed at curing of methyl methacrylate (MMA) from the commercial acrylic glue B20 (BERKEL).

Since Chagas et al (2013) used a factorial arrangement  $5 \times 2$  to evaluate the performance and pathophysiological of tambaquis responses (*Colossoma macropomum*) fed with feed supplemented with  $\beta$ -glucan corresponding to five different concentrations of immunostimulatory two sampling times.

For this same species, (TOMALA, 2014) with the objective of evaluating the consumption of oxygen according to body weight at different temperatures, we used a completely randomized design with a factorial arrangement  $5 \times 3 \times 3$ , and (40, 60, 90, 140 and 250 g), and ( $21.26$  to  $31^\circ \text{C}$ ), respectively, with three replications. Associated with other statistical tool. ANOVA, the results

showed that oxygen consumption is related to temperature and inversely proportional to body weight.

Amaral et al (2017) used the experimental design for assessing the production of protease *Aspergillus niger* (SIS18) present in agroindustrial waste media, whey and cream residue. In his work took 22 type, ie adopted two levels +1 and -1 with two variables represented by the serum concentrations of glucose and Leite to the Leite and cream and residual glucose concentration for the second residue tested.

Also according to the authors, it could be seen through the results expressed in matrix encoded factorial design, that was maximum proteolytic activity in the assay two, ice cream and represented by residue glucose concentrations.

Already Arancibia et al (2010) used the factorial design in two stages, in order to optimize a procedure for determining zinc in seawater using voltammetric square wave stripping voltammetry (SWAdSV). In both cases, we used the planning on two levels, with four factors at first, being the variables analyzed pH, concentration of oxine (Cox), time (TADs) and potential (Eads) and the second adsorption optimum values of pH and Cox, by variance analysis showed that these two are the most significant parameters mentioned. The factorial analysis showed the best contractions are  $6.0$  to  $25 \text{ mmol L}^{-1}$ , respectively.

Peloi (2016) to determine the antioxidant capacity and determination of total flavonoids in *Verbena minutiflora* also appealed to the factorial design. Initially used in the extraction method where the variables for the determination of antioxidant capacity were pH, liquid extraction method, and extraction time. Subsequently the determination of total flavonoids evaluating variables: the concentration of hexamethylenetetramine, type of acid, acid volume, and heating time. According to their results the authors concluded to be the factorial design an important tool for extraction optimization of chemical components in natural products.

The effect of some variables on the enzymatic hydrolysis of sugarcane bagasse was investigated by Lima Gouveia (2012) using the factorial design at two levels with four variables 24, temperature, stirring (rpm), ethanol concentration and steps of adding enzymes, the latter being variable that showed significant result according to the authors.

A randomized block design in a factorial  $4 \times 2 + 6$  was adopted by Lisboa et al (2018). This type of design, beyond the principle of repetition and randomization, considers the principle of local control by establishing blocks. In his factorial design, the authors contemplated four cultivars of common bean intercropped with hybrid cultivars of castor, plus the cultivars mentioned in monoculture.

Together with other statistical tools, the aforementioned authors were able to identify which of the tested bean species showed better adaptation to the consortium with castor hybrids.

Maretti et al. (2016) used full factorial design of two levels, with no focal points and with three replicates for each level to assess the influence of new parameters pre-freezing of post SLNas (sets of solid lipid nanoparticles) and factors related to the process of pre-freezing aiming to increase the inavailability SLNas filled with inhalable rifampicin. From the application of a DoE the author concluded that a quick freezing associated with a certain degree of dilution of the sample prior to the freezing step was able to refrain from the use of cryoprotectants, leading to extremely inhalable SLNas production showing income powder they require the use of excipients.

#### IV. FINAL CONSIDERATIONS

Given the above it was found that the experimental design is a very important tool in the application of statistical analyzes in scientific papers, to allow a more complete analysis covering all the variables that make up the system, evaluating them simultaneously from the one fewer experiments compared with other univariate models. We found that many of the works for

this article the most essential relative contribution resulting from the interaction of the researchers who make use of statistical methods has been to bring a better understanding of the logical questions that relate to the study. Further to this, we note that many of the scientific contributions are made during the early stages of the experimental design, which proceed to formal consideration of questions of a statistical project with data analysis.

Its application proved effective in the various areas of study, such as medicine, chemistry, agribusiness, veterinary, biotechnology and pharmaceuticals, reinforcing the finding of other authors of the force that this type of system has shown in recent years in various fields of knowledge. A large fragment of statistical literature focuses on the contribution that aleotorização and factorial experiments, and other formal statistics beliefs, contribute to the logic of the development of experimental programs.

A limited number of authors argue the methods that can obtain quantitative and qualitative information that is important to the logo of the period of project planning stages for a search. In examples we can mention that this important information can be obtained from construction diagrams with logic that should describe the proposal of the actions of experimental programs that the researcher want to study. Create exercises diagrams serve as a stimulus to manage evidence to support the needs of the shares, to remove logical inconsistencies in the experimental approach or to generate new ideas.

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# Double-Display Media in Geometrical Optics Learning in Vocational High School

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**Abstract**— *This research is oriented on analysis of the impact of Double-Display media on Geometrical Optics learning used by students to improve students' learning outcomes and concept understanding. This research aims to determine the effectiveness of Double-Display media in Physics's subject Geometrical Optics. The effectiveness of Double-Display media as a learning tool is determined by the improving of students' learning outcomes and concept understanding. It is a quasy experimental research which is implemented in Vocational High School Islam Pajarakan class IX academic year 2017/2018 with a number of 36 people. Data collection techniques used in this research, are observation, tests, and documentation. The result showed that the use of Double-Display media in Geometrical Optics subject can improve learning outcomes by increasing the N-Gain score of 0.9 and it can be said as high category with the level of concept understanding of translation, interpretation and extrapolation are 97%, 86%, and 68%. Concluded the use of Double-Display Media on Geometrical Optics subject can increase students' learning outcomes and students' concept Understanding.*

**Keywords**— *Media Double-Display, Effectiveness, Geometrical Optics, Concept Understanding.*

## I. INTRODUCTION

Physics is one branch of Natural Science. Physics as the heart of the development of information and communication technology has fundamentally changed human life. Physics consists of many concepts that are generally abstract and concrete. The difficulty many students face is interpreting various concepts of physics. It is because students are required to be able to interpret the physical knowledge precisely and not vague or unambiguous meaning. Physics is one of the lessons that has contributed greatly to the development of science and technology and is widely used in everyday life (Sanders, 2007).

Physics' subject which has an obstacle in direct observation is Geometrical Optics. One of its material taught is formation of shadows in mirror and lenses. It is an abstract subject and difficult to observe directly. So, the students need a fit media to understand physics' subject

more actively (Coca, et al., 2013). Physics with abstract characteristic is difficult to visualize and makes the students difficult in studying the concept of physics. (Yanti, 2017) Generally, students solve physics problems by using formulas. Whereas physics is a science that begins with analyzing the symptoms or natural processes. It often happens because students do not understand the concept of physics so that students see physics as a difficult lesson (Omek, et al., 2008).

One strategy of using computers as a learning medium is composing a multimedia-based media. These new concepts and the developments show that the advances in the digital era have broadened the learning processes and enabled higher levels of learner interactions in order to make learning more meaningful for overcoming the insufficiency in rote learning (Dembo & Seli, 2012). Utilization of multimedia as a source of information in learning methods can improve the achievement of learning outcomes (Anitah, 2009:61).

Multimedia can be defined as a mixture of various media (text, images, audio, video, animation) that is compiled in a complete, integrated, and appropriated to the learning objectives by utilizing computer equipment. In this way the process of teaching and learning will be more interesting, so that will improve the achievement of student learning outcomes. Combining various media (text, image, audio, video, animation) can use Kvssoft Flipbook maker application.

The interactive simulation display can be equipped by combining video, animation, audio, even virtual labs so that it can use Double-Display Media to blend them all. By using Double-Display, it is expected to help students to visualize an abstract subject matter, so that students can understand the material maximally.

Double-Display Media is an animation media that blends all visuals of verbal, graphic, image, audio, animation, and video into a simple view with a double display. Double-Display can be interpreted two views. The Double-Display media is designed by combining two views with a first view contain of the physical phenomena in everyday life that can be viewed from videos and other displays showing how the process of physical phenomena occurs. The application of Double-Display is packaged in

two views aimed at letting learners get a clear visualization of the concept under study and become a special advantage. It is because learners are indirectly invited to understand concepts in the real environment. The virtual laboratory is an interactive medium, so it not only shows but also allows students to manipulate equipment, collect, analyze data, prepare experimental reports, and draw conclusions based on data and graphs (Darrah, Humbert, Finstein, Simon, & Hopkins, 2014).

The development of computer-assisted learning software is considered proper and important to do (Wagiran 2008: 229). It is because it can give a great effect to the learners in improving the quality of learning, learning motivation, and support individual learning. The use of e-Flipbook (Double-display) can also improve understanding and achievement of learning outcomes (Nazeri, 2013). The use of interactive multimedia in Physics learning creates a student-centered learning environment. Students can be entertained, relaxed and can produce a better understanding of what they learn, and can improve students' science process skills (Chuang & Yang, 2005; McLaughlin & Arbeider, 2008; Knighton & Smoak, 2009; 2005; Rohaida & Kamariah, 2005). Objectives raised by the researchers is analyzing the effectiveness of student learning outcomes by using Double-Display media in Physics Learning Geometrical Optics subject.

Based on the description above, this research aims to determine the effectiveness of Double-Display media on Physics' subject Geometrical Optics. The effectiveness of Double-Display media as a learning tool is determined by the improving of students' learning outcomes and concept understanding.

## II. METHODOLOGY

The type of this research is quasy experimental research. It was implemented at Vocational High School Islam Pajarakan class XI academic year 2017/2018 consisting of 36 students. This research is oriented on analysis of the impact of Double-Display media on Geometrical Optics learning used 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 conceptual understanding is in the form of written tests on post test amounted to 2 esay 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 Double-Display 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 Double-Display media can be seen in table 1.

Table.1: The effectiveness of student learning outcomes using double-display media

No.	Pre-test average value	Post-test average value	N-Gain	Category
1.	14	91	0,9	High

Conceptual understanding is the ability to grasp insights such as being able to understand or understand what is taught in a particular problem or situation. Conceptual understanding can be classified into 3 categories, namely understanding of translation, understanding of interpretation, and understanding of extrapolation. In this development test 3 understanding of the concept is measured through post-test activities implemented at the last meeting. The result of the analysis of students' physics concept after using Double-Display media can be seen in Figure 1

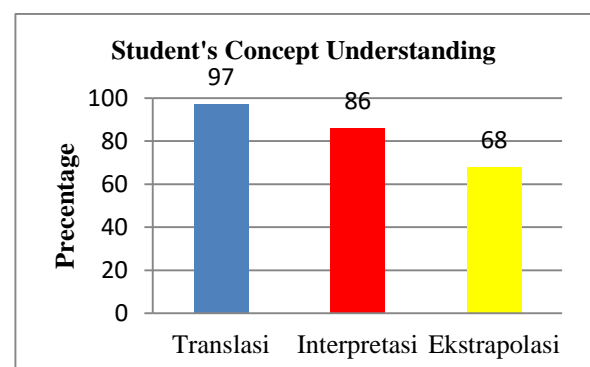


Fig.1: Students' conceptual understanding outcomes after using double-display media.

## IV. DISCUSSION

Figure 1 shows that improving of students' learning outcomes using Double-Display Media has a high category with a total N-Gain score of 0.9. Another study implemented by Hayati in 2012 media flipbook used to measure student learning outcomes. The result of the analysis shows that using Flipbook media (double-display) improves learners' learning outcomes (Hayati, 2012). Sugianto, et al (2013: 115) states that flipbook maker based e-module get a positive assessment because the learning materials become very easy to understand by students, in addition, the operation of the module is very easy, the elements of music and animation is considered to increase the motivation, and learning activities of the learners. Thus learning using Double-Display media can increase student learning outcomes.

Data of students' physics conceptual understanding shows that the percentage of translation's conceptual understanding reaches 97% and interpretation's conceptual understanding reaches 86% with very understandable category, whereas in extrapolation comprehension reaches 68% with enough understood category. So as a whole of students' physics conceptual understanding can already be categorized "understood" with an average of 84% with the most percentage on Translation conceptual understanding. Thus using the Double-Display media can also help the students in understanding the concepts, moreover on the material difficult to delivered by using real media and abstract material. students more easily understand the concept with the existence of learning media (Jatmiko, et al., 2016) and (Wicaksono, et al., 2017).

Students' physics conceptual understanding is divided into three categories, namely understanding of translation, understanding of interpretation, and understanding of extrapolation. Understanding of translation with indicator of students able to write and translate symbols of known variable, questioned and described the matter into the form of the image has a percentage of 97% greater when compared with understanding of translation and extrapolation. However, extrapolation understanding has the lowest percentage when compared with the other aspects of conceptual understanding. Understanding of extrapolation is a conceptual understanding that prioritizes students able to predict the continuation of the existing tendency according to certain data, on this matter of extrapolation understanding refers to the question of analysis. From the value of conceptual understanding obtained prove that learning using media Double-Display is effective. It is as written by Shabiralyani (2015) suggests that visual Aid arouses students' interest and help teachers explain concepts easily. A visual aid is a learning tool used in the classroom to encourage teaching and learning process.

The results of this study supported by Wijayanto's research (2014) states that the development of module that is packed in electronics allow students to be able to learn independently because it can be read by using a computer or electronic book reader. Meanwhile, according to Gunawan (2010) electronic module that is interactive will involve audio visual, sound, movie and others and the program is easy to understand so that it can be used as a good learning media.

## V. 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 Double-Display Media on Geometrical Optics subject can increase student learning outcomes with increased score N-Gain 0.9 and fairly high category. It is supported by the average percentage of students'

conceptual understanding after using the Double-Display Media on Geometrical Optics subject of 91% with the "very understood" category so that Double-Display media can be said to be effective.

Suggestions that can be given for further research are 1) This Double-Display Media will be more effective if the number of computers used equals to the number of students; 2) Double-Display Media Development can be applied to the broader scope of educational institutions with different materials to know the level of effectiveness.

## ACKNOWLEDGEMENTS

The author would like to thank the Faculty of Teacher Training and Education (FKIP) of Jember University which had provided support in writing this journal.

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# Performance of Reference Evapotranspiration Estimation Methods at the Southern Paraná, Brazil

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**Abstract**— Knowing the atmospheric potential demand (ET<sub>o</sub>) implies in quantifying the ability of vegetated surfaces in absorbing water from the soil aiming at irrigation scheduling, crop yield prediction and water balance studies at a given site. Such information is extremely useful even under non-irrigated systems, for it makes possible to adjust sowing date within the crop growing season as a function of the local soil water availability, conditioning therefore a better reclamation of rainfall regime. Crop yield is significantly affected by the atmospheric conditions in order to galvanize researchers to scrutinize the regime of physical environment variables which directly interfere into the consumption of natural resources of crops in production fields. The aim of the current work was to investigate which of the atmospheric evaporative demand estimation methods are more suitable to depict physical reality of the water loss process in order to maximize crop yield and optimize irrigation scheduling under the climatic conditions of Southern Paraná, Brazil. The following methods were tested at two distinct sites of the studied region concerning its performance, taking into account the Penman-Monteith (FAO-56) approach as a standard reference for comparison purposes: simplified Penman, modified Bowen, Hargreaves-Samani, Camargo, and Linacre. The meteorological elements used for the calculation of ET<sub>o</sub> were monitored by an automatic weather station from Campbell Scientific Inc. throughout the years of 2008 through 2013. We concluded that empirical methods showed an unsatisfactory performance, whereas those methods that took into consideration net radiation as an input variable performed better, being the latter hence to be considered for agricultural planning and also for agrometeorological studies aiming at sustainability of the regional agriculture. The simplified Penman and modified Bowen methods were more accurate for estimating ET<sub>o</sub> in order to provide irrigation scheduling and indicate local soil water status at the region in study, because dismiss information on wind regimes that govern evapotranspiration rates.

**Keywords**—Potential evapotranspiration, modeling, agrometeorological studies, irrigation, sustainable agriculture.

## I. INTRODUCTION

Reference evapotranspiration is a biometeorological element depicting in practical terms atmosphere evaporative demand with the aim of defining the ideal amount of water irrigation to be adopted at the right time throughout the crop growing season at a given site, conducting prediction studies of crop production and water balance. It is defined as the amount of water lost from the surface grown with grass or alfalfa fully covering the soil at an active development stage, with a uniform height, leaf area index of roughly 3 exposed to the prevailing atmospheric conditions under no water restriction and with a fetch sufficiently large and well irrigated to minimize advection towards the experimental area (Thornthwaite, 1948; Allen et al., 1998; Pereira et al., 2011).

Regimes of local meteorological elements condition atmosphere evaporative demand and in turn water loss rates by means of stomata along with water uptake by the roots so that the plants might perform its metabolic processes within an optimal of physiological efficiency to provide maximization of crop production. Either photosynthesis or plant transpiration takes place at a given site as a function of atmosphere evaporative demand. Being crop transpiration considered to be a physiological loss to assure photosynthetic activity and therefore primary productivity expression, it is quite pivotal to get to know potential atmospheric demand at a particular site for the purpose of planning agricultural practices in production fields.

Crop water consumption may be measured by means of high precision lysimeters. However, owing to high installation costs and management of equipment determining crop water consumption by making use of mathematical equations in conjunction with specific crop coefficients comes to being a feasible alternative to be borne in mind (Medeiros, 1998).

Silva and Rao (2006), by working with sub-irrigation lysimeters at the region of Rodelas, Bahia State, Brazil, assessed the performance of different estimation methods of reference evapotranspiration (ET<sub>o</sub>) aiming at determination of peanuts water ideal climatic demand and verified that Class A pan, Hargreaves, and Thornthwaite methods were the most appropriate for an efficient irrigation management.

Sousa et al. (2010), by scrutinizing the performance of ET<sub>o</sub> estimation methods at four irrigated perimeters belonging to the state of Sergipe by the Class A pan, Solar Radiation, Hargreaves-Samani, Linacre, and Penman-Monteith, being the latter taken as a reference in a comparative study, drew the conclusion for the region in study that the Solar Radiation approach was the one that provided the best performance.

Several scientists sought to evaluate ET<sub>o</sub> at different sites aiming at recommendation of methods more accurate and suitable for calculation as a function of availability of local meteorological data (Zhang et al., 2008; Syperreck et al., 2008; Ambas; Baltas, 2012; Nouri et al., 2012; Luo et al., 2014; Shiri et al., 2015; Ershadi et al., 2015; Qiu et al., 2015).

Faced with the aforementioned, the aim of the current manuscript was to monitor agricultural environmental variables that govern biological responses of crops grown at the region of Campos Gerais, state of Paraná, Brazil. In order to give support to irrigation planning of crops with regional economic importance, prediction of crop production and water balance studies we evaluated the performance of ET<sub>o</sub> estimation methods that most approached to calculated values obtained by the Penman-Monteith approach at the studied sites (Villa Nova and Pereira, 2006; Villa Nova et al., 2006; Villa Nova et al., 2007; Alfaro et al., 2013; Pereira et al., 2014).

## II. MATERIAL AND METHODS

An automatic weather station from Campbell Scientific Inc. was installed at an experimental area belonging to the State University of Ponta Grossa – UEPG – Ponta Grossa, PR, Brazil, under the following geographic coordinates: latitude of 25°11'S, longitude of 50°08'W, and altitude of 800 m. For the municipality of Arapoti, PR, the geographic coordinates are as follows: latitude of 24°16'S, longitude of 50°06'W, and altitude of 966 m. The climatic formula according to the Köppen climate classification for both sites in study was Cfb (Alvares et al., 2014).

The following local meteorological data were monitored by the weather station over the course of the years comprised between 2008 and 2013 at both Ponta Grossa and Arapoti municipalities, state of Paraná, Brazil: air temperature and relative humidity (HMP45C Temperature and Relative Humidity Probe), precipitation

(CSI model TB4), barometric pressure (CS106), wind speed and direction (MET ONE model 034B), global solar radiation flux density (pyranometer LI-200X), net radiation (NR LITE), and photosynthetic active radiation (Quantum LI-190SB).

All of the sensors were coupled to a data acquisition system; model CR-1000, from the Campbell Scientific Inc., which were programmed to perform readings with a frequency of 60 seconds storing averages at each 15 minutes.

For ET<sub>o</sub> assessments the following estimation methods were taken into account herein: Penman-Monteith (FAO Standard – 1998) (ET<sub>o</sub>PM), modified Bowen (Villa Nova et al., 2007)(ET<sub>o</sub>BM), simplified Penman (Villa Nova et al., 2006)(ET<sub>o</sub>PS), Camargo (Camargo, 1971)(ET<sub>o</sub>C), Hargreaves-Samani (Pereira et al., 2002) (ET<sub>o</sub>HS), and Linacre (Linacre, 1977) (ET<sub>o</sub>L).

In a study dealing with assessment of estimation methods of alfalfa maximum evapotranspiration, Santos et al. (1994) cited by Medeiros (1998) concluded that estimation for a five-day period or larger intervals showed satisfactory outcomes whilst on a daily basis it revealed uncertainties, evidencing that there is a proclivity for error stabilization from estimates obtained for a five-day period.

The Penman-Monteith approach was chosen as the standard method to estimate ET<sub>o</sub> because it demonstrates that calculated values are rather close to measured grass evapotranspiration at a given site and also points out its superiority in relation to other methods (Cai et al., 2007; Gavilan et al., 2007; Xing et al., 2008). Such a method is based on physical processes and, explicitly incorporates physiological and aerodynamic parameters into it. There are several methods reported in the literature to estimate ET<sub>o</sub>, but their performances at different agricultural environments vary, since most of them present empiricism in their conceptualization (Sentelhas et al., 2010).

By taking into consideration ET<sub>o</sub> information one might be able to determine crop coefficient or relative water consumption, which varies as a function of crop and physiological age of the plants. Such a bio-meteorological element allows for an ideal irrigation water amount determination to be applied throughout the whole crop growing season in such a way as to assure maximization of crop yield and minimization of costs of production at a farm level. ET<sub>o</sub> turns out to be a physical environmental variable of a great importance for irrigation projects that can be utilized to provide support for assessment surveys associated with climatic risks, which in turn are directly related to the zoning of sowing dates of non-irrigated farming systems.

ET<sub>o</sub> data calculated at the region of Campos Gerais, Paraná state, were subjected to analysis of variance along with application of F test, as well as to a simple

linear regression analysis study aiming at a definition of the best ETo estimation approach. Coefficients of determination ( $R^2$ ) were calculated to assess precision of the estimates and agreement indices (d) proposed by Willmott et al. (1995) were determined to quantify accuracy or exactness of the studied methods.

In addition to such statistical parameters, we determined the coefficients of performance of mathematical models proposed by Camargo and Sentelhas (1997), given by the product between the Pearson correlation coefficient (r) and Willmott agreement index (d), as well as mean absolute error (MAE) of estimates in conjunction with NSE (Nash Sutcliffe Efficiency) index, which refers to a standardized index of optimization analysis of models proposed to correlate residual variance to measured variance (Nash and Sutcliffe, 1970).

### III. RESULTS AND DISCUSSION

The model proposed by Villa Nova et al. (2006) (EToPS) refers to a simplification of the method originally

idealized by Penman-Monteith (FAO Standard – 1998) (EToPM) based on the fact that a considerable portion of evapotranspiration is essentially ascribed to available energy and considering that other input variables of the original equation (FAO Standard – 1998) are built in the value of S (tangent to the water vapor saturation pressure curve). Under a sensitivity analysis on different estimation methods of evapotranspiration, Ambas and Baltas(2012) concluded that solar radiation and air temperature constitute the main meteorological elements that predominately govern water loss process from soil-plant system, since air relative humidity and wind regimes affect less evapotranspiration rates.

ETo values estimated by the simplified Penman method were quite similar to those obtained by the Penman-Monteith approach for both sites in study (Figure 1), with overestimates for increasing values in conjunction with deviations lower than 1 mm day<sup>-1</sup> (MAE corresponding to 0.019 and 0.041 for Ponta Grossa and Arapoti, PR, Brazil, respectively).

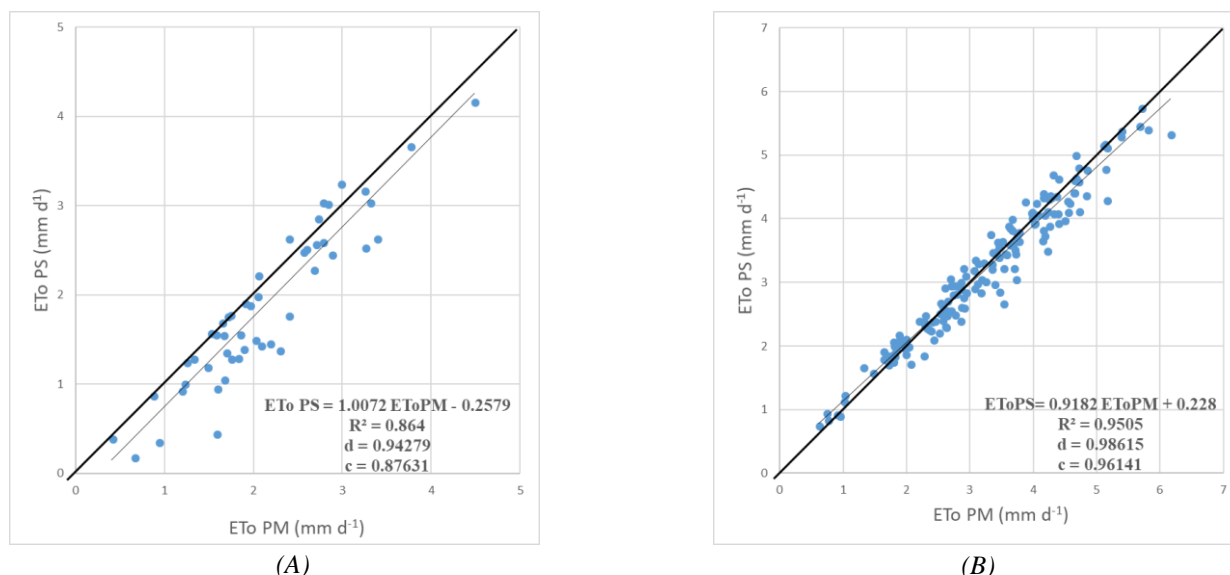


Fig.1: Confrontation between reference evapotranspiration estimated by the classical Penman-Monteith approach (EToPM) and potential demand calculated by the simplified Penman method(EToPS) for the period comprised between March 27, 2008 and August 22, 2011 at Ponta Grossa (A), and between August 26, 2011 and October 14, 2013 at Arapoti (B), PR, Brazil (averages of a 5-day period).

Ershadi et al. (2015), by making use of the NSE statistics to confirm the outcomes obtained from their studies, found NSE values ranging from 0.07 to 0.66 for the model idealized by Penman-Monteith, once NSE varying from 0 to 1 indicate good fittings to the model under confrontations between predicted and observed data. Such a statistical tool is based on comparison of the moment of magnitude 2 for each individual observation in relation to the moment of magnitude 2 centered on averages of observed data. Therefore, NSE index evidences the average of deviation squares for punctual

observations in comparison to the variance of original data.

Under the prevailing atmospheric conditions of the current study NSE indices ranging from 0.68 to 0.94 as a function of confrontation between EToPS and EToPM at the municipalities of Ponta Grossa and Arapoti, PR, respectively, were obtained. The aforementioned statistical parameter depicted an excellent fitting of the estimates generated by the simplified Penman model, being then in consonance with calculated Willmott agreement indices (d) for both sites, as well values of performance coefficient

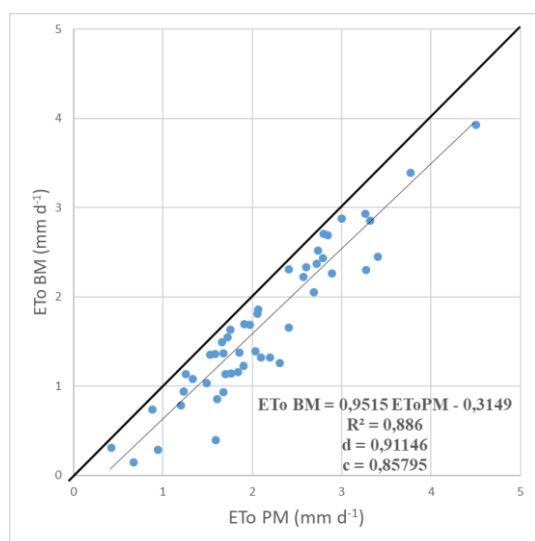


(c) considered to be classified as optimal (Camargo and Sentelhas, 1997) (Figure 1).

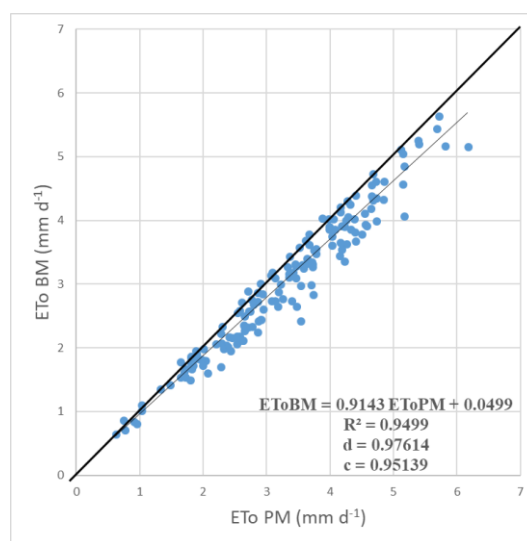
Energy balance approach allows for evapotranspiration estimation even under inadequate soil water supply conditions, besides turning out to be a straightforward and cheap approach (Nouri et al., 2012). Given its applicability and direct relationship with other methods often has been adopted as a reference for evapotranspiration estimation (Qiu et al., 2015).

The simplified Penman model demonstrated to be more accurate and precise than the modified Bowen approach (Villa Nova et al., 2007) at the studied sites

(Figures 1 and 2). The confrontation between EToBM and EToPM provided MAE ranging from 0.026 to 0.053 mm day<sup>-1</sup> along with NSE between 0.62 and 0.90 for Ponta Grossa and Arapoti, PR, respectively. Such statistical parameters apart from relating positively with Willmott agreement index (d) and model performance coefficient (c) have been considered to be optimal for both sites, and also denote a lesser sensitivity of the model to the local climatic variations by taking into account the similarity of responsiveness of such methods tested at the sites in scrutiny.



(A)



(B)

Fig.2: Confrontation between reference evapotranspiration estimated by the classical Penman-Monteith approach (EToPM) and potential demand calculated by the modified Bowen method (EToBM) for the period comprised between March 27, 2008 and August 22, 2011 at Ponta Grossa (A), and between August 26, 2011 and October 14, 2013 at Arapoti (B), PR, Brazil (averages of a 5-day period).

The modified Bowen method overestimated reference evapotranspiration in relation to the classical FAO Penman-Monteith approach, agreeing with the outcomes reported by Zhang et al. (2008) who also obtained evapotranspiration rates way above those ones determined by the energy balance – Bowen ratio approach – in comparison to the Standard FAO estimation method.

By evaluating the performance of the Hargreaves-Samani approach at Ponta Grossa and Arapoti municipalities, we came up with for both sites values of angular coefficients of the regression equation rather close to 1. The need for a preliminary local calibration of the Hargreaves-Samani model to meet regional atmospheric demands has been the target of concern on the part of

scientists from all over the world, such as Shiri et al. (2015) and Luo et al. (2014).

In general, the Hargreaves-Samani approach overestimated evapotranspiration at 0.5 mm day<sup>-1</sup> in relation to the FAO Standard model at the region of Campos Gerais of Paraná. This is because such a model was developed for dry climate regions, generating then overestimates of ETo at humid climate regions. By scrutinizing NSE values for the specific-studied sites (0.57 and 0.63, respectively, for Ponta Grossa and Arapoti, PR), it was possible to conclude that such a model could not be generally utilized to calculate ETo without local preliminary calibrations (Figure 3).

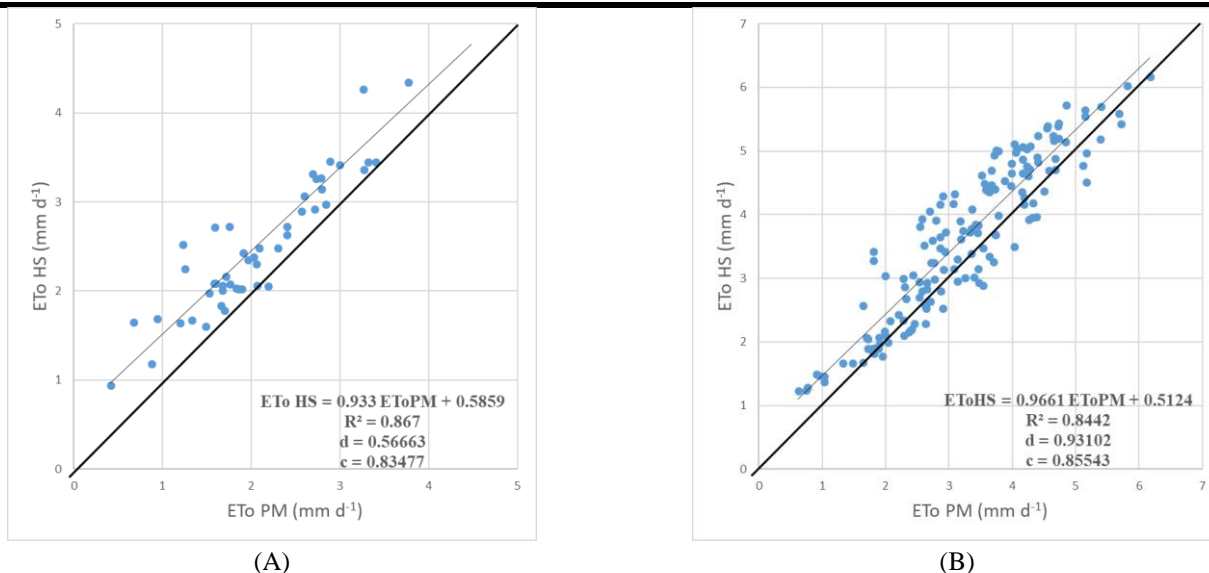


Fig.3: Confrontation between reference evapotranspiration estimated by the classical Penman-Monteith approach (EToPM) and potential demand calculated by the Hargreaves-Samani method (EToHS) for the period comprised between March 27, 2008 and August 22, 2011 at Ponta Grossa (A), and between August 26, 2011 and October 14, 2013 at Arapoti (B), PR, Brazil (averages of a 5-day period).

The model proposed by Camargo (1971) takes into consideration environmental variables governing evapotranspiration rates at a given site, such as daily extraterrestrial solar radiation, expressed in mm day<sup>-1</sup>, daily mean air temperature and number of days for the period in analysis. Such a model replaced in the Thornthwaite nomogram the annual calorific index (I) with a thermal index (T), which corresponds to the mean air temperature throughout the period and location in study (Camargo and Camargo, 2000; Carvalho et al., 2011).

By comparing the performance of Camargo method with the FAO Standard approach at the bay of the

river Jacupiranga, located in São Paulo state, Brazil, Borges and Mendiondo (2007) observed a good correlation between both potential demand estimation methods, having the Camargo approach showed high reliability indices and being opportune to highlight herein that such a model turns out to be more suitable to assess evapotranspiration rates at hot climate regions. When tested under the climatic conditions of Palotina, PR, Brazil, the aforementioned method presented good results that might be confirmed by the model performance index c (Syperreck et al., 2008).

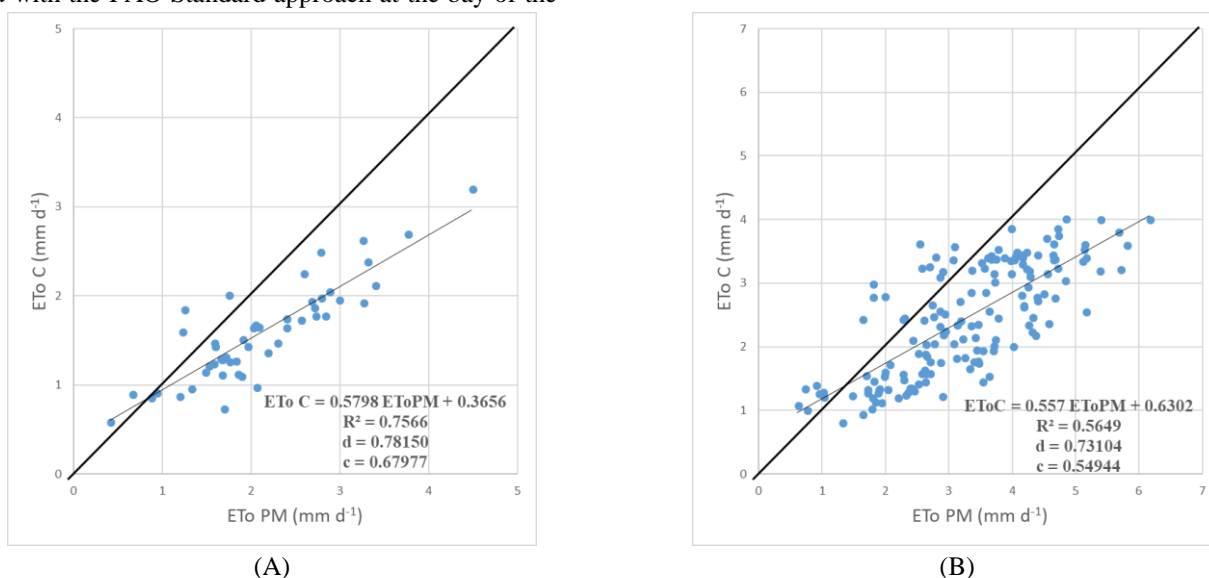


Fig.4: Confrontation between reference evapotranspiration estimated by the classical Penman-Monteith approach (EToPM) and potential demand calculated by the Camargo method (EToC) for the period comprised between March 27, 2008 and August 22, 2011 at Ponta Grossa (A), and between August 26, 2011 and October 14, 2013 at Arapoti (B), PR, Brazil (averages of a 5-day period).

Scrutiny on the relationships between EToPM and EToC values demonstrates that the dispersion of the data around the trend line is greater than that promoted by other tested methods (Figure 4). The method of Camargo (1971) revealed to be adequate to estimate ETo at a monthly scale, and for such a reason it showed more pronounced fluctuations in a daily basis when compared to the FAO Standard approach. The values of Willmott agreement index (d) were corresponding to 0.782 and 0.731 for Ponta Grossa and Arapoti, PR, respectively, in conjunction with a model performance index (c) of 0.679 and 0.549, respectively, classified as sufferable according to performance criteria proposed by Camargo and Sentelhas (1997). NSE value for the municipality of Ponta Grossa was of -0.64, whereas for the municipality of Arapoti was of -0.66, a point that restricts its utilization at the region of Campos Gerais of Paraná for five-day periods due to its lower precision as opposed to that one provided by the modified Bowen and simplified Penman methods.

The method proposed by Linacre (1977) is a mere simplification of the original Penman method. The term that expresses the difference between mean air temperature and dew point temperature present in such a method may be estimated as a function of local altitude, mean air temperature and extreme air temperatures, as well as by the difference between mean air temperatures of the most hot and cold months in a monthly basis (Carvalho et al., 2011).

Mendonça et al. (2003) compared rates of reference evapotranspiration measured at weighting

lysimeters with calculated values of ETo obtained from different estimation methods at the Northern Rio de Janeiro state, Brazil. The outcomes coming from such a correlation study indicated that for the 10-day periods the coefficients of determination ( $R^2$ ) were of 0.82 for the Penman-Monteith, Linacre and Jensen-Haise methods. Nevertheless, high correlations between observed and calculated ETo values revealed that the latter came to being the most appropriate estimation method for the hot climate regions, highlighting according to Henrique and Dantas (2007) that Linacre and Thornthwaite methods did not generate satisfactory results to estimate ETo in a daily basis.

Henrique and Dantas (2007) found variations of ETo estimates obtained by the Linacre approach ranging from 2.0 to 2.5 mm day<sup>-1</sup>, whose values were quite similar to those calculated by the same method at both studied sites. For the region of Campos Gerais of Paraná, EToL rates did not surpass 3.0 mm day<sup>-1</sup>. The observed values of Willmott agreement index (c) yoked to the confrontation between EToPM and EToL were of 0.408 and 0.241 at Ponta Grossa and Arapoti, PR, respectively, in conjunction with model performance indices (c) of 0.289 and 0.190, having been therefore classified as terrible according to Camargo and Sentelhas (1997). The NSE value for Ponta Grossa was of -16.03, whilst for Arapoti it was corresponding to -59.07, which denotes a conspicuous unfeasibility of application at both specific-sites in study (Figure 5).

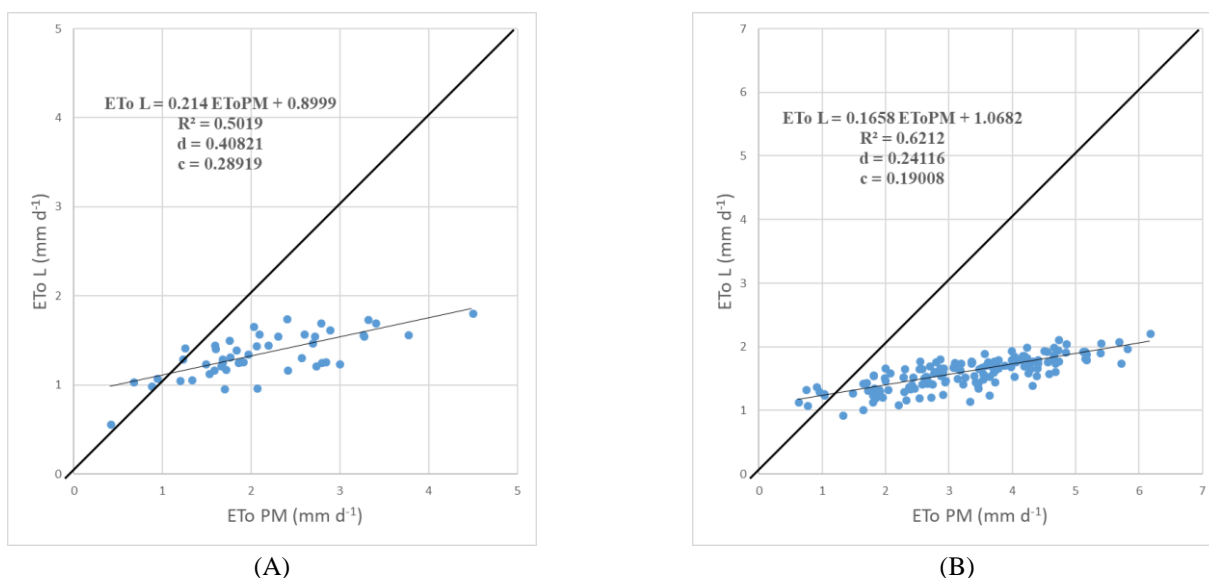


Fig.5: Confrontation between reference evapotranspiration estimated by the classical Penman-Monteith approach (EToPM) and potential demand calculated by the Linacre method (EToL) for the period comprised between March 27, 2008 and August 22, 2011 at Ponta Grossa (A), and between August 26, 2011 and October 14, 2013 at Arapoti (B), PR, Brazil (averages of a 5-day period).

The unsatisfactory performance of the Linacre method at the studied region is attributed to the mild prevailing local climate, with normal annual mean temperature of Arapoti being quite lower than that observed in Ponta Grossa besides the fact that such a method does not estimate ETo with a high precision for short periods of time.

A crucial point to be borne in mind concerning the choice of potential demand estimation methods at a given site is directly related to the time scale required. Usually empirical methods, such as Thornthwaite and Camargo, estimate ETo quite well in a monthly basis, whereas either physical or combined approaches involving net radiation assessments lead to better estimates of ETo in a daily scale (Pereira et al., 2007).

A matrix correlation analysis between potential demand estimation methods for the studied locations (Tables 1 and 2) evidenced more consistent precision and accuracy for both modified Bowen and simplified Penman

methods in comparison to the FAO Penman-Monteith approach, as well as the agreement degree between Camargo and Linacre methods.

The observed correlations between the Penman-Monteith FAO Standard method and the modified Bowen, simplified Penman, and Hargreaves-Samani methods were superior to 0.90 ( $p < 0.0001$ ), described as being almost perfect according to Souza et al. (2010), whereas for the Camargo and Linacre methods such correlations ranged from 0.70 to 0.90 ( $p < 0.0001$ ), classified as very high for the specific-sites in study.

By making use of the same analogy on the comparison of potential demand estimation methods, high correlations between modified Bowen and simplified Penman methods were observed ( $>0.99$ ;  $p < 0.0001$ ), as well as between Camargo and Linacre approaches ( $>0.80$ ;  $p < 0.0001$ ). However, such a correlation considerably decreases whenever two methods groups (one based on net radiation and other on air temperature) are to be compared.

*Table.1: Correlation matrix between reference evapotranspiration estimated by the classical Penman-Monteith approach (EToPM) and potential demand calculated by the simplified Penman (EToPS), Camargo (EToC), Hargreaves-Samani (EToHS), modified Bowen (EToBM) and Linacre (EToL) methods, throughout the period comprised between March 27, 2008 and August 22, 2011 at Ponta Grossa, PR, Brazil (averages of a 5-day period).*

	EToPM	EToPS	EToC	EToHS	EToBM	EToL
EToPM	1.0000					
EToPS	0.9295	1.0000				
EToC	0.8698	0.8282	1.0000			
EToHS	0.9311	0.8705	0.9482	1.0000		
EToBM	0.9413	0.9981	0.8568	0.8899	1.0000	
EToL	0.7084	0.5100	0.8039	0.7170	0.5520	1.0000

All correlation coefficients showed to be statistically significant by the Student t Test at 1% probability level.

*Table.2: Correlation matrix between reference evapotranspiration estimated by the classical Penman-Monteith approach (EToPM) and potential demand calculated by the simplified Penman (EToPS), Camargo (EToC), Hargreaves-Samani (EToHS), modified Bowen (EToBM) and Linacre (EToL) methods, throughout the period comprised between August 26, 2011 and October 14, 2013 at Arapoti, PR, Brazil (averages of a 5-day period).*

	EToPM	EToPS	EToC	EToHS	EToBM	EToL
EToPM	1.0000					
EToPS	0.9749	1.0000				
EToC	0.7516	0.7838	1.0000			
EToHS	0.9188	0.9268	0.9232	1.0000		
EToBM	0.9746	0.9973	0.8100	0.9357	1.0000	
EToL	0.7882	0.7433	0.8886	0.8475	0.7772	1.0000

All correlation coefficients showed to be statistically significant by the Student t Test at 1% probability level.

#### IV. CONCLUSIONS

It is possible to evaluate atmosphere evaporative demand for agrometeorological investigation purposes by means of reference evapotranspiration estimation methods scrutinized at the region of Campos Gerais of Paraná, Brazil.

The simplified Penman and modified Bowen methods had the best performance and are to be recommended for agricultural planning purposes at the studied region, for dismiss meteorological information with regard to wind regimes.



## ACKNOWLEDGMENTS

The authors are very grateful to the CNPq for the instrumental infrastructure that enabled local environmental variables monitoring, as well as Fundação Araucária (FA) for the concession of a productivity scholarship in research bestowed to the second author of the current manuscript.

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# Appliance of Textbook Basic on Process Image of Human Respiratory System against High School Student's Critical thinking Ability

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**Abstract**— Study in 21<sup>st</sup> century having much transformation in science and technology. An effective knowledge is a knowledge that includes student's ability in understanding study subject. Therefore, to support an optimum study process there is a need of a text book. Therefore, Process Image (PI) is a series of pictures/diagrams in a shape of object in an order that have a differences in situation, position, shape and combination in a whole and certain complexity. Study in Biology especially in a main study of human respiratory system is a study that have the most complexity. This happened because the study subject is abstract in a process that can't be seen directly because it is inside human body. Objective of this research is to knowing the effectivity of textbook basic on process image. Human respiratory system processing subject against high school student's ability in criticism. Subject of the research is students in XI Science 3 in Senior High School of Arjasa 2017/2018 academic Period. Data collecting technique is performance test. The results showing that textbook basic on process image on student's ability to critical thinking in a good criteria

**Keywords**— Textbook, process image, human respiratory system, critical thinking.

## I. INTRODUCTION

Progress in science and technology require human skill, one of the methods is using a good textbook. Basic on the research results of 10 Senior High School in Jember (5 school in Jember regency and 5 school in Jember City) that textbook with much sentences doesn't support them to train and develop thinking analyzing skill. This result is

supporting Tania *et al.*, (2015) statement, that ever textbook existed is not good enough to support students study activity.

Lack of thinking skill is shown by a low score on student's study result. This can be seen from the average score from Jember Regency and Bondowoso Regency (5 schools from Jember Regency and 5 schools from Bondowoso Regency) in the human respiratory system subject academic year 2016/2017 the score is 56,6 or below the minimum score of 80. Lack of processing and thinking skill caused by student and teachers that too much rely on subject presentation (Bannert, *et al.*, 2015). Therefore, it is vital that good study activity can improve student's ability to thinking and processing subject.

A good learning activity is an activity that able to teach the student how to use their cognitive ability, so students able to evaluate the methods of their studies as an appliance of high-level thinking ability. Basically, high-level thinking ability is one of Critical Thinking Ability. Critical Thinking is a directed and clear process that used in mental activity such as analyzing assumption, taking decisions, problem-solving, and doing scientific research (Johnson, 2011: 183). Critical thinking ability can be used by student in analyzing skill and in understanding certain concept in a subject. Ennis (2011) states that, Critical Thinking skill can be used by the student in analyzing, evaluating information, logic thinking, and deciding certain actions. Other than that Critical Thinking can be a tool that stimulates students to think and helps students to get a better study result (Choy and Chech, 2009). Critical Thinking Ability capable to get someone to prepare in realistic career life. A study that orientates on developing

student's Critical Thinking Ability is relevant to be applied basic on process image.

The process image is series of pictures that visualize certain situation (thing, phenomenon or genesis) through pictures, different phase/series in position, situation, form either its coherent combination and a whole, so it helps the readers understand it (Sutarto: Widita, 2017). Usage of process image help students in analyzing a genesis or problem with more detail because in Process Image there are different phases in a genesis. This caused Process image's role in learning can create student's creativity and interest in understanding such complex concept (Yusmar, 2017). This process image appropriate to use specially in Biology subject that categorized as a difficult subject.

Learning Biology is supposed to be applied with appropriate approach and methods. This is because of many difficult concepts in Biology subject. While learning Biology a teacher is supposed to know that Biology is more than just fact and concept, because in Biology there are compilations of a process and a concept that can be applied also developed in real life. The main subject respiratory system is a subject that has high complexity. This is because the subject is abstract that the all process cannot be directly seen (inside the human body). Human Respiratory System subject is about organ structure, mechanism and also respiration dysfunctional (breathing) that less effective if presented with lecture method and memorizing. The Process Images textbook subject can be interpreted as a medium that used to help students understanding a Biological (genesis, thing, or phenomenon) genesis. Basically, in stimulating student's memory, there is a need for effective hints (Allan et al., 2001). Because of that, with the usage of Process Images textbook, this process can enhance student's critical thinking ability.

## II. METHODOLOGY

This kind of research is still a prototype (Research and Development). This research method is a (mixed methods) composed of quality and quantity method. Prototype research is a developing research method that used to design a new product or new procedure, then systematically tested in the field and perfected high quality and effective criteria. The product of this research is Process Image textbook in Senior High School Respiratory System subject. Developing research Biology textbook is using developing model Sugiyono (2011) that composed in phases such as Introduction, Design, and Develop. The research design is performance test of critical thinking ability. Assessment is taken while the student is in study activity with assessment indicator such as analyzing; answering and questioning; consider relevant sources;

making hypothesis; definition; and reviewing. This design is used to know the effectiveness of this textbook. Subjects of the research are students in XI SCIENCE 3 in Senior High School of Arjasa, Jember academic period of 2017/2018. Analysing technique that used to know the effectiveness of textbook basic on Process Image against Critical Thinking ability using critical thinking formula (Watson, 2008). Basically textbook basic on Process Image of Human Respiratory System is effective if the minimum critical thinking criteria are "good". Therefore the formula to calculate critical Thinking ability is:

$$Cs = \frac{C}{N} \times 100$$

Information:

Cs = Critical Thinking Score

C = Critical Thinking

N = Total score

Criteria Assessment of Critical Thinking Percentage can be seen in Table 1

Average Critical Thinking Indicator	Critical Thinking Category
$20 \leq P < 36$	Bad
$36 \leq P < 52$	Not Enough
$52 \leq P < 68$	Good Enough
$68 \leq P < 84$	Good
$84 \leq P \leq 100$	Vey Good

## III. RESULTS

Collecting data method that is used to measure the effectiveness of textbook on process image is performance test. This assessment is executed when students had a study session in class, students are being tested with some indicator such as analyzing, answering and questioning; consider the relevant source; making hypothesis; making definition, and reviewing. Study session in class is done with dividing students into some group, then students are asked to explain Process Images in the book without teacher involvement and make presentation the subject in front of the class.

The result of this research is a quantity and quality data that is analyzed descriptively then interpreted according to the chosen criteria. Based on Table 2. we can notice that the average critical thinking ability of XI SCIENCE 3 against textbook basic on Process Image Human Respiratory System subject is 83,46 % that interpreted as "Good".



Table.2: Average Percentage of Student’s Critical Thinking in XI SCIENCE 3 and XI SCIENCE 5 in Highschool of Arjasa

Component Aspect	XI SCIENCE 3		Interpretation
	Every Aspect Average	Value	
Analysing	4,21	84,2	Very good
Answering and Questioning	4,26	85,2	Very good
Considering Relevant Source	4,13	82,6	Good
Making Hypothesis	4,18	83,6	Good
Definitioning	4,21	84,2	Very good
Reviewing	4,05	81	Good
<b>Total score</b>	<b>25,04</b>	<b>500,8</b>	-
<b>Value (%)</b>	-	<b>83,46</b>	<b>Good</b>

Based on Table 2, there is a result that student’s Critical Thinking ability is affected by textbook based on Process Image human respiratory system subject. Results of the both class XI SCIENCE 3 aquired in a good criteria with a conclusion that textbook basic on Process Image in human respiratory system subject can enhance student’s Critical Thinking ability. Percentage of Student’s Critical Thinking ability Histogram can be seen in Table 1.

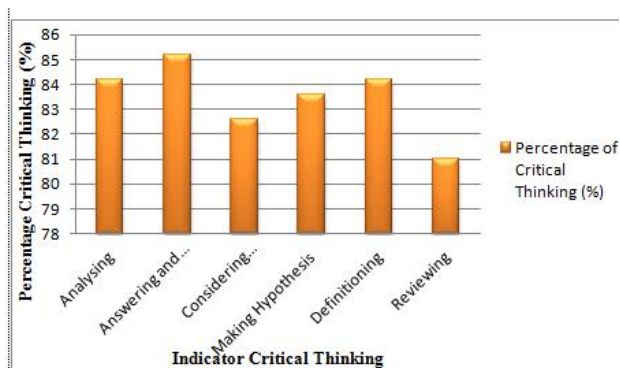


Fig 1: Average Percentage of Critical Thinking Histogram in Senior High School of Arjasa

#### IV. DISCUSSION

This Research is a research and development method. The objective of this research is to know the effectiveness of textbook basic on process images with human respiratory system against student’s critical thinking ability. There is a need for a field test of the effectiveness using Process Images textbook as the main study source.

Measurement in Critical thinking criteria (*Performance Test*) Students in XI SCIENCE 3 can be seen on Tabel 2 in order 83,46 % with criteria of “good”. In measuring critical thinking ability student is tasked to

analyzing, answering and questioning, considering the relevant source, making a hypothesis based on a literature, make definition, and reviewing is also affected by learning process that forced them to be able to discuss things in a group and understanding also solved a few problems. Critical thinking measurement is done by measuring process through discussion. This makes student able to reconstruct their knowledge and build a presentation model that used from previous study group from solving problems. This is alike with the statement of Tan et al., (2013) states that discussion in learning can be done with a group of students discussing a natural phenomenon, explaining and propose some possibilities of answers than the problems is presented as a relevant solution. Because of that Process Images study can actually affect student’s critical thinking ability. This is alike with Livingston (1997) states that high-level thinking ability (critical thinking ability) can be practiced through group discussion, thinking training, and evaluation of behavior.

Critical thinking ability of student has a big connection with intelligent and also processing process image information. Gardner states (Hadywinoto dan Setiabudi. 2003:52) that intelligence is used to solve problems. This means everyone has a different level of intelligence. In learning process, it creates an ability to think critically in the performance of brain to process information. Therefore, students ability to think is stimulated so they can develop their critical thinking ability. In learning Biology specially human respiratory system textbook basic on Process Image, brain have a role to invite students to optimize their brain memory capacity through freeing students to make their own concept, using variations of pictures and attractive colour, and giving the students to give brain a chance to transfer memory to long-term memory saving. This is a like with Craig state (2007) that studies using picture component, colour, writing, and diagram caused brain to be used in different situation in facilitating their ability to critical thinking.

Commonly, brain (*cerebrum*) composed in two part that called right hemisphere and left hemisphere that connected with corpus callosum (Chambell and Reece, 2008; Kalat, 2010; Pinel, 2009). In left brain have a role in the ability for verbal/writing (verbal), language, logic, math, number, and intelligence. In right brain it’s role is responsible for picture, music, global understanding, creativity, and visual (Albrechth, 2013; Corballis, 2014; Long et al., 2012). In the right brain, it has holistic and intuitive cognitive style in the left brain it has analitical and rational cognitive style (Dehaene et al., in Supradewi, 2010). From the explanation above it is important to keep brain having a balance performance. Balance in the right brain (right hemisphere) and left brain (left hemisphere is needed in the learning process.

## V. CONCLUSION AND SUGGESTIONS

From the results and explanations above we can conclude that textbook basic on Process Images is effective against student's critical thinking ability with a "good" criteria.

From the result of research, researchers suggest for a further research for a greater good this developing research can be done on a large scale, so the textbook effectiveness is undoubted.

## ACKNOWLEDGEMENTS

The author would like to thank the Faculty of Teacher Training and Education (FKIP) of Jember University.

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# Effect of “AERBETON” on the Mechanical and Physical Properties of Concrete

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**Abstract**— This study aims to use "AERBETON" which is an air entraining material added to the concrete mix to take advantage of its properties in construction in Gaza Strip.

Through this work, AERBETON, which is an air entraining material, was used as an additive to concrete mixture. The purpose is to study its properties when added to concrete before and after hardening, as well as comparing the results with concrete having the same ingredients but without adding this material.

In general, the test results has shown it is possible to add AERBETON by 5%, 10%, 15% of the weight of cement to the concrete mixture and so there is a change in the strength of concrete which becomes higher than that of normal concrete mixes.

As for the durability of concrete, samples of normal concrete and concrete containing the AERBETON air entraining material with different rates of 5%, 10% and 15% of cement weight have been prepared. The test of compressive strength at 7 and 28 days and through the results it showed that the durability of concrete gradually decreases when increasing the proportion of the added material to normal concrete.

In addition to this, the ratio of absorption of water of test samples was at its best percentage when adding 5% of the air entraining material by weight of cement. Moreover, among regular concrete mix results, it is shown that the percentage of absorbed water is less than normal concrete absorption and this shows the extent of resistance to moisture, salt water and sea water.

**Keywords**— Admixture, AERBETON, Air entraining material, Concrete

## I. INTRODUCTION

An admixture can be defined as a chemical product which, except in special cases, is added to the concrete mix in quantities not larger than 5 % by mass of cement during mixing or during an additional mixing operation prior to placing of concrete, for the purpose of achieving a specific modification, or modifications, to the normal properties of concrete.

Admixtures may be used in solid or liquid state. The latter is usual because a liquid can be more rapidly dispersed in a uniform manner during mixing of concrete. The admixtures can be added to the concrete at the plant during the mixing or at the job site before placing the concrete in form.

ACI Committee 212 lists 20 important purposes for which admixtures are used, for example, to increase the plasticity of concrete without increasing the water content, to reduce bleeding and segregation, to retard or accelerate the time of set, to accelerate the rates of strength development at early ages, to reduce the rate of heat evolution, and to increase the durability of concrete to specific exposure conditions, as well as to overcome certain emergencies during concrete operations.

The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and temperatures of the concrete and air. Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture: reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation.

One of these admixtures is the “Air Entraining admixture”. The use of air entrainment has been a common practice in concrete technology for more than 60 years. Air is intentionally entrained in the concrete mixture to reduce the potential for damage from freezing and thawing.

## II. RESEARCH AIM AND OBJECTIVES

### 2.1 The Aim

This work is directed towards establishing the use of air entraining in concrete mixtures and nonstructural elements. The successful use of air entraining will help in increasing the concrete resistance to humidity and salt water.

### 2.2 The Objectives

The objective of this research is to develop procedures for evaluating and qualifying air-entraining admixtures for use in cement in concrete. Three control mixes (5%, 10%

and 15%) were prepared to investigate the effect of air entraining on concrete properties.

To accomplish this objective, the following tasks were performed:

1. Information relative to the use of air-entraining admixtures in concrete was collected and reviewed. This information was obtained from performance, test methods, test data.
2. Test procedures currently used many countries for evaluating the effectiveness of air entraining admixtures were identified based on the information gathered in Task 1.
3. A detailed experimental research plan, which encompasses laboratory tests, was developed for evaluating the relative importance of the various factors affecting air entrainment identified in Task 1, modifying the test procedures proposed in Task 2, and validating the modified procedures.
4. The plan developed in Task 3 was executed. The plan included testing of fresh and hardened concrete properties. Also, a plan for putting the results of this research into practice was suggested.
5. A set of test procedures for evaluating air-entraining admixtures was developed based on the results of the entire research effort. For these test procedures were prepared in an (ASTM C 109-95) format.

### III. LITERATURE REVIEW

#### 3.1 Mechanism of Air Entrainment

Air bubbles are not formed by air-entraining agents (AEA), but stabilized by them. As the air-entraining agent molecules are inserted between adjacent water molecules at the water surface, the mutual attraction between the separated water molecules is reduced.

Lowering the surface tension stabilizes the bubbles against mechanical deformation and rupture, making it easier for bubbles to be formed. Without the presence of an air-entraining agent, the smaller bubbles, which have higher internal pressure, coalesce to form larger bubbles that have a greater tendency to escape to the surface and burst.

Absorbed AEA molecules at the surface of the bubble form a film, with their polar heads in the water phase. If the molecule is charged, the bubble acquires this charge. The electrostatic repulsion keeps bubbles separated and prevents coalescence (Dodson, 1990).

The ends of the AEA molecules that protrude into the water are also attracted to cement grains. This allows for a coating of calcium salts (i.e., products of cement hydration) to form around each air bubble, making it more stable than bubbles formed in plain water.

#### 3.2 Benefits of Admixtures

The reason for the large growth in the use of admixtures is that they are capable of imparting

considerable physical and economic benefits with respect to concrete. These benefits include the use of concrete under circumstances where previously there existed considerable or even insuperable difficulties. They also make possible the use of a wider range of ingredients in the mix.

Admixtures, although not always cheap, do not necessarily represent additional expenditure because their use can result in concomitant savings, for example, in the cost of labor required to effect compaction, in the cement content which would otherwise be necessary, or in improving durability without the use of additional measures.

It should be stressed that, while properly used admixtures are beneficial to concrete, they are not remedy for poor quality mix ingredients, for use of incorrect mix proportions, or for poor workmanship in transporting, placing and compaction.

#### 3.3 Effects of Air Entrainment on Properties of Concrete

##### 3.3.1 Effects on Fresh Concrete

The adherence of the entrained air bubbles to the cement particles reduces inter-particle friction between cement and aggregate grains. An increase in air content by 1/2 to 1 percentage point can increase the slump by about 2.54 cm (Whiting and Nagi, 1998), allowing a reduction in water needed to achieve the same slump. On the other hand, the attraction between bubbles and cement particles imparts a cohesion or “stickiness” to the concrete that makes it more difficult to place, consolidate, and finish, particularly at high air contents, and the compressibility of air can sometimes lead to problems in pumping.

##### 3.3.2 Effects on Hardened Concrete

An increase in air content leads to reductions in compressive strength, elastic modulus, and flexural strength. For example, increase in air content by a percentage point leads to average reductions of 2 to 6

Ratio	7 Days
Normal	<b>263</b>
(5%) admixture	<b>228</b>
(10%) admixture	<b>226</b>
(15%) admixture	<b>237</b>
5% admixture - 15 % water	<b>222</b>
10% admixture - 15 % water	<b>229</b>
15% admixture - 15 % water	<b>226</b>
(5%) admixture - 15 % - 15% water – 15% sand	<b>264</b>
(10%) admixture - 15 % - 15% water – 15% sand	<b>265</b>
(15%) admixture - 15 % - 15% water – 15% sand	<b>176</b>



percent in compressive strength, 3 to 6 percent in elastic modulus (in compression), and 2 to 4 percent in flexural strength (Whiting and Nagi, 1998).

Compressive strength reductions of 20 percent or more have been reported for concrete having normal air contents compared with design strength. In some cases, when Vinsol resin was replaced by non-Vinsol admixtures, the 28-day compressive strengths decreased for comparable air contents; a failure mode of mostly shear at the interface between aggregate and paste with very few fractured aggregate particles was noticed. Microscopic examination indicated accumulations of air voids around the aggregate particles that reduced the bond strength between the aggregate and surrounding mortar.

#### IV. TEST PROGRAM

##### 4.1 Material Properties

The materials used to develop concrete mixes in this study were air entraining admixture, coarse aggregate, and fine aggregate as well as cement as shown in Fig. 1.



Fig. 1: Materials for tests

##### 4.2 Compressive Strength Test

For each of the selected 6 admixtures, 10 different concrete mixes were prepared (60 mixes in total tested for compressive strength in accordance with ASTM C 109-95). Fresh concrete properties were determined for each mix. Compressive strength was determined at 7 and 28 days. The compressive strength ranged from 283 to 377 kg/cm<sup>2</sup>.

The average value of compressive strength of each control mix at various curing age is presented in Tables 1 and 2 and plotted in Fig. 2 and 3.

Table.1: Compressive Strength Test Results after 7 Days

Ratio	7 Days
<b>Normal</b>	263
<b>(5%) admixture</b>	228
<b>(10%) admixture</b>	226
<b>(15%) admixture</b>	237
<b>5% admixture - 15 % water</b>	222
<b>10% admixture - 15 % water</b>	229
<b>15% admixture - 15 % water</b>	226
<b>(5%) admixture - 15 % - 15% water – 15% sand</b>	264
<b>(10%) admixture - 15 % - 15% water – 15% sand</b>	265
<b>(15%) admixture - 15 % - 15% water – 15% sand</b>	176

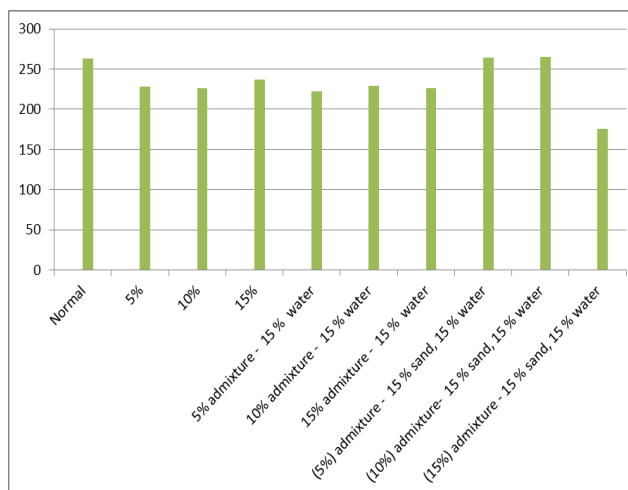


Fig. 2: Compressive strength test results after 7 days

Table.2: Compressive Strength Test Results after 28 Days

Ratio	28 Days
<b>Normal</b>	327
<b>(5%) admixture</b>	313
<b>(10%) admixture</b>	300
<b>(15%) admixture</b>	283
<b>5% admixture - 15 % water</b>	335
<b>10% admixture - 15 % water</b>	332
<b>15% admixture - 15 % water</b>	301
<b>(5%) admixture - 15% water – 15% sand</b>	377
<b>(10%) admixture - 15% water – 15% sand</b>	356
<b>(15%) admixture - 15% water – 15% sand</b>	335

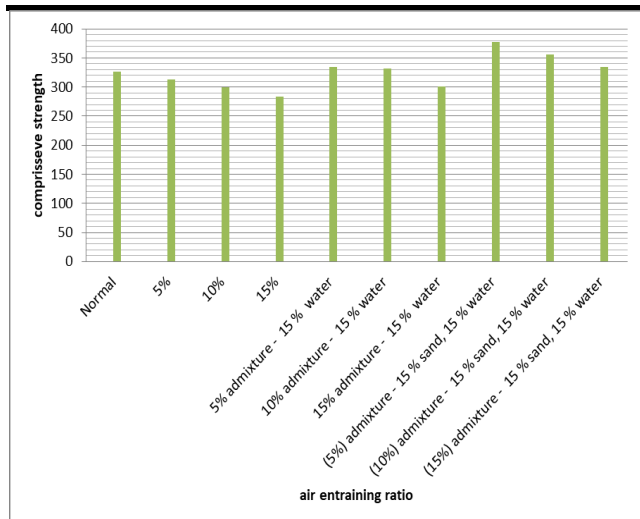


Fig. 3: Compressive strength test results after 28 days

4.3 Water Absorption Test

The water absorption was used as indication of mix water content for the best ratio. The water absorption value for control mix is shown in Table 3.

Table3: Water Absorption Test Results

Ratio	Dry weight (g)	Wet weight (g)	absorption %
Normal	7313	7728	5.7
5% Admixture	7135	7517	5.4

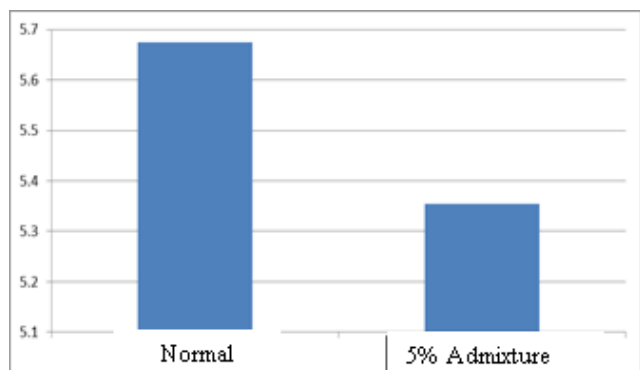


Fig. 4: Water absorption test results

4.4 Slump Test

The test measures consistency of concrete in a specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the ease with the test is popular due to the simplicity of apparatus used and simple procedure.

Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformity of different batches of concrete under field conditions, and to ascertain the effects of plasticizers on their introduction.

The slump value was used as indication of mix workability. The slump values for different percentages of control mix are as shown in Table 4:

Table.4: Slump Test Results

Ratio	slump (cm)	Form of slump
Normal	6.5	Medium
5%	8.5	Medium
10%	9	Medium
15%	9	Medium

4.5 Density Test

In this research, the density of concrete cube specimens is the theoretical density. The density is calculated by dividing the weight of each cube by the cube volume.

The same cube specimens which are used to determine compressive strength were used to determine the density.

The average density values of control mixes at different curing ages are summarized in Tables 5 and 6 and presented in Fig. 5 and 6.

Table 5: Density Results after 7 Days

Ratio	Density after 7 days
Normal	2.47
5%	2.44
10%	2.44
15%	2.37
5% admixture - 15% water	2.40
10% admixture - 15% water	2.39
15% admixture - 15% water	2.38
(5%) admixture -15% water – 15% sand	2.41
(10%) admixture -15% water – 15% sand	2.42
(15%) admixture -15% water – 15% sand	2.41

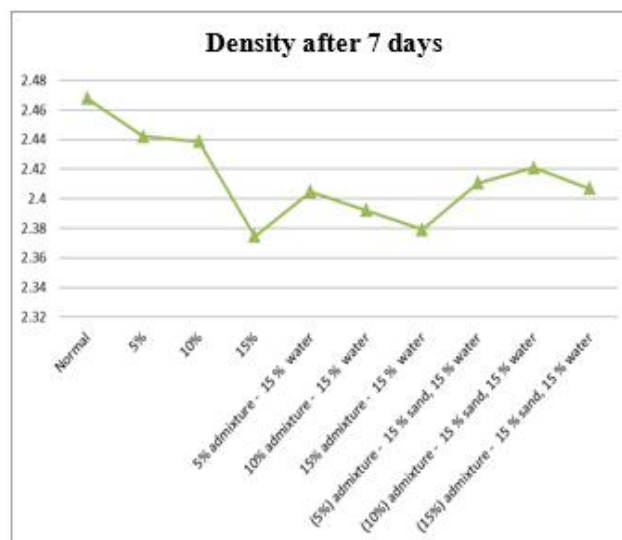


Fig. 5: Density results after 7 days

Table.6: Density Results after 28 Days.

Ratio	Density after 28 days
Normal	2.49
(5%) admixture	2.42
(10%) admixture	2.38
(15%) admixture	2.42
(5%) admixture - 15 % water	2.40
(10%) admixture - 15 % water	2.40
(15%) admixture - 15 % water	2.37
(5%) admixture -15% water – 15% sand	2.44
(10%) admixture -15% water – 15% sand	2.52
(15%) admixture -15% water – 15% sand	2.40

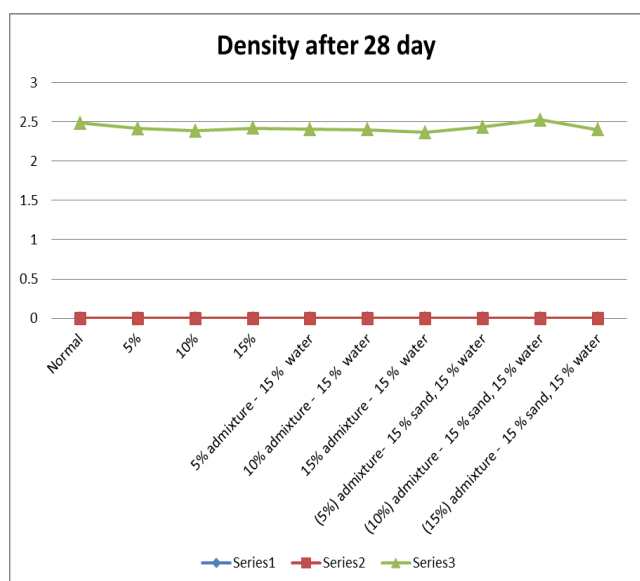


Fig. 6: Density results after 28 days

## V. RESULTS AND DISCUSSION

### 5.1 Conclusion

Concrete materials, concrete production procedures, construction practices, and field conditions affect, to varying degrees, the air-void system of concrete.

1. The type of air-entraining admixture has a statistically significant effect on the concrete air-void system.
2. Compressive strength decreases with increasing ratio of admixture.
3. Decrease of w/c ratio leads to increase of strength of concrete which leads to segregation and failure of compressive strength and reduces the workability.
4. AERBETON material increases durability, ensures higher resistance to frost and thaw as well as thawing salts.
5. The admixture reduces the density of concrete.
6. It improves the concrete pump ability.

7. Reduces shrinkage and bleeding.
8. Permits to reduce sand or fine component dosages.
9. The use of AERBETON permits to obtain a mix with volumetric and advantageous results.

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# Comparative Analysis of three Growth Medium for *Arthrospira platensis* Cultivation based on Lab-Scale Results

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**Abstract** —*Arthrospira platensis* is a rich source of essential amino acids, vitamins and it is used as a feedstock for energy sources. The high cost of the growth medium used in its cultivation is a problem for increasing the production viability. The present study aimed to compare the technical viability and the cost elements in different growth medium for *A. platensis* cultivation. For that purpose, it was proposed the use of three different growth medium, named as M1, M2 and M3 in a lab scale. The growth of the treatments presented a microbial process with characteristic phases. M1, M2 and M3 maximum concentration ( $X_{max}$ ), productivity ( $P_x$ ) and the maximum specific growth rate ( $\mu_{max}$ ) showed no significant difference among treatments. However, M3 presented the lowest cost element, about 45.75% less than the M1 and 38.92% lower than M2. Therefore, the comparison enabled the result that M3 presented the best performance to be used, thus increasing profitability of this production in a lab-scale analysis.

**Keywords**—*Arthrospira platensis*, medium, growth rate, technical viability, costs analysis.

## I. INTRODUCTION

The provision of food security for the growing population, higher oil prices, environmental concerns and increased interest in energy security have encouraged a private and public investment in microalgae biofuels and microalgae food research. It was a challenge to be aware of this potential thus far has been finding a process that can be scaled in a cost competitive manner [1].

Microalgae are simple organisms that are mostly in farm water [2, 3]. Throughout its evolution, microalgae have become a very diverse group of photosynthetic organisms, and a particular example is the *Arthrospira Platensis* (*A. platensis*) [4].

For food, microalgae *A. platensis* represents one of the most promising sources of compounds with biological activities possibly used as functional ingredients [5]. Its use is stimulated in order to increase the nutritional value of the food because it is a source of pigments, unsaturated fat, vitamins, sterols, among others [6].

This microorganism has received considerable interest as a potential feedstock for biofuel production, thereby leading to a marketing appeal by decreasing greenhouse gas emissions, as well as using renewable energy sources. Its big advantage is that it easily adapts to the environmental conditions of cultivation, high photosynthetic efficiency and is not a competitor in food production areas [7]. In addition, it can produce large amounts of polysaccharides (sugar) and triglyceride (oil), these are materials for the production of bioethanol and biodiesel [8].

Regarding the national production of microalgae, companies which started producing bio compounds claim about the lack of investment in production technology and competitive pricing, which ended up preventing the advance of large-scale production projects. Consequently, proposals must concern about lower production costs and high efficiency. Furthermore, the new growth medium sources should be encouraged to achieve this purpose.

Raouf et al. [9] emphasized that the growth medium is a significant part of production costs. Several lab-scale recent studies demonstrated the potential of alternative growth methods in increasing the production of *A. platensis* biomass [1, 3, 5, 6, 7]. However, regarding its importance, a few number of scientific articles concern about comparing a new growth medium in order to verify their gains.

In this context, the objective of this paper is to perform a comparison analysis related to the technical feasibility and the cost element of three different growth medium for



*A. platensis* cultivation using lab-scale experimental results.

## II. REVISION AND STATE OF THE ART

### Microalgae

The cultivation of microalgae is a branch of modern biotechnology, although there are records that it has already grown in 1890. Commercial production began in the 1960s in Japan. Since then, the microalgae biotechnology industry has expanded and diversified significantly [10].

Microalgae are autotrophs that develop from the process of photosynthesis, as well as plants. Photosynthesis is recognized as a natural media of CO<sub>2</sub> sequestration and aquatic microalgae are the fastest photosynthetic organisms that can fix carbon at a moderate rate in comparison to terrestrial plants. Microalgae also have the ability to use free CO<sub>2</sub>, carbonate and bicarbonate ions as growth substrates [11].

This designation includes two types of cell structure: prokaryotic, with representatives in the division *Cyanophyta* (cyanobacteria) and *Eukaryotic*, with representatives of *Chlorophyta* divisions, *Euglenophyta*, *Rhodophyta*, *Haptophyta* (*Prymnesiophyta*), *heterokonts* (*Bacillariophyceae*, and *Chrysophyceae* *Xantophyceae*) and *Cryptophyta* *Dinophyta* [12, 13].

The microalgae biomass is used for the production of: (1) biosynthesis and ethanol by fermentation using algae hydrogen, (2) carbohydrate biosynthesis (producing ethanol and biobutanol acetone-butanol- via fermentation and ethanol), hydrocarbons (that can be taken to the production of diesel, kerosene, among others) and the production of triglycerides itself for biodiesel production [14].

### *A. platensis*

The specie *A. platensis*, from *Oscillatoriaceae* family, includes multicellular filamentous cyanobacterium group (blue-green microalgae), formed by cylindrical cells arranged in helical trichomes [15].

Humans learned early how to use the *A. platensis* as a power source, by noting the migration of birds being safely fed and also encouraging them to use it [16]. Kebede [17] reported that, in Ethiopia, farmers and shepherds living close to the alkaline lakes made the cattle feed mixed with *A. platensis* water monthly, and they believed it had therapeutic effect and was a supplement in the daily diet.

They are able to adapt in certain environments where other microorganisms would not survive, such as those in media with high salt concentration. Through photosynthesis, it converts nutrients into cellular material and produces oxygen. Necessary nutrients are water and a

source of carbon, nitrogen, phosphorus, potassium, iron and other minerals [15].

Microalgae are also vectors for the production of bioactive agents that can be applied to medical field, compounds with specific biochemical characteristics, and compounds which are energy sources such as bio-diesel, bio-methane, and hydrogen biobutanol, biomethanol [18, 19].

*A. platensis* is legally permitted as a food supplement in Europe, Japan and in the United States by the Food and Drug Administration (FDA), with no toxic effects on the human body [20]. In Brazil, ANVISA (National Health Surveillance Agency) allowed its sale provided that the final product, which microalgae have been added, is properly registered [21].

### Growth Medium

The current interest in expansion of industrial use of microorganisms is leading to a greater attention to the growth medium used. As a matter of profitability and environmental protection, it is essential to ensure the productivity optimization with the lowest cost [22].

The growth of *A. platensis* and the composition of the biomass produced depend on many factors. The most important are temperature, light intensity and specially the amount of available nutrients. Therefore, the costs elements are considered the second major influence that impacts on its production [23].

*A. platensis* growth requires carbon because their cells contain approximately 50% (v/v) of this element. Carbon costs represent a higher impact, for the reason that this element being the most important chemical constitution. For an autotrophic growth (recommended to open large-scale cultivation), carbon can be replaced by CO<sub>2</sub>, carbonate or bicarbonate. If bicarbonate is used, it will represent about 60% of the costs of nutrients [24].

Scientific literature lacks information while proposing alternative growth medium components and their impacts in the synthesis of compounds [25].

## III. MATERIALS AND METHODS

**Microorganism:** It was used the cyanobacterium *A. platensis*, classified as *Arthrospira platensis* (*Nordstead*) by Gomont [26], obtained from Federal University of Santa Catarina, Brazil.

**Culture medium and cultivations:** The inoculum was prepared according to the criteria established in previous studies: 8-day process, temperature  $\pm 30$  ° C using shaker *Marq Labor CFW 08*, fitted with artificial light. Initial concentration of inoculum was 50 mg.L<sup>-1</sup> [27].

The experimental design was a completely randomized design (C.R.D.), using a factorial 3x4, with three proposed medium and 4 replicates.

Three culture media were proposed and analyzed: a standard medium [29] – Medium 1 (M1); a standard modified medium [30] with no trace elements – Medium

2 (M2); and finally, a medium proposed with alternative commercial substances replacing natural elements – Medium 3 (M3). All three growth mediums elements are presented in Table 1.

Table.1: Composition of Growth Medium for three cultivation treatments.

Elements	Medium 1 (M1)		Medium 2 (M2)		Medium 3 (M3)	
	g.L <sup>-1</sup>	Modified Elements	g.L <sup>-1</sup>	Modified Elements	g.L <sup>-1</sup>	Modified Elements
NaCl	0.92	-	0.92	-	0.92	Commercial Salt
Na <sub>2</sub> SO <sub>4</sub>	1.88	-	1.88	-	1.88	
K <sub>2</sub> HPO <sub>4</sub>	0.50	-	0.50	-	0.50	
Na <sub>2</sub> CO <sub>3</sub>	8.89	-	8.89	-	8.89	
NaHCO <sub>3</sub>	15.15	-	15.15	-	15.15	Commercial Sodium Bicarbonate
CaCl <sub>2</sub> .2H <sub>2</sub> O	0.05	-	0.05	-	0.05	
KNO <sub>3</sub>	2.57	-	2.57	-	2.57	Commercial fertilizer double sodium and potassium nitrate.
MgSO <sub>4</sub> .4H <sub>2</sub> O	0.25	-	0.25	-	0.25	
Fe-EDTA Solution	1.0	-	1.0	-	1.0	
Microelements Solution*	1.0	-	1.0	-	1.0	

\*Microelements Solution – Composed by H<sub>3</sub>BO<sub>3</sub>.4H<sub>2</sub>O (2.86 g.L<sup>-1</sup>), ZnSO<sub>4</sub>.7 H<sub>2</sub>O (0.222 g.L<sup>-1</sup>), NaMoO<sub>4</sub>.2 H<sub>2</sub>O (0.390 g.L<sup>-1</sup>), MnSO<sub>4</sub> (1.543 g.L<sup>-1</sup>), CuSO<sub>4</sub>.5 H<sub>2</sub>O (0.079 g.L<sup>-1</sup>) and CoCl<sub>2</sub>.6 H<sub>2</sub>O (0.038 g.L<sup>-1</sup>).

**Determinations and analyzes:** The parameters monitored were growth with biomass maximum concentration ( $X_{max}$ ), productivity (Px), maximum specific growth rate ( $\mu_{max}$ ) and the cost element. The comparison between these three mediums, with the same day sampling, was conducted by using Tukey test, also considering a significance level of 5% ( $p < 0.05$ ) [28].

**Growth and biomass maximum concentration ( $X_{max}$ ):** Biomass concentration was determined daily by turbidimetry at 560 nm [30] in 8-day process.

**Productivity (Px):**

$$Px = \frac{(X_m - X_i)}{T_c} \quad \text{[equation 1]}$$

In equation 1,  $X_m$  is the final biomass concentration,  $X_i$  is the initial biomass concentration,  $T_c$  is time of analysis (days). Px was expressed in biomass concentration (mg.L<sup>-1</sup>.d<sup>-1</sup>) growth per day.

**Maximum specific rate ( $\mu_{max}$ ):** Determined using Monod model [31]:

$$\ln\left(\frac{C_x}{C_{x_0}}\right) = \mu_{max} \cdot t \quad \text{[equation 2]}$$

In equation 2,  $C_x$  is the final biomass concentration,  $C_{x_0}$  is the initial biomass concentration,  $\mu_{max}$  is expressed in d<sup>-1</sup>.

**Cost Element:** The cost element analysis was about all the nutrients included in the used mediums [32]. It was determined by surveying suppliers directly.

The total capital element investment (TCEI) was calculated according to the cost of each element. This analysis was subjected to variations, as it considered values in American Dollar (US\$).

Afterwards, a direct comparison was made considering the cost of the component medium. For a better analysis, it was calculated the cost for 1 Kg of *A. platensis* biomass production.

IV. RESULTS AND DISCUSSION

Experimental results obtained from *A. platensis* biomass concentration growth are shown in Figure 1.

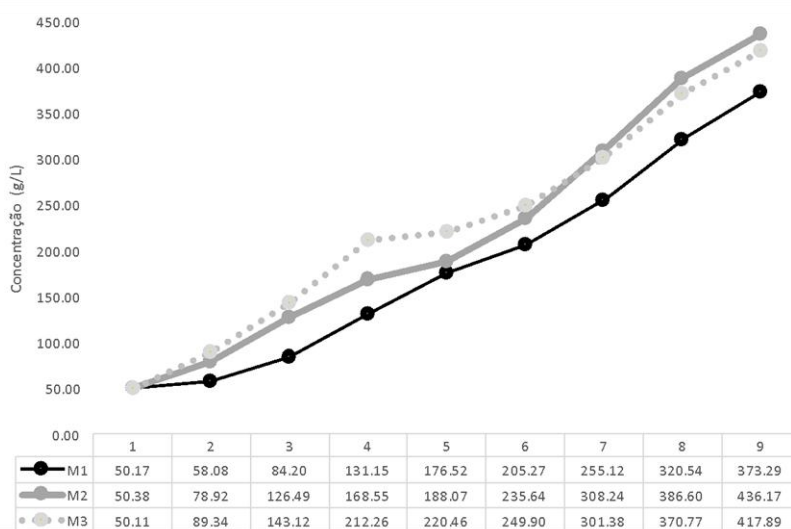


Fig.1: Comparison of biomass growth in the experimental medium

As presented in figure 1, the three analyzed experimental medium initiated biomass concentration around 50 mg.L<sup>-1</sup>. M1 started with a stationary phase and then culminating in a maximum concentration (X<sub>max</sub>) of 373.29 mg. L<sup>-1</sup>. M2 also presented the same phase, culminating in maximum concentration (X<sub>max</sub>), of 436.17 mg L<sup>-1</sup>. M3 had the stationary phase and a maximum concentration (X<sub>max</sub>) of 417.89 mg. L<sup>-1</sup>.

Thirumala [33] also studied *A. platensis* biomass growth by using different growth medium from distinct

combinations. As a result obtained from growth medium, slightly different from this paper findings, it established that it had a maximum concentration on the 9<sup>th</sup> and 12<sup>th</sup> day of incubation.

The experimental results and statistical analysis maximum concentration (X<sub>max</sub>), productivity (Px) and specific maximum growth rates (μ<sub>max</sub>) are shown in table 2.

Table 2. Comparison of growth parameters.

Growth Medium	X <sub>max</sub> (mg . L <sup>-1</sup> )	Px (mg. L <sup>-1</sup> . d <sup>-1</sup> )	μ <sub>máx</sub> (d <sup>-1</sup> )
M1	373.29 ± 100.62 a*	40.39 ± 12.57 a	0.27 R <sup>2</sup> = 0.977 a
M2	436.17 ± 107.48 a	48.22 ± 13.43 a	0.30 R <sup>2</sup> = 0.928 a
M3	417.88 ± 113.72 a	45.97 ± 14.21 a	0.31 R <sup>2</sup> = 0.805 a

\* Same letters indicate no significant differences between treatments analyzed by Tukey analysis (p <0.05).

**Maximum concentration (X<sub>max</sub>)**

As demonstrated in Table 2, maximum concentration in M1 was 373.29 ± 100.62 mg. L<sup>-1</sup>, for M2 the result was 436.17 ± 107.48 mg. L<sup>-1</sup> and for M3 was 417.88 ± 113.72 mg. L<sup>-1</sup>. Although the numerical result of M2 was higher, Tukey test (p <0.05) confirmed that all three treatments resulted in a statistically equal amount.

Several authors found out similar results. Kaushik et al. [34] cultivated *A. platensis* in different dilutions of effluents from industrial activities. Similarly to this paper analysis, after 14 days of growth it achieved maximum concentration values ranging from 460 mg.L<sup>-1</sup>.

Also cultivating *A. platensis* in a low-cost medium, Madkour et al. [23] affirmed maximum concentration values (X<sub>max</sub>) starting from 591 ± 0.018 mg. L<sup>-1</sup> for different concentrations of nitrate ammonia. Finally, Pandey et al. [35] in his research cultivated *A. platensis* in Zarrouk medium confirmed maximum concentration values (X<sub>max</sub>) from 390 ± 0.020 mg. L<sup>-1</sup>.

**Productivity (Px)**

In Table 2, the productivity at M1 was 40.39 ± 12.57 mg.L<sup>-1</sup>.d<sup>-1</sup>, M2 was 48.22 ± 13.43 mg.L<sup>-1</sup>.d<sup>-1</sup> and M3 was 45.97 ± 14.21 mg.L<sup>-1</sup>.d<sup>-1</sup>. Results were also expressed in

% mg.L<sup>-1</sup>.d<sup>-1</sup>, therefore, M1 productivity was 80% mg.L<sup>-1</sup>.d<sup>-1</sup>, M2 was 96.4 % mg. L<sup>-1</sup>.d<sup>-1</sup> and M3 was 91.9 % mg.L<sup>-1</sup>.d<sup>-1</sup>.

The results indicated that there is no effect of treatments on productivity because, although numerically the result of M2 was higher, statistical Tukey (p <0.05) test analysis showed that the three treatments were equal. Jitendra et al. [37] presented similar results in *A. platensis* cultivation. For productivity results, it was obtained values between 60% and 90% mg.L<sup>-1</sup>.d<sup>-1</sup>. Madkour et al. [24] also found results between 16 ± 0.0005 mg.L<sup>-1</sup>.d<sup>-1</sup> and 52 ± 0.0005 mg.L<sup>-1</sup>.d<sup>-1</sup>

### Specific growth rate ( $\mu_{max}$ )

According to Table 2, the specific rate for M1 was 0.27 R2 = 0.977 d<sup>-1</sup>, for M2 was 0.30 R2 = 0.928 d<sup>-1</sup> and for

M3 it was 0.31 R2 = 0.805 d<sup>-1</sup>. The results were statistically (Tukey test) the same, in 5% level.

Similar results were found by Borges et al. [38], Soletto et al. [39] and Madkour et al. [24], showing that this specific maximum growth rate found in this study indicates good results. which are similar to those found in this work.

### Cost Element Analysis

According to the maximum biomass production (table 2), it was established that to produce 1 Kg of *A. platensis* will be needed approximately 2679 liters for M1, 2293 liters for M2 and 2393 liters for M3.

The analysis of cost element for 1 Kg of *A. platensis* biomass in US\$ (quoted at January 27th, 2018) for the treatments is shown in Table 3.

Table.3: Element cost analysis.

Elements	Medium 1 (M1)		Medium 2 (M2)		Medium 3 (M3)	
	US\$	% Total	US\$	% Total	US\$	% Total
NaCl	1.73	0.14	1.48	0.14	1.54	0.24
Na <sub>2</sub> SO <sub>4</sub>	132.34	10.91	113.26	10.92	118.22	18.66
K <sub>2</sub> HPO <sub>4</sub>	51.64	4.26	44.20	4.26	46.13	7.28
Na <sub>2</sub> CO <sub>3</sub>	333.47	27.50	285.40	27.51	297.88	47.02
NaHCO <sub>3</sub>	546.58	45.07	467.78	45.09	39.06	6.17
CaCl <sub>2</sub> .2H <sub>2</sub> O	1.97	0.16	1.68	0.16	1.76	0.28
KNO <sub>3</sub>	42.85	3.53	36.67	3.53	38.27	6.04
MgSO <sub>4</sub> .4H <sub>2</sub> O	15.63	1.29	13.38	1.29	13.96	2.20
Fe-EDTA Solution	85.9	7.08	73.52	7.09	76.13	12.11
Microelements Solution*	0.60	0.05	-	-	-	-
Total	1212.69		1037.36		633.55	

\*Microelements Solution Costs– Composed by H<sub>3</sub>BO<sub>3</sub>.4H<sub>2</sub>O (2.86 g.L<sup>-1</sup>), ZnSO<sub>4</sub>.7 H<sub>2</sub>O (0.222 g.L<sup>-1</sup>), NaMoO<sub>4</sub>.2 H<sub>2</sub>O (0.390 g.L<sup>-1</sup>), MnSO<sub>4</sub> (1.543 g.L<sup>-1</sup>), CuSO<sub>4</sub>.5 H<sub>2</sub>O (0.079 g.L<sup>-1</sup>) and CoCl<sub>2</sub>.6 H<sub>2</sub>O (0.038 g.L<sup>-1</sup>) was US\$ 0.60.

The cost element for 1 kg of *A. platensis* biomass, at lab-scale, in M1 was US\$ 1212.69 and the biggest costs identified, based on the percentage over the total, were NaHCO<sub>3</sub> (45.07%) followed by Na<sub>2</sub>CO<sub>3</sub> (27.5%) and Na<sub>2</sub>SO<sub>4</sub> (10.91%). For M2 the cost element was US\$ 1037.36 and the biggest costs were NaHCO<sub>3</sub> (45.09%) followed by Na<sub>2</sub>CO<sub>3</sub> (27.51%) and Na<sub>2</sub>SO<sub>4</sub> (10.92%). For M3 the cost was US\$ 633.55 and the biggest costs were Na<sub>2</sub>CO<sub>3</sub> (47.02%), followed by Na<sub>2</sub>SO<sub>4</sub> (18.66%) and Fe-EDTA solution (12.11%).

M1 showed the highest cost (US\$ 1212.69), it is probably because it is needed a higher growth medium amount to reach 1Kg of *A. platensis* biomass. The biggest costs were almost the same as M2.

M2 cost (US\$ 1037.36) represents a 14.5% lower cost than M1 and it is still approximately 38.92% higher than

in M3. The element that most charges the growth medium cost, NaHCO<sub>3</sub> (45.09%), was replaced by commercial sodium bicarbonate in M3.

M3 cost (US\$ 633.55) was the lowest among the three growth medium analyzed. Some of the higher costs in the other growth medium were replaced in M3. It represents about 47.75% lower cost than M1 and 38.92% lower than M2. Several authors have also proposed the use of alternative growth medium for this cyanobacterium growth process.

For the purposes of biofuels production, commercially viable biomass production today is only 5 Kt/ year with a production cost of \$ 25.00 / ton [14]. However, to occupy only 5% of biofuel demand for a country as the United States, it would be required a production of more than



66.000 Kt/year of biomass rich in oil costing less than US\$ 400/t [40].

Analyzing the European market to get more acquainted with the whole transport network of microalgae biodiesel, a 9.25 million ha crop would be required resulting in an output of 40.000 liters/ ha.day [41]. Thus, this number shows that according to the results in this paper, productivity should be improved in order to become viable regarding profitability.

Norsker et al. [42] estimated the cost of producing algal biomass on a commercial scale. As a conclusion, the important factors resulted in the irradiation conditions, mixing, efficient photosynthetic system, the medium and the cost of carbon dioxide, in agreement with this study also demonstrating that carbon source has one of the higher costs.

Acien et al. [43] conducted a cost analysis for the actual production of the microalgae *Scenedesmus almeriensis* and Madkour et al. [24] studied a low cost medium of cultivation for the large-scale production of *A. platensis*, both resulted in the economic analysis showing the production itself and depreciation as the main offenders of the cost. Also concluded that the simplification of the technology used and the scaling tests could increase productivity and reduce production costs.

In lab-scale process, the costs will probably be higher than the commercial value of the product, mainly due to the productivity scale and the small amount of purchased resources [24, 40].

## V. CONCLUSIONS

As stated in experimental results, this research conducted efficient conversion. It had specifically grown from 0,50 mg.L<sup>-1</sup> until for M1 373.29 ± 100.62 mg. L<sup>-1</sup>, for M2 436.17 ± 107.48 mg. L<sup>-1</sup> and for M3 417.88 ± 113.72.

M1 biomass productivity had results statistically identical to the other culture medium (M1 and M2) which did not contain macroelements confirming such a no need of these elements in order to increase *A. platensis* biomass.

Productivity (Px) and specific rate (μ<sub>max</sub>) also showed good results regarding the ones presenting their similarity among other carried out researches.

Even though M3 cost element for 1 kg of *A. platensis* production was the lowest between them, its maximum concentration, productivity and specific growth rate had no statistical difference from the others. Therefore, the use of M3 is strongly recommended in this comparative study.

## VI. ACKNOWLEDGMENT

The authors are grateful for the support provided by Universidade Federal do Triângulo Mineiro (UFTM); Instituto Federal de Educação, Ciência e Tecnologia do

Triângulo Mineiro – Campus Uberlândia (IFTM); and Universidade Federal de Santa Catarina (UFSC).

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# Network Data Security for the Detection System in the Internet of Things with Deep Learning Approach

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**Abstract**— we thought to set up a system of interconnection which allows sharing the communication network of data without the intervention of a human being. The Internet of Things system allows many devices to be connected for a long time without human intervention, data storage is low and the level of data processing is reduced, which was not the case with older solutions proposed to secure the data for example: cyber-attack and other systems. But other theories like for example: artificial intelligence, machine learning and deep learning have a lot to show their ability and the real values of heterogeneous data processing of different sizes and many researchers had to work on it. In the case of our work, we have used deep learning theories, to achieve a light data interconnection security solution; we also have TCP/IP protocol for data transmission control, algorithm drillers for classifications. In order to arrive at a good solution; First, we thought of a model for anomalies detection in Internet of Things and we think about the improvement of architectures of the Internet of the existing objects already proposed a system with a light solution and especially multilayer for an IoT network. Second, we analyzed existing applications of machine learning, deep learning to IoT, and cybersecurity. The recent hack of 2014 Jeep Cherokee, iStan pacemaker, and a German steel plant are a few notable security breaches. Finally, from the evaluated metrics, we have proposed the best neural network design suitable for the IoT Intrusion Detection System. With an accuracy of 98.91% and False Alarm Rate of 0.76 %, this research outperformed the performance results of existing methods over the KDD Cup '99 dataset. For this first time in the IoT research, the concepts of Gated Recurrent Neural Networks are applied for the IoT security.

**Keywords**— data security; Internet of Things; deep learning.

## I. INTRODUCTION

By definition, it can be said that networked or interconnected systems often have a long list of interconnected data in parallel; this type of system facilitates the rapid sharing of data as they are distributed and errors are easily reduced according to each connected device. And these kinds of networks are also like a mathematical regression that is linear because the solution between the input variables and the output produced is often captured by nonlinear relations and this final solution which is found from variables results represents the set of many hidden layers of each predefined function. Our studies are very much about the analysis of a new domain that is the Internet of Things with the presentation of architecture and neural networks. We then made the comparison on security issues and privacy between the field of deep learning and that of the Internet of Things. This may be possible with the concepts of machine learning or deep learning because IoT generates a huge amount of heterogeneous data. And we note that with this research we fall into a multilayer architecture and the new technology of the Internet of Things for a unique system. And the algorithms we had to apply during this research are to monitor network data interconnect and classify activities are application attacks for multiple layers of each architecture. And for our research we thought about using the KDD 99 Cup intrusion detection dataset that many researchers who have been working on internet data security consider as a combination of referential data. For all the work related to our work are in part (2), the methodology used for our work is in part (3) and the last part focuses on the implementation and outcome of our work (4).

## Motivation

In the world of IoT, the datasets are high-dimensional, temporal and multi-modal. Deep Learning algorithms with robust computation power are more suitable for complex



IoT datasets compared to legacy machine learning techniques. The application of deep learning to the IoT domain, particularly in IoT security is still in the initial stages of research and has a great potential to find insights from the IoT data. With smart use of deep learning algorithms, we believe that IoT solutions can be optimized. For example, recurrent neural networks in deep learning have the capability to learn from previous time-steps of the input data. The data at each time-step is processed and stored and given as input to the next time-step. The algorithm at the next time step utilizes the previous information stored to process the information. Though the neural network structures are complex, the hyper-parameters can be tuned to obtain light-weight functionality for IoT solutions. This hypothesis motivated us to apply deep learning concepts to IoT network security.

### Problem statement

The goal of this thesis is to analyze and answer the following research questions:

- What are the security and privacy issues relevant to the IoT environment?
- Does GRU better than the other machine learning approaches for Intrusion Detection on the IoT?
- Does a separate GRU based IDS for each network layer perform better than the all layer GRU?

### Contribution

This research can be extended by applying the algorithms on GPU environment on real-time IoT data. Though there are various deep learning algorithms such as deep neural networks, auto encoders, convolutional neural networks and recurrent neural networks, the research problem requires an algorithm that can learn from historical data. Therefore, we have selected the family of recurrent neural networks for the research. Considering the need of building smart and lightweight solutions for the IoT network, we have performed the experiments with only the Gated Recurrent-Unit (GRU) algorithm while the vanilla RNN and LSTM are ignored. We have modified the data by dividing it into various layers such that the same procedure can be applied in an IoT network.

## II. RELATED WORKS

There are also several existing works in this area. In this section, we will discuss the most recent work that uses methods and architectures. We were motivated and inspired from this work "Cyber-Physical-Social Based Security Architecture for Future Internet of Things" because after taking a lot of time to study and read this work, we found tremendous benefits from doing our research in this area. Alrawashdeh and Purdy [18] proposed using a RBM with one hidden layer to perform unsupervised feature reduction. The weights are passed to another RBM to produce a DBN. The pre-trained weights

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are passed into a fine tuning layer consisting of a Logistic Regression classifier (trained with 10 epochs) with multi-class soft-max. The proposed solution was evaluated using the KDD Cup '99 dataset. The authors claimed a detection rate of 97.90% and a false negative rate of 2.47%. This is an improvement over results claimed by authors of similar papers.

Similarly, Tang et al. [19] also propose a method to monitor network flow data. The paper lacked details about its exact algorithms but does present an evaluation using the NSL-KDD dataset, which the authors claim gave an accuracy of 75.75% using six basic features. Kang and Kang [20] proposed the use of an unsupervised DBN to train parameters to initialise the DNN, which yielded improved classification results (exact details of the approach are not clear). Their evaluation shows improved performance in terms of classification errors. You et al. [16] propose an automatic security auditing tool for short messages (SMS). Their method is based upon the RNN model. The authors claimed that their evaluations resulted in an accuracy rate of 92.7%, thus improving existing classification methods (e.g. SVM and Naive Bayes). In addition, there is other relevant work, including the DDoS detection system proposed by Niyaz et al. [21]. They propose a deep learning-based DDoS detection system for a software defined network (SDN). Evaluation is performed using custom generated traffic traces. The authors claim to have achieved binary classification accuracy of 99.82% and 8-class classification accuracy of 95.65%. However, we feel that drawing comparisons with this paper would be unfair due to the contextual difference of the dataset. Specifically, benchmark KDD datasets cover different distinct categories of attack, whereas the dataset used in this paper focuses on subcategories of the same attack

## III. METHODOLOGY

We designed an innovative architecture for an IoT home network that would reduce the size of the datasets for the IDS classifier. We have selected the KDD Cup 1999 Intrusion Detection Dataset for the experiments and proposed an intelligent solution which satisfies the key requirements of the IoT solutions. We have performed the feature engineering using a Random Forest classifier and selected those features with high importance. We performed a rigorous data analysis and prepared the data in the required format before it was used as an input to the model.

### Proposed Multi-Layer architecture for IoT network

Out of various security measures, we have selected network security as the use case to prove the defined features are apt for an IoT network. In a regular wireless system, the Intrusion Detection System (IDS) monitors the network data using either a "Signature-based approach" or

an “Anomaly-based approach”. The IDS mounted at a point in the network obtains 27 all the network data and classifies the data into “normal” or “attack”. Other than traditional approaches, Machine Learning (ML) algorithms are applied to a dataset and classification is performed through supervised learning. However, this legacy approach may not be suitable for smart IoT network systems due to their heterogeneity. The security solutions for intrusion detection should be light-weight, multi-layered and have a good amount of longevity. Hence, we developed a multi-layered architecture and applied light-weight machine learning algorithms which can work with better performance for longer periods of the time. An IoT system contains various devices which are placed at different locations with long distances between them. The number of devices involved in IoT systems is higher when compared to a regular wireless or wired system. A single IDS system must have the memory capacity to process the network data among all the devices and must be responsive in a short amount of time. In this case, the performance will be poor in the IoT network due to the high number of devices and the large distance between the devices. Each IDS placed at a TCP/IP layer monitors only the data obtained from the devices that belong to that layer. We chose this architecture as the main architecture of our work because this architecture has many advantages and uses a multilayer system that is a potential system in today's world.

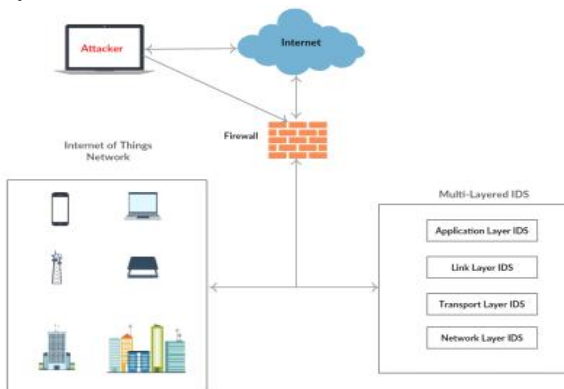


Fig. Multi-Layer architecture for IoT network

#### IV. EVALUATION AND RESULTS

##### Feature Selection

We have explained well in the above step-by-step chapters of this research and the random forest classification algorithm used to select the main important features of all the classifiers one by one and Intersecting graphical results for each classifier's characteristics are presented. The "Protocol Type" feature has been selected in all intrusion detection layers.

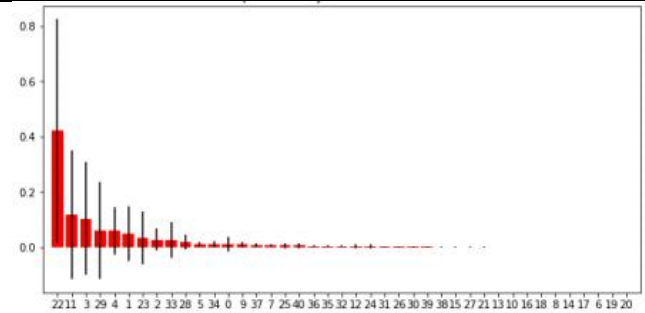


Figure: Feature Importance graph for Application Layer IDS

##### Data Loading and pre-processing

Functions defined for Data Loading and Data Pre-processing  
 DataLoading - Loads the csv data into the system  
 DataPreprocessing - Performs below operations on the loaded dataset.

- Dropping the Duplicates.
- Dividing the dataset into features set and the labels set.
- Converting categorical data into numerical data.
- Encoding the normal as '1' and abnormal as '0'.
- Converting input data into float which is required in the future stage of building in the network.
- Adding another column to the labels set - kind of one hot encoding  
 i.e normal = '1' is represented as '1 0'  
 abnormal = '0' is represented as '0 1'

This is required so that the softmax entropy function can efficiently calculate the accuracy. Loading the data into the system And applying the data preprocessing and feature selection for the dataset. Dividing into train and test datasets, performing the above operations are required before training and testing the model.

- **Normalizing the Input Features and Hyper Parameters:** Here we are not restricting the input size, therefore it batch\_size is given as "None", weights and biases are initialized in random using tf.random\_normal function. Sizes are defined appropriately as per the logic, the biases output either '1 0' or '0 1'
- **Building the Model:** Before building the model, we have to reshape the inputs in to 3D tensors of size from 2D tensors of size. We can specify a loss function just as easily. Loss indicates how bad the model's prediction was on a single example; we try to minimize that while training across all the examples. Here, our loss function is the cross-entropy between the target and the softmax activation function applied to the model's prediction.

##### Evaluation Metrics

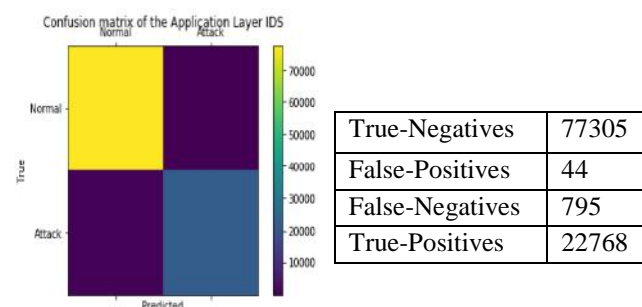
Compared to this part, we make a simple comparison of the following values: the precision of the training, the

rhythms of learning and for a good understanding on the behavior of the model according to the change of these hyper-parameters in relation to the time steps, after testing the performance of each class of IDS classifier by adding the hyper-parameters of the GRU algorithm. We performed a similar type of experiments for all IDS classifiers (all layers, the application layer, the transport layer, and other layer classifiers such as: for the network). And we are much interspersed with the results of the following classifications with their performance.

**Classifier performance results with application layer:**

With this experience we have achieved the best training accuracy with time steps of "40"; which is our complete result of this layer. The confusion matrix of the optimized (time-steps = 40, learning rate – 0.01) and the corresponding plot for the Application-Layer IDS can be analyzed in Table

Time-Steps	Train Accuracy	Precision	Recall	F-1 Score	Far
10	98.694	0.9994	0.99	0.9977	0.0022
20	98.833	0.9943	0.3296	0.9922	0.0077
30	96.71	0.9996	0.9952	0.9418	0.05812
<b>40</b>	<b>98.706</b>	<b>0.9967</b>	<b>0.9902</b>	<b>0.9983</b>	<b>0.0016</b>



**Comparing the results of all classifiers and their layers**

The optimized results of all the IDS classifiers are compared and it was found that the performance of the All-Layers IDS classifiers is inferior to the Individual layer IDS classifiers in terms of training accuracy and training time. The light-weight algorithms, when used in a multilayer architecture, perform better which is suitable for an IoT system. The comparison of the results can be found in Table.

Feature Selection Method	IDS Type	Number of features	Training Accuracy	Training Time
Random Forest Classifier	All Layer IDS	12	98.9	50.04 secnds
	Application layer IDS	6	98.7	20.54 secnds
	Transport	6	99.469	18,85

	layer IDS			secnds
	Network layer IDS	6	98.706	30.05 secnds

**Comparison of the classifiers performance with existing work**

We are at the end of our research. We performed additional analysis and reported that we compared the results with existing research performed by machine learning algorithms on intrusion detection classification, as shown in Table. We can see that our search has exceeded the performance of all existing jobs. We intend to continue in this area of research in the future time.

Algorithm	Precision (%)	Recal l (%)	Accuracy (%)	FAR (%)
DIR, PAYLOAD	74.33	78.55	78.55	75.00
SRC_PORT	95.43	96.32	96.32	95.74
GNNN[22]	87.08	59.12	93.05	12.46
FNN[22]	92.47	86.89	97.35	2.65
RBNN[22]	69.56	69.83	93.05	6.95
K-Mean-KNN[27]	98	98.68	93.55	47.9
GRU RNN[20]	95.72	98.65	97.06	10.01
All layer IDS	98.811	98.42	99.97	0.02
Application layer IDS	99.67	99.02	99.83	0.0016
Transport layer IDS	99.81	99.10 9	99.1	0.1
Network layer IDS	99.67	99.38	99.83	0.16

**V. CONCLUSIONS**

Our studies are very much about the analysis of a new domain that is the Internet of Things with the presentation of architecture and neural networks. This research focused on the processing of IoT elements where processing power is low with data size that is not as huge. This interdisciplinary research is novel in a way that, it has applied deep learning methods for IoT security. We have proposed light-weight architecture for an Intrusion Detection System (IDS) in an IoT network. Based on TCP/IP layer architecture and the attack types at each layer, we have suggested placing IDS classifiers at each layer. This has reduced the data set size at each classifier and improved the performance in terms of accuracy, recall, training time and false alarm rate. We have applied deep learning algorithms to classify the data at each IDS classifier. This approach has achieved outstanding results with better results than existing work in the literature. Moreover, we have used the full KDD 99'cup 22% data set for the

experiments, unlike previous research work. The training time of Transport Layer IDS, Application Layer IDS and Network Layer IDS is almost half of the All Layer IDS which is important for dynamic IoT networks. The accuracy and false alarm rate of All-Layer IDS is 98.91% and 0.76% respectively which outperformed all other existing IDS classifiers in literature. As the IoT deals with user's personal data and industry's information, it is crucial to implement robust solutions to protect from security threats. This can be possible with the concepts of machine learning and deep learning as IoT generate a humongous amount of heterogeneous data. We have applied Gated-Recurrent-Unit neural networks to the dataset. However, there are many improvised versions of recurrent neural networks such as Dynamic RNN, Bi-Directional RNN which can achieve better performances than basic GRU cells. One can also build a hybrid network using convolutional neural networks and recurrent neural networks to deal with multi-modal data. And here we are at the end and this research that was focused on data security; we say here that our goal was achieved given the end result which was satisfactory. We say that our research has positive results and exceeded the capacity levels of all existing work. We will continue to deepen our knowledge and the suggestions of everyone are welcome.

#### ACKNOWLEDGEMENT

In terms of gratitude, I first thank my God and my family (my father and mother) for this life that gave me. This research is the result of enormous support from my dear teacher MAYAO. I am thankful for his humble and simple personality, I would like to thank him with all my heart for all the sacrifices, directions, understanding and advice despite the language that does not allow us to communicate well but my teacher was always present for me. I thank all the teachers of my department and those who taught me the Chinese language for their support and encouragement. I am also grateful to all the friends who helped me a lot and motivated me to reach my goal, especially I would like to thank Jean Marie Cimula and Miguel Kakanakou for their love, motivation and encouragement. I think that the man must have the hard spirit to support the realities of life and the determination to accomplish his goals.

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# Factorial Economic Planning Applied to Agricultural Experimentation

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**Abstract**—Innovation may be limited by the scarceness of resources, such as financial, homogeneous area, skilled labor or other research needs, for example the difficulty in experimental control of large areas in the field. In research areas such as chemistry and physics, designs are used in such a way that when compared to the agronomic designs, they result in a reduced number of experimental units, which in this work are called economic designs. Thus, the objective of this study was to identify significant factors and effects ( $p$ -value<0.05) with the application of economic factorial plans for agricultural experiments in the field. For this, two studies were carried out, the first comparing the  $3^k$  experimental designs with the full factorial, using the same number of experimental units for both, in order to evaluate the regression model. In the second study, the three experimental designs were compared, maintaining the number of repetitions and evaluating the influence of the reduction of the number of experimental units in the approach of the regression models. At the end of the two experiments, it was observed that the  $3^k$  design was able to identify the same effects and response surface similar to the control with a significant reduction (64) in the number of experimental units.

**Keywords**— Response surface methodology, Innovation, Process efficiency, Economy.

## I. INTRODUCTION

The Response Surface consists of a set of mathematical and statistical methods used in the study of the relation between factors and responses [1,2,3], that may be the result of a first-order polynomial or more complex interactions with polynomials of a higher order [4], this relation may be stated by equation (1):

$$\hat{y} = f(x_1, x_2) + \epsilon \quad (1)$$

where  $\hat{y}$  is the answer, because of the variables  $x_1$  and  $x_2$ , added to the experimental error  $\epsilon$  [5,6].

The designs of the Rotational Central Composite Design - RCCD and  $3^k$  are second order designs, that is, the regression equation that describes the behavior of the variables also presents the quadratic terms and has the

characteristic of repeatability in the central point, are flexible and require smaller numbers of experimental units [7,8] compared to the full factorial applied in the investigation the effect of many treatments. For example, a full factorial with two factors, each factor with five levels, contemplates twenty-five treatments repeated four times, which results in one hundred experimental units. However in  $3^k$ , in the same analysis we would have nine treatments repeated four times. When observing the Rotational Central Composite Design RCCD, the addition of the vertices ( $\pm 1.41$ ) that form the star increases the coding matrix for eleven treatments repeated four times [9]. Both the  $3^k$  and RCCD are members of DOE (Design of Experiments) that includes an important framework of designs that support scientific findings [11].

The major difficulty is to adapt the economic factorials ( $3^k$  and RCCD) for agronomic experimentation, observing the basic principles of agricultural experimentation [10,12], which is characterized as a different scenario when compared with controlled environment research, presenting a low coefficient of variation (less than 3%) [13], observed the sensitivity of the statistical tests in the higher variation coefficients (higher 6%) [14], influenced by the uncontrolled factors for the field experiments.

Thus, this study aimed to identify significant factors and effects ( $p$ -value<0.05) through the application of economic factorial planning and response surface for field experiments. The studies show that for both, linear and nonlinear models, it was possible to identify the same significant effects reducing experimental units.

## II. EXPERIMENTAL PROCEDURES

The research was divided into two studies, the first aims to compare the regression models generated by  $3^k$  and the control (full factorial), taking into account the maintenance of the same number of experimental units and repetitions. In the second, the regression models generated by  $3^k$  and RCCD were compared with the control, maintaining the number of repetitions, but reducing the number of experimental units.

The data from study I are an integral part of Zimmermann's [15] research and consist of a factorial 3x3, whose factors were factor 1, soil density (1.12, 1.26 and 1.39 g.cm<sup>-3</sup>) and factor 2, doses of a nutritional compound called "FTE-BR12 microelement" (0, 1, 2g) for the rice dry mass response variable in logarithm RBD (Randomized Blocks Design) was used to allocate the field experiment that resulted in nine treatments, repeated three times.

The study II consisted of an experiment organized in a full factorial (5x5), in RBD with four repetitions of treatments, being the factor 1, the days after emergence (dae) of corn, factor 2, the days after the application (daa) of corn defensive agent and the variable response to leaf width of the corncob in millimeters [16].

The data were coded per Montgomery methodology [4], presented in Table 1, resulting in the different number of treatments in the full factorial, 3<sup>K</sup> and RCCD.

Table.1: Encoding matrix, with treatment numbers for: 5x5 full factorial (two factors with five levels each), 3<sup>2</sup> (two factors with three levels each) and Rotational Central Composite Design RCCD (two factors with three levels + vertex), without repetition.

treatment	-----full factorial-----		-----3 <sup>2</sup> -----		-----RCCD-----		experimental responses
	code factor A	code factor B	code factor A	code factor B	code factor A	code factor B	
1	-2	-2	-1	-1	-1	-1	Y1
2	-1	-2	0	-1	+1	+1	Y2
3	0	-2	+1	-1	+1	-1	Y3
4	+1	-2	-1	0	-1	+1	Y4
5	+2	-2	0	0	0	0	Y5
6	-2	-1	+1	0	0	0	Y6
7	-1	-1	-1	+1	0	0	Y7
8	0	-1	0	+1	-1,41	0	Y8
9	+1	-1	+1	+1	0	1,41	Y9
10	+2	-1			0	-1,41	Y10
11	-2	0			1,41	0	Y11
12	-1	0					Y12
13	0	0					Y13
14	+1	0					Y14
15	+2	0					Y15
16	-2	+1					Y16
17	-1	+1					Y17
18	0	+1					Y18
19	+1	+1					Y19
20	+2	+1					Y20
21	-2	+2					Y21
22	-1	+2					Y22
23	0	+2					Y23
24	+1	+2					Y24
25	+2	+2					Y25

Source: Adapted from Montgomery (2016)

Considering the full factorial for the two experiments, a general model of variance analysis was fitted, equation (2):

$$\hat{y} = \beta_0 + b + \beta_1x_i + \beta_2x_j + \beta_{11}x_i^2 + \beta_{22}x_j^2 + \beta_{12}x_ix_j + \epsilon \quad (2)$$

where  $\hat{y}$  is the estimated response,  $\beta_0$  is intercept,  $b$  is the block,  $\beta_1$  is the linear coefficient of factor 1,  $x_i$  is the normal distribution of waste (Shapiro-Wilk and Kolmogorov-Smirnov test), block additivity (Tukey test) and confirmed by visual inspection of residues.

variable 1 in level  $i$ ,  $\beta_2$  is the linear coefficient of factor 2  $x_j$  is the variable 2 in level  $j$ ,  $\beta_{11}$  is the quadratic coefficient of factor 1,  $\beta_{22}$  is the quadratic coefficient of factor 2,  $\beta_{12}x_ix_j$  is the interaction between factors 1 and 2,  $\epsilon$  is the experimental error, with the factors considered qualitative, were observed the assumptions of variance homogeneity (Bartlett and Levene tests) The regression models were adjusted (quantitative variables) after the validation of the  $F$  test, starting from the most complete model and subtracting terms, tested the significance ( $p\text{-valor} \leq 0,05$ ) of the coefficients (t-test).

In the selection of the most adequate model for describing the response, it was observed:

1. The absence of non-significant coefficients ( $p\text{-value} > 0.05$ ) in all the regression models tested;
2. Analysis of variance (ANOVA) for the hypotheses:  $H_0$ : the models are the same; the regression models did not differ significantly ( $p\text{-value} \leq 0.05$ );  $H_1$ : the regression models differ significantly;
3. Comparison of the  $R^2_{\text{adjusted}}$ , the regression model being the best fit, which presented the highest  $R^2_{\text{adjusted}}$ ;
4. Comparison of the Akaike Information Criterion (AIC), the best fit regression model, which presented the lowest AIC [17].
5. In the absence of differences between the models, the "law of parsimony" was observed.

The AIC was chosen as an adjustment test because it penalizes the lack of adjustment and complex models, being in agreement with the law of parsimony [18, 19].

Comparison between the coefficients of determination ( $R^2$ ) were not accomplished, since this is influenced by the number of terms of the regression model, according to Adair and Silva [20], the withdrawal of terms increases the

sum of the squares and, consequently, there is an increase in  $R^2$ .

In the development of  $3^k$ , according to Montgomery's methodology [4], the data were coded (-1, 0 and +1) and for RCCD, according to the same author's methodology, the vertices were added ( $\pm 1,41$ ). We observed the assumptions for both, tested the need to work with pure error ( $\epsilon_p$ ) (ANOVA) and repeated the process of selecting the best-fit model, as described in the full factorial.

The pure error ( $\epsilon_p$ ) does not have correlation with the model [21, 22], therefore, it does not depend on the estimative responses ( $\hat{y}$ ), reflecting only the dispersion at each factor level of the repeated responses ( $y$ ) around the mean ( $\bar{y}$ ), calculated by  $\sum(y-\bar{y})^2$ , summation of the squared differences between the original response ( $y$ ) and its mean ( $\bar{y}$ ), which results in the estimation of the variance for the model, influencing the values of the F test, whether the model is adjusted or not [23].

Since methodologies are from different areas, each factorial presents different particularities. The R software was the program chosen for this study because it presents an immense range of packages [24]. For didactic purposes, the functions and packages used in this study are detailed in the mentioned sources in Table 2.

Table 2 - Packages, functions, applications and sources for the development of full factorial,  $3^k$  and Rotational Central Composite Design -RCCD in software R, used in this study.

packages	functions	applications	source of the package:
R-base	AIC ()	Akaike Information Criterion	R Core Team (2018)[24]
	aov()	Analysis of variance (ANOVA)	
	bartlett.test()	Homogeneity of variance test	
	boxplot()	BoxPlot	
	hist()	Histogram	
	ks.teste	Kolmogorov-Simirnov test	
	lm()	Regression analysis	
	plot()	Builds graphics	
	qqplot()	Accumulated distribution chart	
	shapiro.test()	Normal distribution of waste	
	s.test()	Normal distribution of waste	
	summary()	Coefficients, ANOVA, coefficients of variation	
MASS	boxcox()	Tests the need of data transformation	Venables; Ripley (2002)[30]
rsm	persp()	Builds response surface	Lenth (2013)[31]
	PurreError()	Pure error	
	SO()	Quadratic models or second order	
	Varfcn()	Contour graphs	
openxlsx	read.xlsx()	Reading data straight from excel	Walker (2015)[32]
car	leveneTest()	Levene test	Fox; Weisberg (2011)[33]
dae	tukey1()	Block additivity test	Brien (2014)[34]
ExpDes.pt	fat2.dbc()	Analysis of qualitative and quantitative variance	Ferreira, <i>et al</i> (2013)[35]

Source: Self-elaboration

### III. RESULTS AND DISCUSSIONS

In study I, verification of the assumptions for the full factorial and  $3^k$  (Bartlett, Levene, Shapiro-Wilk,

Kolmogorov-Simirnov for both, Tukey for block additivity and pure error test only in  $3^k$ ) revealed higher  $p\text{-value}$  scores that the significance ( $\alpha < 0.05$ ), therefore, there is



not evidence to reject the hypothesis  $H_0$ , satisfying the assumptions of homogeneity of variance and normal distribution of residues. For the full factorial, the effect of the blocks was not significant. In  $3^k$  it was observed that it is not necessary to work with pure error. All assumptions were confirmed by visual inspections.

For the two designs tested, the linear regression effect was significant ( $p\text{-value} \leq 0.05$ ), in agreement with ANOVA for the regression coefficients (t test), in which only the coefficient of linear density soil factor with significant

effect on the response variable, however, to exclude the other terms from the model, there is a need for adjustment tests in order to eliminate the possibility of a collinearity effect, since a variable may not have a significant effect in isolation, but may influence the total effect of the model and its exclusion would make the model less explanatory or less adjusted [20].

In ANOVA between the models it was observed that there is no evidence against  $H_0$ , therefore, the models do not differ significantly (Table 3)

Table.3: Regression equations, ANOVA for regression models, and fit test: coefficient of determination ( $R^2$ ) and  $R^2_{adjusted}$  Akaike's Information Criterion (AIC) for experiment I, coefficients of variation of 6.36%.

Model	Regression equation of the proposed models	DF	p-value	$R^2$	$R^2_{ajusted}$	AIC
-----Full factorial-----						
1	$\hat{y} = 3,331+0,335x_i+0,061x_j-0,085x_i^2-0,042x_j^2 -0,009x_ix_j$	21	0,720	0,256	0,078	7,574
2	$\hat{y} = 3,346+0,335x_i -0,024x_j -0,085x_i^2 -0,009_2x_ix_j$	22	0,696	0,250	0,157	12,10
3	$\hat{y} = 3,374+0,164x_i -0,024x_j -0,009_2x_ix_j$	23	0,438	0,228	0,107	9,093
4	$\hat{y} = 3,384+0,154x_i -0,034x_j$	24	0,897	0,227	0,163	7,114
5	$\hat{y} = 3,384+0,154x_i$	25	0,589	0,217	0,185	5,483
-----3 <sup>k</sup> -----						
1	$\hat{y} = 3,590+0,154x_i+0,0341x_j-0,085x_i^2-0,045x_j^2 -0,009x_ix_j$	22	0,681	0,255	0,120	10,12
2	$\hat{y} = 3,561+0,154x_i+0,0341x_j-0,085x_i^2$	23	0,688	0,249	0,152	8,328
3	$\hat{y} = 3,533+0,154x_i+0,0341x_j-0,042x_j^2$	23	0,688	0,233	0,133	8,918
4	$\hat{y} = 3,504+0,154x_i+0,0341x_j$	24	0,580	0,227	0,163	7,114
5	$\hat{y} = 3,504+0,154x_i$	25	0,427	0,217	0,185	5,483

Where:  $x_i$  variables of factor 1 at level  $i$ ;  $x_j$  variables of factor 2 at level  $j$ ; DF are the degrees of freedom; p-value is the is the probability of  $F_{calculated}$ , significant ( $p \leq 0.05$ );  $R^2$  is the coefficient of determination and  $R^2_{adjusted}$  is the is the coefficient of determination adjusted both for regression; AIC is Akaike's Information Criterion; Source: Self-elaboration.

Confirming the model selection (Table 3), the highest  $R^2_{adjusted}$  and lowest AIC belong to Models 5. The  $3^k$  identified the same factor and significant effects when compared to the control (full factorial), however with the results estimated by  $3^k$  model were 2.91% higher. The comparison between the models revealed homogeneous variances (0.01654) and the difference between the residues quantified by  $R^2 = 0.9623$ .

This result is agreement with Konishi and Kitagawa [25], models with small variability fit well the reduction of experimental units. But to validate an experiment subject to variations of the environment a greater number of experimental units and repetitions is recommended, minimizing the experimental error [15, 22, 23], and, the Surface Response Methodology is an efficient tool to optimize the properties of processed foods [26]. Using mathematical and statistical techniques, experimental results indicate a combination of factor levels within an optimal region [4].

Study II observed regression models with more complex interactions. In the analysis of variance (ANOVA), performed for the control (full factorial), composed of one hundred experimental units, the interaction between the

(qualitative) factors was significant ( $p\text{-value} \leq 0.05$ ), therefore, interaction was observed in the Bartlett and Levene test, both with  $p\text{-value} > 0.05$ , given the assumption of homogeneity of variance. Shapiro-Wilk and Kolmogorov-Simirnov indicated the normal distribution of waste and the Tukey test confirmed that the blocks were not additive to the model.

In the development of  $3^k$ , thirty-six experimental units were used. The assumptions were met, but also it was identified the need to work with pure error. In RCCD, composed of forty-four experimental units, the assumptions were not met and the model also indicated the need to work with pure error. In all the designs the effect of quadratic regression was significant ( $p\text{-value} \leq 0.05$ ).

All regression models tested (Table 4) showed significant coefficients (t-test, with normal error for full factorial and t-test with pure error for  $3^k$  and RCCD). According to Faraway [27], the identification of the need for pure error in the t-test, refers to the option with the lowest variance and, therefore, increases the accuracy of the test.

The ANOVA (analysis of variance) between the analyzed regression models revealed that they differed significantly ( $p\text{-value} \leq 0.05$ ) (Table 4).

Table.4: Regression models analyzed, regression equations, ANOVA (analysis of variance) for regression models (DF and  $p$ -value), and fit test: Coefficient of determination ( $R^2$ ) and  $R^2_{adjusted}$ , Akaike Information Criterion (AIC) for Experiment II, coefficients of variation of 1.8%.

Model	Regression equation of the proposed models	DF	$p$ -value	$R^2$	$R^2_{adjusted}$	AIC
-----Full Factorial-----						
1	$\hat{y} = 81,543 + 12,861x_i + 13,374x_j - 2,319x_i^2 - 2,109x_j^2 - 4,26x_ix_j$	94	<u>2.4e-14</u>	0,982	<u>0,981</u>	<u>564,9</u>
2	$\hat{y} = 77,325 + 12,861x_i + 13,374x_j - 2,319x_i^2 - 4,266x_ix_j$	95	<u>2.4e-14</u>	0,966	0,965	625,0
3	$\hat{y} = 72,686 + 12,861x_i + 13,374x_j - 4,266x_ix_j$	96	<u>3.1e-16</u>	0,947	0,946	667,5
4	$\hat{y} = 72,686 + 12,861x_i + 13,374x_j$	97	<u>2.2e-16</u>	0,857	0,854	766,0
----- $3^k$ -----						
<u>1</u>	$\hat{y} = 82,976 + 26,179x_i + 24,710x_j - 6,889x_i^2 - 10,689x_j^2 - 15,74x_ix_j$	33	<u>1.51e-1</u>	0,980	<u>0,9775</u>	<u>223,7</u>
2	$\hat{y} = 71,356 + 26,179x_i + 24,710x_j - 15,7406x_ix_j$	32	<u>89e-14</u>	0,945	0,9407	256,9
3	$\hat{y} = 71,2579 + 26,179x_i + 24,710x_j$	30	<u>1.84e-7</u>	0,838	0,8291	294,1
-----RCCD-----						
<u>1</u>	$\hat{y} = 90,350 + 20,291x_i + 18,537x_j - 9,707x_i^2 - 7,402x_j^2 - 15,74x_ix_j$	38	<u>5.05e-7</u>	0,884	<u>0,8737</u>	<u>335,7</u>
2	$\hat{y} = 77,906 + 20,291x_i + 18,537x_j - 15,74x_ix_j$	40	<u>5.05e-5</u>	0,812	0,7981	354,6
3	$\hat{y} = 77,908 + 20,291x_i + 18,537x_j$	41	<u>2.6e-07</u>	0,697	0,6830	373,7

Significate ( $p$ -value  $\leq 0,05$ ); Where:  $x_i$  variables of factor 1 at level  $i$ ;  $X_j$  variables of factor 2 at level  $j$ ; DF: degrees of freedom;  $p$ -value is the probability of  $F_{calculated}$ ;  $R^2$  coefficient of determination;  $R^2_{adjusted}$  adjusted coefficient of determination; AIC- Akaike Information Criterion; RCCD-Rotational Central Composite Design. Source: Self-elaboration.

In order to identify the models that best describe the experiment, we observed the highest  $R^2_{adjusted}$  and lowest AIC found in Models 1 (Table 4), composed of intercept, linear terms, quadratics and interaction for full factorial,  $3^k$  and RCCD. All effects are significant in the model but the nonlinear model is not well adjusted [18].

It is noteworthy that other models were also tested, but presented lower adjustments and for didactic purposes were not included in Tables 2 and 3.

The representation of the three selected models (Figure 1) revealed that despite the reduction of 64 experimental units, the regression model for the  $3^k$  design, estimated from thirty-six experimental units, was able to identify the same factors and significant effects that the control (full factorial-one hundred experimental units). Robust models are more reliable for the researcher and not affected by the loss of information [28].

However, RCCD (forty-four experimental units), although also did so, showed greater distance from the control. According to Mateus et al., [13], RCCD did not adjust well to agronomic data simulation experiments with coefficient of variation (CV) greater than 6%. The CV of this experiment was 1.8% and the precision of the RCCD was lower than the  $3^k$ . There are indications that the estimation

of the vertex for RCCD by the regression model of the full factorial may have interfered in the precision [29].

For Mendonça [14], who used data simulation, the loss of fit of the economic models can be compensated with the increase of repetitions of the treatments, in which the four replicates (full factorial,  $3^k$  and RCCD) were maintained in this experiment for purposes of comparison, with the objective of making achievable large experiments with reduction of experimental units. And [29] all this is source of variability within the experiment and to circumvent these problems in the planning and conduction phase of the experiments is fundamental so that the experimental error is not high. Furthermore, the knowledge of statistical tests and the assumptions for their application is fundamental for the research to be statistically valid.

Therefore, economic models are efficient and indicated to identify the significant result in initial tests or probing tests, especially in experiments without prior knowledge [14] and besides the basic requirements of the tests and observation of agronomic assumptions, the analysis of the particularities of the experiment should be observed [10].

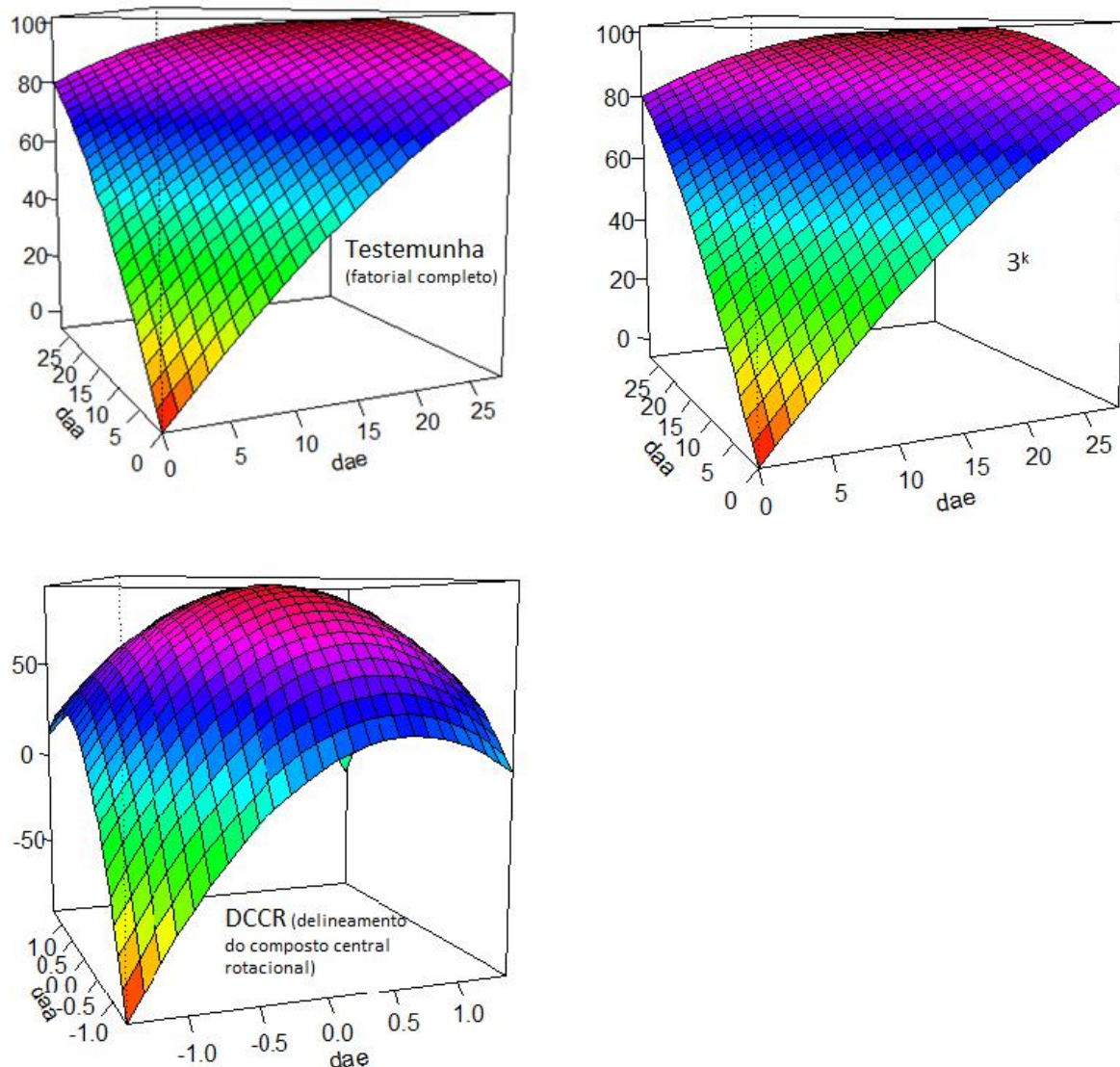


Fig.1: Response surface composed of factor 1 - days after application (daa) of corn herbicide and factor 2 - days after emergence (dae) of corn, variable response leaf width of corncob in millimeters, which represents the adjusted polynomial regression. The control (full factorial) consists of one hundred experimental units,  $3^k$ , consisting of thirty-six experimental units and RCCD (Rotational Central Composite Design) composed of forty-four experimental units.

Source: Self-elaboration

#### IV. CONCLUSION

The  $3^k$  design was presented as an economic factorial capable of identifying the same factors and significant effects in the agronomic experiments, reducing the experimental units and contributing to the technical and economic viability of larger experiments, as long as the number of repetitions of the treatments was maintained. Data simulation was not used to experience actual practices.

#### ACKNOWLEDGEMENTS

The authors thank the Unochapecó and Epagri-SC by support a part of the studies.

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# Selective and Simultaneous Removal of Ni (II) and Cu (II) Ions from Industrial Wastewater Employing a Double Ni-Cu-Ion Imprinted Polymer

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**Abstract**— In this paper, a Ni-Cu ion imprinted polymer was synthesized and employed for the simultaneous removal of high levels of copper (II) and nickel (II) ions from wastewater. Bulk polymerization technique employing methacrylic acid, ethylene glycol dimethylacrylate, azobisisobutyronitrile as the functional monomer, cross linker and initiator respectively was used to synthesize the ionic imprinted polymer. Rigorous template removal was conducted employing increasing hydrochloric acid concentration ranging from 1.0 M to 10.0 M. The chemical characteristic of the prepared polymer was evaluated by employing Fourier Transform Infrared Spectroscopy. Adsorption parameters including contact time, pH and prepared polymer dosage were investigated and found to be 12 min, 7.0 and 665.5 mg/L respectively. The prepared Ni-Cu ions imprinted polymer showed excellent copper (II) and nickel (II) ions removal efficiency from wastewater as indicated by the 89.1% and 83.2% at  $n = 3$  removal of total copper (II) and nickel (II) ions in the wastewater sample.

**Keywords**— Nickel, Copper, ion imprinting, imprinted polymer and adsorption.

## I. INTRODUCTION

In recent years, researchers have devoted more time and resources investigating ways to solve the crisis of fresh water scarcity (Garcia & Pargament, 2015). Some of these studies have led to wastewater being recycled and reused (Amin, Alazba, & Manzoor, 2014). Wastewater treatment plants have been setup in most countries worldwide to treat and recycle wastewater. However, the effluents from these plants often contain excess toxic heavy metal ions that are detrimental to the environment (Barakat, 2011).

Human activities such as agriculture, irrigation, industrialization, urbanization and technological activities often release high levels (toxic) of heavy metal ions in the aquatic environment posing serious health hazard to the environment (Musyoka, Ngila, & Mamba, 2013). Usually, these toxic ions are stable under ambient conditions. They are not biodegradable and hence accumulate over time (Anuja Ashok Bhatt, 2015).

Although some of these ions are essential to life, their presence in high concentrations often results in serious health issues to the environment (National Research Council, 2000). Therefore, it is important that the level of heavy metal ions in the environment remain within acceptable levels as set out international monitoring bodies (Welna, Szymczycha-madeja, & Pohl, 2011).

Several methods and techniques have been employed by researchers to remove heavy metal ions from wastewater. For example, membrane assisted liquid extraction (MALE) (Boeva & Sergeyev, 2014), liquid-liquid extraction (Rao, Kala, & Daniel, 2006) (Shirkhanloo, Mousavi, & Rouhollahi, 2011), membrane filtration (Barakat, 2011); ion exchange (Ozcan, Satiroglu, & Soylak, 2010), biosorbents (Maina, Obuseng, & Nareetsile, 2016) have been employed to remove toxic heavy metal ions from wastewater. As excellent as these methods have proven to be, they have some limitations such as high cost of reagents and equipment, time consumption, high energy consumption and selectivity (Othman, Abd-Kadir, & Zayadi, 2016) (EL-Sharif, Phan, & Reddy, 2014). In the quest to address the challenges faced with the available methods/techniques often used to remove toxic heavy metal ions from wastewater, the development of new technology; molecular imprinting technology, which has proven to be selective, time efficient, low cost, less/no energy

consumption have been proposed. Imprinted polymers exhibit high and specific affinity for a target ion(s) (Yungerman & Srebnik, 2006). They are nano-porous, which upon removing the imprinted ion (template ion) will specifically rebind to that ion based on size, shape and charge of the template ion.

In this paper, Ni-Cu ion imprinted polymer was synthesized for the simultaneous and selective removal of nickel (II) and copper (II) ions from wastewater. There have been lots of works that have been done demonstrating the extraction of a single ion at a time by ion imprinted polymer (IIP). In the need to reduce time, in this case, a double ion imprinted polymer was synthesized.

## II. MATERIALS AND INSTRUMENTS

Reagents used were: analytical grade HCl (32%) acetonitrile (99.9%), Nickel (II) Nitrate Hexahydrate (97.0%), Copper (II) Nitrate Trihydrate ( $\geq 98.0\%$ ) purchased from ACE (Johannesburg, South Africa), Ethanol (99.9%) purchased from Skylabs (Johannesburg, South Africa), analytical grade Methacrylic acid, MAA (99%),  $\alpha, \alpha'$ -Azobisisobutyronitrile, AIBN (98%), analytical grade HNO<sub>3</sub> (50%), 1,10-Phenanthroline (99%), analytical grade Ethylene glycol dimethacrylate (98%), ethylenediaminetetraacetic acid, EDTA (98%), Mercuric Nitrate monohydrate (95%), elemental standard solutions used (1000ppm – Fe, Ni, Cu, Pb, Zn & Hg), 0.45  $\mu\text{m}$  pore sized Whatman filter papers (Hardened Ashless Circles 45 mm) that was used for all filtering processes purchased from Sigma-Aldrich (Johannesburg, South Africa), and NaOH (97%) pellets, purchased from Rochelle Chemicals (Johannesburg, South Africa). Laval stainless steel sieve (5 – 20  $\mu\text{m}$ ) was purchased from Laval Lab (Minnesota, USA) was used for sieving the IIPs and NIPs.

A Varian 220FS Atomic Absorption spectrometer (California, USA) operated with air/acetylene was employed for the analysis of metal ions. A Nicolet iS10 FTIR spectrometer purchased from Thermo Scientific (South Africa) was used for characterization of the washed and unwashed IIPs as well as the NIPs.

### Synthesis of Double-templated Ion Imprinted Polymer and Non-imprinted Polymer and Optimal Template Removal

The double-templated Ni-Cu- IIP material was synthesized by firstly preparing the binary complex of 1 mmol of Ni(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O, 1 mmol of Cu(NO<sub>3</sub>)<sub>2</sub>·3H<sub>2</sub>O, 1.1 g of 1,10-Phenanthroline as complexing agent and 1 mL of methacrylic acid (MAA) as the ligand. After forming the complex, 11 mL of ethylenediaminetetraacetic acid

(EDGMA), 0.24 g  $\alpha, \alpha'$ -Azobisisobutyronitrile (AIBN) and 40 mL of ethanol/acetonitrile (2:1 v/v) was added to the complex mixture and stirred at 900 rpm for 30 min, after which, the mixture was degassed using a sonicator for about 15 min. The bulk polymerization was preceded at 60 °C for 12 h under continuous stirring at 600 rpm until monolith was formed. The obtained monolith was pulverized, sieved and dried in a hot air oven at 60 °C for 3 h. Unreacted materials were removed by employing optimized template removal technique (Stevens & Batlokwa, 2017). A non-imprinted polymer was also synthesized employing the same procedure, but without template ions; as a control material.

The template ions (nickel and copper ions) and other unreacted reagents were exhaustively removed from the prepared materials in three (3) separate steps. Firstly, the unreacted reagents were removed by refluxing the prepared powder with 50 mL of deionized water for a total of 10 hours in a 2 hour cycles. At the end of every cycle the prepared powder was recovered by centrifugation and dried in a hot air oven for 5 hour. Secondly, the obtained material was refluxed at 60 °C with a mixture of a 1:1 v/v of 1.0 M HCl and ethylenediaminetetraacetic acid (EDTA) for a total of 24 hours of 8 hour cycles. At the end of every 8 hour cycle prepared powder was recovered by centrifugation and dried in a hot air oven for 5 hour. Finally, the obtained powder was refluxed at 60 °C with 10.0 M HCl for a total of 8 hours of 2 hour cycles (employing same procedures as in the second step). The eluents from every step was evaluated by employing atomic adsorption spectroscopy to evaluate the level of template ions removed from the washed material (Stevens & Batlokwa, 2017). The last three eluent contained none of the imprinted ions; thus, indicating complete removal of the template ions from the prepared material.

After polymerization as described above, a forest greenish monolith (imprinted polymer) and a white monolith (non-imprinted polymer) were formed as showed in Figure 1 and 2 respectively.



Fig.1: Monolith of the Ni-Cu-IIP



Fig.2: Monolith of the non-imprinted polymer

after filtering out the washing solvents was a whitish IIP powder as seen in Figure 3.



Fig.3: Washed Ni-Cu-IIP Powder

Continuous washing of the greenish IIP powder resulted in the gradual colour change with each succeeding washing cycle. The loss of colour of the mixture to almost colourless from was an indication that indeed the template ions (print ions) were indeed washed off (removed) from the prepared Ni-Cu-IIP powder. The print ions, Ni(II) and Cu(II) are characterized by colour hence their removal by a successful template removal procedure must result in a product with less colour (colourless/white), thus the obtained product

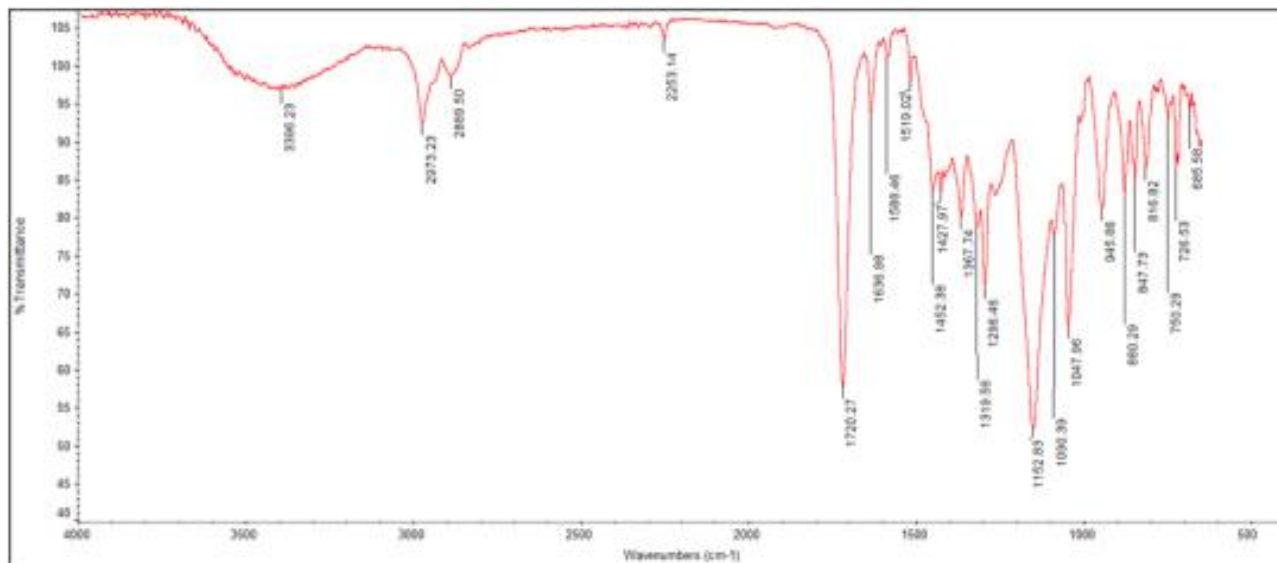


Fig.4: FT-IR of the unwashed Ni-Cu-IIP

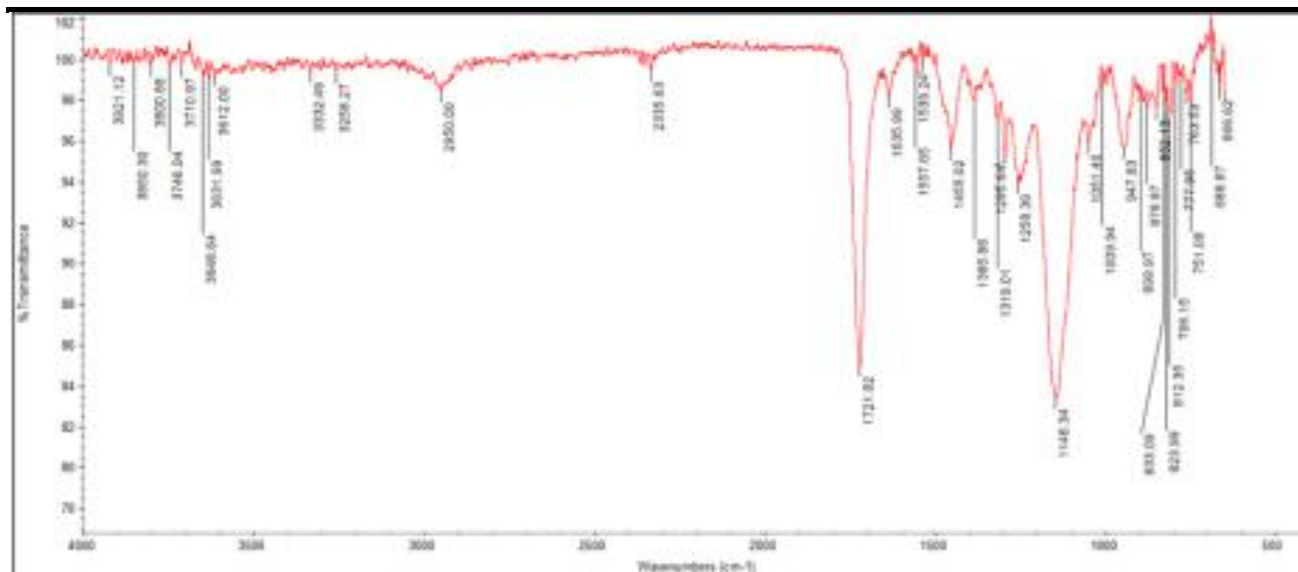


Fig.5: FT-IR of the washed Ni-Cu-IIP

### FT-IR Analysis

Fourier transform infrared (FTIR) spectroscopy was used to identify the functional groups (responsible for the metal uptake and bonding) possessed on the surface of the washed and unwashed IIP as well as the NIP. The FTIR spectra were recorded in the wavenumber range 500- 4000  $\text{cm}^{-1}$  on a Nicolet iS10 Thermo Scientific FTIR. The data were collected at 2.0  $\text{cm}^{-1}$  resolution, and each spectrum was a result of 256 scans (Rao et al., 2006).

Analysis using FT-IR enabled better understanding of the surface features of the powder and the evaluation of the optimal removal of template and unreacted materials as shown in Figure 4 and 5. Figure 4, shows the FTIR of the Unwashed Multi-templated Cu-Ni IIP powder. The band around 3400  $\text{cm}^{-1}$  is very broad, indicating the presence OH groups from the likelihood of incomplete drying hence the presence of OH groups from water molecules within the structure. The two peaks at 2973  $\text{cm}^{-1}$  and 2890  $\text{cm}^{-1}$  are C-H stretch frequencies that belong to CH<sub>3</sub> or CH<sub>2</sub> groups from the backbone structure of the monomers. The large peak at 1720  $\text{cm}^{-1}$  is the stretch frequency of a carbonyl group. There is a similar strong peak at 1153  $\text{cm}^{-1}$ , which, together with the peaks at 3396

$\text{cm}^{-1}$  and 1720  $\text{cm}^{-1}$  evidence the presence of an ester. The minor peaks below 900  $\text{cm}^{-1}$  are the finger print region.

### Rebinding Studies

#### Contact Time

30 mg of the prepared Ni-Cu-IIP was put into 7 separate conical flasks and then 30 mL (5 mg/L equimolar) mixed standard solution of Ni (II) and Cu(II) was added. The mixture was shaken for 90 min, varying from 1 min, 10 min, 15 min, 30 min, 60 min, 90 min and 120 min after which the mixture was filtered using a 0.45  $\mu\text{m}$  pore size Whatman 45 mm filter paper. The filtrate was then analyzed employing AAS.

The percentage removal of Ni (II) and Cu (II) ions by the prepared Ni-Cu-IIP increased with increase in contact time. When the washed Ni-Cu-IIP was applied as described, the optimal removal efficiency of the Ni-Cu-IIP was obtained within 12 minutes. Further increase in contact time did not show any further significant increase in the prepared material efficiency. The optimum time was as such, investigated to be 12 minutes as shown in Figure 6. Consequently, subsequent experiments employing the washed Ni-Cu-IIP were performed within 12 minutes of contact time.

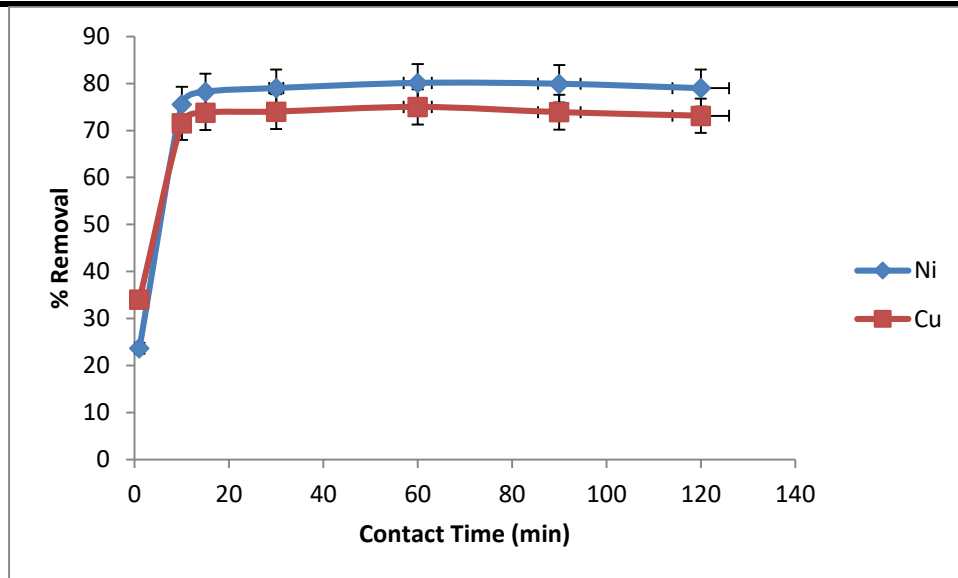


Fig.6: Optimization of contact time

**pH**

To evaluate the optimal pH require for optimal Ni (II) and Cu (II) removal by the prepared Ni-Cu-IIP, 30 mL of the 5 mg/L equimolar mixed standard solution was put into 7 different 100 mL conical flasks and the pH was adjusted to pH 2, 4, 6.5, 7.5, 8, 9, 10 respectively using 0.1 M HCl and 0.1 M NaOH. After which, 30 mg of the prepared Ni-Cu-IIP was added into each flask. The mixture was shaken for 12 min, then filtered with 0.45 μm pore size Whatman 45 mm filter paper. The filtrate was then analyzed employing AAS. The lower the pH of a solution, the higher the presence of hydrogen ions, there if there are cations ions (heavy metal

ions) present in the same medium, both the hydrogen ions and the cations will compete for binding sites on the adsorbents, with the hydrogen ions most likely to bind due to their chemistry. Meanwhile, at higher pH; ≥8.5, cations (heavy metal ions) often form precipitates or oxide with the hydronium ions in the solution. These phenomena were observed during the optimization of pH applying the synthesized Ni-Cu-IIP. It was observed that at a pH of 7.0, the prepared polymer exhibited its highest nickel and copper ions removal efficiency as shown in Figure 7.

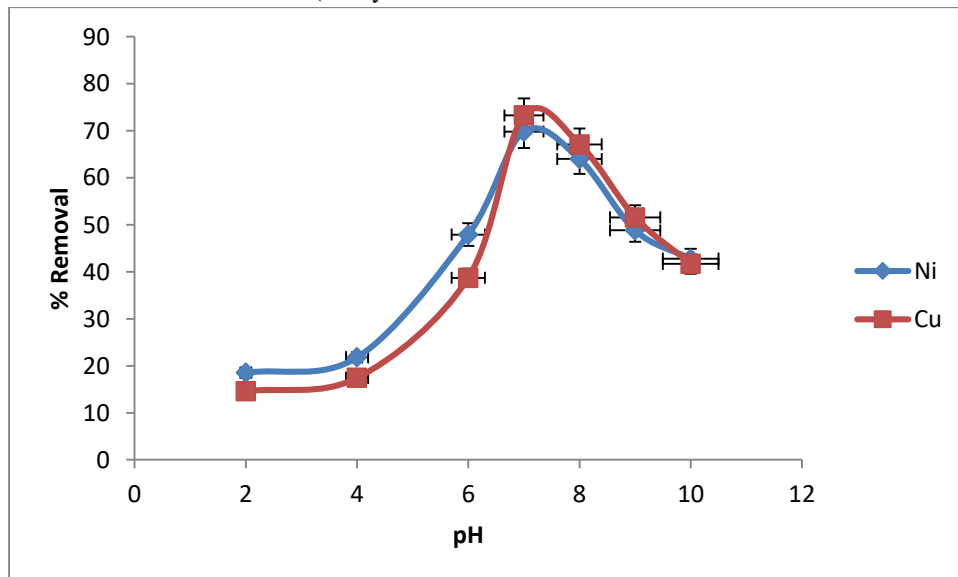


Fig.7: Optimization of pH

Consequently, subsequent experiments employing the washed Ni-Cu-IIP were performed at a pH of 7.



**Ni-Cu-IIP Dosage**

5 mg, 10 mg, 20 mg, 30 mg, 40 mg and 50 mg of the prepared Ni-Cu-IIPs powder were separately put into 6 different conical flasks. Then 30 mL of the 5 mg/L equimolar mixed standard solution at the obtained optimized pH was added to each flask and was shaken for the optimized time, and filtered off with a 0.45  $\mu\text{m}$  pore size Whatman 45 mm filter paper. The filtrate was then analyzed employing AAS.

It was observed that by increasing the Ni-Cu-IIP dosage from 5 mg to 50 mg, the percentage removal of the selected ions was also increased. This was due to the adsorbent and selected ions concentration ratio. In other words, the more the Ni-Cu-IIP in the solution, the more binding sites present to allow the binding of the selected ions. With about 20 mg of the prepared material added, the highest optimal removal of the selected ions in the order of  $\text{Cu} > \text{Ni}$  was achieved as shown in Figure 8.

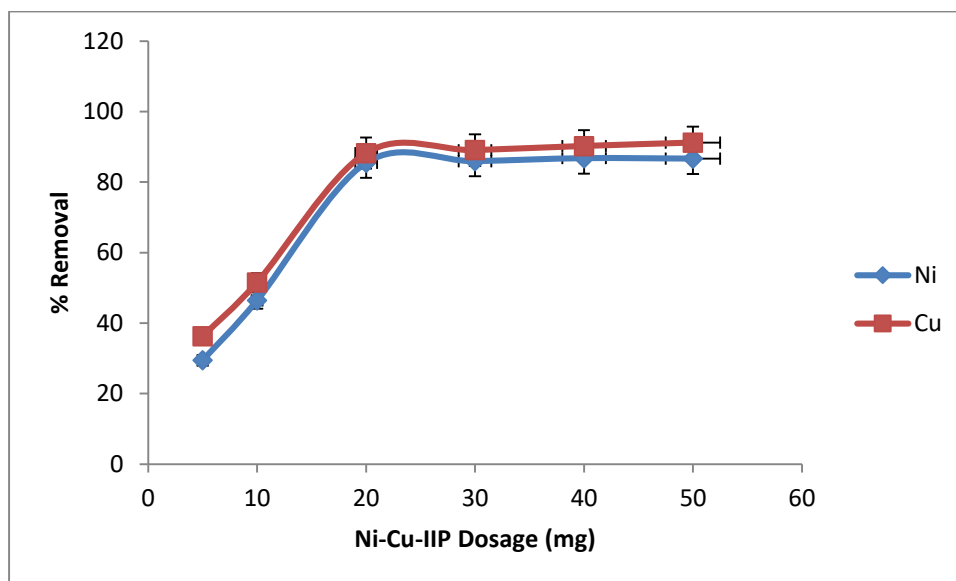


Fig.8: Optimization of Ni-Cu-IIP dosage

Consequently, subsequent experiments employing the washed Ni-Cu-IIP were performed employing 20 mg of the prepared Ni-Cu-IIP.

**Selectivity Studies**

Selectivity of both the prepared Ni-Cu-IIPs and non-imprinted polymer were investigated by employing either of the materials to a mixture of Fe(III), Fe(II), Ni(II), Cu(II), Pb(II) and Zn(II). An optimal amount of each of the materials was separately added to a 30 mL of the 5 mg/L standard mixture solution containing all of the ions at optimal

conditions and shaken for optimal time, after which they were filtered employing a 0.45  $\mu\text{m}$  pore size Whatman 45 mm filter paper. The filtrate was then analyzed employing AAS.

Pb (II), Zn (II) and Hg (II) were chosen as the competitor ions, due to their similarities in their chemistry and the fact that most often these heavy metals exist in the environment together, especially in industrial wastewater. It was observed that the percent removal of Ni (II) and Cu (II) by the prepared Ni-Cu-IIP was higher than that of Pb (II), Zn (II) and Hg (II) as shown in Figure 9.

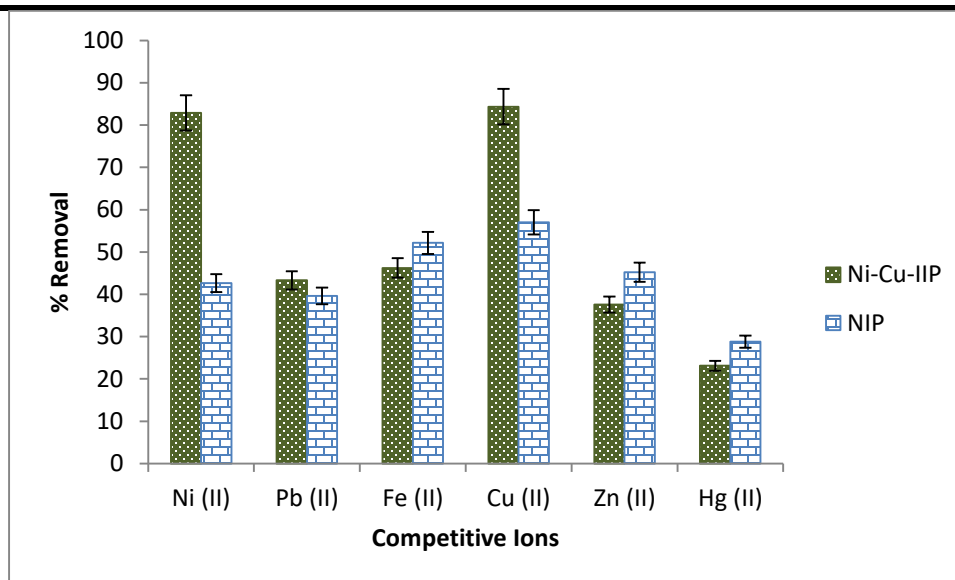


Fig.9: Selectivity studies

It was also observed that the NIP showed relatively similar removal percentage towards all of the ions. The non-selectivity of the NIP was due to the fact that it was not imprinted during the synthesis procedure. The selectivity of the Ni-Cu-IIP towards Ni (II) and Cu (II) was due to the imprinting of both ions on the polymer. By imprinting, one creates a binding site that will mostly rebind to an ion(s) that is similar in shape, size and charge to the imprinted ion(s).

#### Evaluation of Ni (II) and Cu (II) in the Raw Wastewater Sample

100 mL of wastewater was pulled in five 250 mL conical flasks. 3 mL of an aqua regia solution of HNO<sub>3</sub> and HCl was added to the flask. The mixture was heated until the initial volume was reduced to approximately 2 mL (Mitra & Brukh, 2003). The obtained mixture was then filtered into a 50 mL volumetric flask and filled to the mark with deionized water. The filtrate was then analyzed employing AAS to determine the concentration of nickel and copper.

The selected heavy metals ions concentrations in the wastewaters sample were observed to be lower than the toxic levels which are set by waste water specification-bobs

93:2012 in Botswana and US. Therefore, to test the full capability of the prepared Ni-Cu-IIP, the sample was spiked with 15 mg/L of each of the selected ions.

#### Application of the Prepared Ni-Cu-IIP to the Raw Wastewater Sample

The prepared double-templated Cu-Ni-IIP powder was applied to a raw wastewater samples under optimal conditions for the selective and simultaneous removal of Ni (II) and Cu (II) ions. The experiment was done in triplicate. Percentage removal of the selected ions from the raw wastewater sample was obtained by employing:

$$\% \text{ Removal} = \frac{\text{Initial ion concentration} - \text{final ion concentration}}{\text{Initial ion concentration}} \times 100\%$$

The obtained optimized parameters were applied to the spiked wastewater samples. The percentage removal of the selected ions was determined employing AAS and using the above formula to obtain the values. Figure 10, showed Ni recorded a low percentage removal (83.23%) as compare to Cu (89.14%) with highest percentage removal.

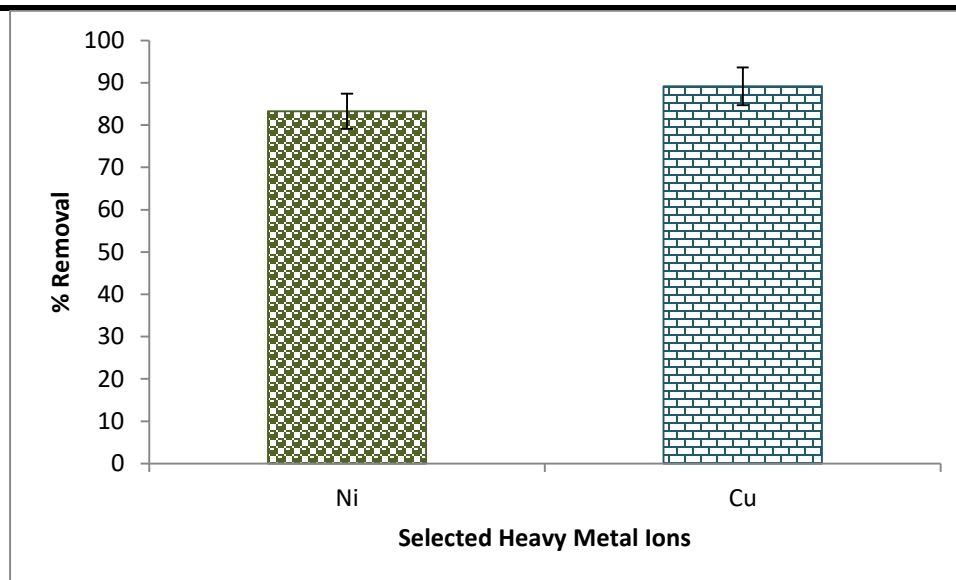


Fig.10: Ni-Cu-IIP percentage removal efficiency

### III. CONCLUSION

Double-templated ion imprinted polymers with Ni (II) and Cu (II) ions binding sites for the adsorptive removal of Ni (II) and Cu (II) from industrial wastewater was prepared in this study. The prepared Ni-Cu-IIP was synthesized using a non-covalent bulk polymerization approach and while it has demonstrated group selectivity towards two heavy metal ions; Ni (II) and Cu (II)), it also demonstrated the ability to differentiate between closely related structural analogues. The double-templated Ni-Cu-IIP was investigated for use as an extraction application as adsorbents and it was proved to be specific, selective and time efficient in recognizing and retaining the target ions.

### ACKNOWLEDGEMENT

This research has been supported and financed by the Botswana International University Science and Technology (BIUST).

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# Family Health Strategy and More Doctors Program in Rural Area of Porto Velho, Brazil: A Qualitative Analysis under the Nurse's Perspective

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**Abstract**—The Family Health Strategy (FHS) together with the implementation of the More Doctors Program (MDP) has an effective contribution to the strengthening of Primary Health Care (PHC) and the consolidation of the Unified Health System (SUS), which has intended to meet the health needs of the population in need of care less complex. Thus, this study aims to analyze the Family Health Strategy and the Program More Doctors implanted in the Rural Municipality of Porto Velho, Rondônia, from the perspective of nurses. This is a qualitative research, descriptive exploratory performed in the field, based on the assessment the perspective of nurses working in the FHS, which are favored by the MDP. The data collection

was carried out through a questionnaire, Primary Care Assessment Tool (PCA Tool), in its version validated in Brazil entitled PCA Tool - Brazil (BRAZIL, 2010). This instrument is widely used by national research that evaluates the quality of primary care. For the construction of the database was used Microsoft Word software. For qualitative data, the collection was carried out through interviews recorded by a script containing open questions. The response were discussed based on the content analysis technique proposed by Bardin (2011). The results achieved indicate that the MDM enabled the structuring of teams that were incomplete in the rural area of the town, however presents numerous challenges in the



*organization of the work process and the understanding of program objectives.*

**Keyword—Family Health Strategy, Quality, Health Education, More Doctors Program.**

## I. INTRODUCTION

One of the best ways to be a progression of public policies for the health sector is to have mechanisms that constantly provide information to improve and or expand the proposed actions aimed at citizens' quality of life covering as much of the Brazilian territorial extension with due doctor.

In Brazil, there are 40 700 Family Health Units (USF) operating in all states. Work in these health posts more than 39,100 family health teams - FHS, which represents an increase of 135% compared to 2002 when 16 700 teams were registered. The number of community health agents (CHA) also rose 49%, from 175,400 in 2002 to 265,200 in 2015. There was also an increase of 459% in the number of oral health teams from 4.2 thousand in 2002 to 23 800 teams today (BRAZIL, 2015).

In 1996, the FHS was established in Porto Velho, the adequacy of the program teams of Community Health Agents (PACS), existing in the urban east area and the rural area of Porto Velho. In the rural area of the city, now the city has 22 family health teams, distributed in 20 Basic Health Units in 20 locations (Santos et al, 2012).

In 2013, Brazil had a need for medical widely discussed by international bodies. The national average was 1.8 doctors / thousand inhabitants. Reality in contrast countries such as Argentina, Uruguay and Spain, which have 3.2, 3.7 and 4.0 doctors / thousand inhabitants, respectively. Nationally, 22 Brazilian states presented themselves below the national average, with less than 1 / thousand inhabitants, they Acre, Amapá, Maranhão, Pará and Piauí (BRAZIL, 2015).

Based on this reality, the Most medical program for Brazil aims to strengthen primary care, in which through intergovernmental partnerships, directs medical professionals to the reduction of the assistance gaps, to ensure improved access to users of the Unified System Health throughout the Brazilian territory (PAHO, 2016).

As a supervisor and coordinator of the team, the nurse professional, has a huge and important responsibility regarding the organization of actions and health services to the community, which is responsible for the organization of the whole team work process.

Enlarge care with primary health care to the entire Brazilian population is a prerequisite for the improvement of various health indicators and, more than that, for the very consolidation of the Unified Health System -SUS- (BRAZIL, 2012).

According to Castro (2012), the implementation of the Family Health Strategy in 1994, adopted by the Ministry of Health in Brazil, promotes the expansion of PHC.

From what was presented, it emerges as guiding question of research: What is the vision of the nurse as a member of the multidisciplinary team of the Family Health on the implementation of More Medical program in rural Porto Velho?

In this sense the opinion of nurses about health services and above all, the process to develop, it is extremely important when seeking the quality of service provided to users. Thus one can not ignore the perception of this professional who deals directly with the structural reality, planning, management and involving directly and indirectly in their work process and assistance to the user's health.

So analyze the health strategies of the family and most medical program in the rural area of the old port from the perspective of the nurse is the best way to constantly find reliable data in order to expand and improve such tactics for implementation of various actions for health of the family.

Through this context, this study is justified by the opportunity to know the quality of primary health care in rural Porto Velho, after twenty years of implementation of the FHS and four years of implementation of the More Doctors program, through the present research science with a focus on nurse vision.

Thus, this study aims to analyze the quality of the Family Health Strategy and the Program More Doctors implanted in the rural municipality Porto Velho, Rondônia, from the perspective of nurses. In addition to secondary objectives as: To describe the profile of nurses of Health teams Porto Velho family; Unveiling the understanding of these professionals about the More Doctors program (MDP); identify the challenges that lay ahead for the effective implementation of the Family Health Strategy in the rural area of Porto Velho, in the FHS nurses' perspective.

## II. METHODOLOGY

This is a qualitative research, descriptive exploratory performed in the field, based on the assessment the perspective of nurses working in the FHS, which are favored by the Program More Doctors in Rural areas of the city of Porto Zone Velho, RO.

This research consisted of an offshoot of a mother project entitled Health Strategy Quality assessment and Family Program More Doctors in the city of Porto Velho, Rondônia: the perspective of the medical professional, whose aim is to assess the quality of health strategy Family and program More Doctors in Porto Velho, Rondônia, in the doctor's perspective.

According Augustus et al. (2014), qualitative research provides a fundamental base of great importance to the testimony of the social actors involved, speeches and definitions transmitted by them. In this sense, this type of research values the detailed exposition of phenomena and of the elements that surround it.

The collections were previously scheduled seven (07) professional nurses, which are conducted via telephone by determining date and time for the meeting. The survey was conducted with four (4) nurses working in primary health care units, located in the extension of Br 364 towards Rio BrancoAC and 319 Br sense Humaita - AM of the Rural Municipality of Porto Velho Zone.

Data collection began on August 23, 2017, is carrying out two interviews, with nurses being one of USF and USF 2 followed for the next data collection that was of USF 3 on day seven (07 ) September and the last collection in this study was the USF 4 on the ninth (09) September 2017, both were held outside the Health Unit at the request of professionals.

The study population consisted of nurses of the Family Health teams, who were working and living in your daily routine together with doctors of the Program More Doctors at the time of data collection.

For this research included all nurses who acted for at least six (06) months in the UBS Rural Zone of city of Porto Velho in their respective districts surveyed.

The study excluded all professional nurses who were not properly registered as Health team of nurse supervisors family or were replacing interim holder nurse of UBS staff in addition to those who for whatever reason could not or did not feel the urge to participate in the data collection for the study.

It was used in data collection an adaptation of the instrument *Primary Care Assessment Tool (PCA Tool)*, in its version validated in Brazil entitled *PCA Tool-Brazil*. This instrument is widely used by national surveys that assess the quality of care provided by Family Health Teams. The PCA Tool was considered the most complete and suitable to measure the attributes needed to APS, to accept the assessment framework and procedural characteristics of primary care services and be available in different formats. Adaptations in the original PCA Tool instrument were necessary when the validation process for Brazil, which took into account the cultural characteristics of the population and the national health system (PAULA et al, 2016).

Nine (09) open questions related to the work process, instruments and development of USF Rural Zone and the arrival of the Program More Doctors were conducted semi-structured interviews, by appointment with the professionals of health facilities in which they were used. The collection was carried out through interviews recorded in digital device (mobile phone) in order to

preserve the accuracy of the information obtained. Before the interviews, the collection procedures were exposed, and resolved the doubts of respondents on the issues concerning the questionnaire was left to the interviewee at ease to answer questions both through digital means and in writing.

Of the seven (07) interviews scheduled in one case the scheduled professional after the first contacts demonstrated a lack of interest by not confirm and or respond to various types carried out communications, phone calls, emails and text messages to concretize the interview stage demonstrating thus be unavailable for us to meet, even after confirming the participation in the research process.

Six (06) professionals were approached which, however, in this study had two more (02) losses due to factors beyond our will: One of professionals fell ill during the interview and can not complete the same; in another unit the professional was not effective because it was replacing the holder and even recording could not be considered by the lines have less than six months ahead of the unit provided service. So we completed four successful approaches. Among these four (04) interviews, we have the longest 39 minutes 57 seconds, and the shorter with 8 minutes and 22 seconds.

The analysis method of qualitative data in this study, we used the thematic modality that defines a set of communication analysis techniques aimed at achieving, by systematic procedures and Description of the objectives of the content of messages, indicators (quantitative or not) that allow the inference knowledge relating to the conditions of production / reception of messages (Bardin, 2011).

Content analysis in a research involves research techniques which allow, in an orderly manner, the description of the messages and attitudes linked to the context of the subject's assertion researched and deductions on the collected data (Cavalcante et al, 2014).

Bardin (2011), the construction of the collected data is to find the core meanings that compose a communication frequency and whose presence means something to the purpose of the study. Thus, the following three hases to develop:

1. Pre-analysis is the stage of the organization, ie a first contact with the transcript content. superficial reading of the testimonies collected in the interview.
2. Exploration of material: made cutouts of the statements in record units expressed in words and ideas the form of categorization that reach the understanding of the study.
3. Processing of data and interpretation: the material was subjected to qualitative analysis, making received treatment - if valid and meaningful for the study as comparison with the literature.

Interviews were conducted in which they were recorded and the data collected were transcribed for Office Word 2013 program, to be analyzed and categorized keeping the data orders to highlight the results and discussions.

This study was developed ensuring compliance with the determination of Resolution 466/12 of the National Health Council (CNS). Which regards respect for human dignity and the unique adequate protection to participants of scientific research involving human beings, development and ethical engagement, which is intrinsic to the scientific and technological development (BRAZIL, 2012).

The research was submitted after approval by the Municipal Health Secretariat (SEMUSA) and approved by Brazil Platform, through the Research Ethics Committee of the Integrated College AparicioCarvalho - FIMCA under Opinion No. 1,782,125.

The subjects participating in the interviews, after explanations about the research objectives, as well as the technical development to be applied, made the signing of the Consent and Informed (IC) which was prepared in duplicate, one was with the participant and another with the responsible researchers. Freedom of participation and guarantee of secrecy of the information obtained was ensured, and they are informed of the publication of this information for scientific studies. Data collection occurred from August to September 2017.

### III. RESULTS AND DISCUSSION

The study included four professional nurses from four different USF Rural Porto Velho Zone, two of which are female and two male, with ages ranging 31-36 years working in the FHS - Strategy and Health between 1-7 years, these post-graduates, and are duly registered as a professional nurse in the FHS.

The speeches made during the interviews allowed the construction of four thematic categories: **nursing work process in USF rural area; Professional nursing vision of primary health care; More medical program's contribution to primary health care; Weaknesses and strengths identified by the strategy nurses and family health in the Rural Area of PVH - RO.**

#### Category 1 - Nursing Work Process In Rural Area USF

Based on the lines, emerged the category dealing with the work process that the nurse holds in USF Rural Area of Porto Velho - RO, since activities and assignments are used described in specific clinical protocols to meet the Basic Health Units, effecting what is in their power to bring health community it is inserted, as expressed speech cited.

*"[...] realize activities in accordance with the clinical protocol guidelines [...]" Nurse USF 2*

About it, is denunciation as stated by Brazil (2010), on the preparation and publication of the Clinical Protocols and Therapeutic Guidelines (PCDTs) that plays a key role in the proper use of care practices in order to create better impact on health.

As Rodrigues et al. (2011), nurses of UBS are responsible for a large portion of the aspects necessary to ensure a quality life to users. To reorder these professionals care health strategy protocols It is created which are instruments that exercises a call on health according to the rules of professional practice. Thus the professional to be supported and regulated when exercising their functions ensuring the quality of service.

However it is known that the nurse in a Family Health Unit (USF) should support and supervise the work of community health agents (CHA), assisting people in need of care, organize the daily life of USF, plan actions and run activities along the community. In addition to exercising the continuing education of professionals on your team. However it is known that this is not a reality in these localities surveyed, speaks as described below.

*"[...] and what we talked continuing education for professionals, planning, guidance, training and the sharing of knowledge with the health team, so we can optimize the time we prepare to serve the population, when in contact with them at the facility [...]" Nurse USF 3.*

Thus the nurse is in charge the execution of actions in primary care epidemiological and health surveillance in the areas of attention to children, adolescents, the woman, the worker and the elderly; It has the autonomy to conduct continuing education activities of nursing staff and other members, participate in the management of the inputs necessary for the proper functioning of UBS (BRAZIL, 2012; SOUSA, 2012).

It is believed that all the work in the health area should be vested by procedures that have worked and or experienced should realize confirm good practices in prevention and maintenance and recovery of health, for this to occur should know and apply knowledge arising, for example: the BANP, protocols and guidelines.

The professional nurse has another important role in USF for the materialization of a health care more acceptable and worthy to be provided to its customers. This being the performing nursing consultations as a way to better understand the health history of the person who will be provided assistance. This was a point this speech below.

*"[...] individual consultations, group consultations, everything that is the responsibility of the nurse in the family health strategy [...]" Nurse USF 4.*

As the BANP nurses must fulfill several assignments that are your responsibility performs them in basic health units. These being: performing health care to individuals

and families enrolled in their team, perform nursing consultations, procedures, group activities as protocols, provided by the Ministry of Health (BRAZIL, 2012).

It is known that the reality faced by professionals working in the rural area is difficult because there are problems arising from the lack of constant and uninterrupted public policy. As well as the lack of planning to be a minimum of materials and equipment to develop continuing education for staff.

### Category 2 - Vision Professional Nurses On Basic Health Warning

The subjects of the study show, from the speeches made during the interviews, the professional nurse vision that acts in the countryside presents on Primary Health Care, expressing that to have good health it is necessary that first there is the prevention of diseases, using health education as the main tool, and foster care for small injuries are healed at primary level, as expressed the lines below.

*" [...] For you to live healthy you need to prevent disease, so primary care is basically prevention [...] and health education." Nurse USF 1*

Based on the speech above is in Roecker and Marcon (2011), the same affinity that health education, exercised in the FHS, should be a very important activity, both for professionals and for the community because the goals the FHS will only be achieved through educational practices aimed at enhancing the health of individuals. However, it is necessary for the team to plan and organize with user participation activities that involve the entire population in different life cycles .

Based on that primary care is proposed, it agrees with the view that nurses reported in this study. Thus the basic attention is the first user access to the health system, which according to their health status, this can be resolved on the first contact or directed to other levels of care. The speech below describes.

*"Well, the attention is the health sphere, where citizens should be brought into the public health system. Where theoretically he should have solved about 80% of the problems [...]" Nurse USF 3*

Continually check that the Primary Care (AB) is a joint health action at individual and collective level, following the principle that involves the promotion, protection and community health recovery, aiming that at this moment are about healed of 80% of public health problems. Developing a comprehensive care to alter the health status of the individual according to the determinants and health conditions (BRAZIL, 2013).

So follow a schedule of service in a rural primary care unit will not always be easy, as these come to meet beyond their enrolled area, in this direction the team should be prepared to meet spontaneous demand, as these units are

only references to these individuals in search of health care. As speaks next.

*" Good, Basic attention she's related to primary care. Staff should act in the fight against diseases, and the prevention, promotion and recovery of health, that particular locality. The important thing is that the team can meet local demand and also spontaneous demand as we try to meet, because people sometimes comes from a locality as the BR, local far [...]" Nurse USF 4*

As expressed in the speeches, Brazil (2013), points out the need to schedule follow-up on the agendas of professionals from UBS. It is also essential that the units are open and ready to receive the patient who previously did not schedule your query by casualties account and or unforeseen.

It defines that the primary health care are basic health units or family health strategy, which craves that this be the first counted user with the Unified Health System (SUS). The secondary and tertiary attention consist of hospitals and outpatient unit, in which the same user will receive a more specific health care (BRAZIL, 2012).

In the countryside is no different, because the contact of community health workers to the population of its coverage area allows the nurse, doctor and other staff of professionals can intervene in the health and population of the disease, ie through home visits , active surveillance, health education and other activities that can be undertaken by staff of the Family health Strategy.

### Category 3 - Program's Contribution More Medical For Primary Health Care

In this category it is observed that the coming of the Program More Health Ministry Physicians, is causing for Primary specific contributions which brought improvements in service within the APS.

*"[...] there are two excellent professionals Program More Doctors, two Cuban [...] they have improved care in the family health, 100% of what was before them come [...]" Nurse USF 1*

According to the description of the speech input from medical professionals in the FHS strengthens and expands the intervention capacity, particularly in view of the adoption of a model of care that involves the different demands of health promotion, disease prevention, diagnosis and treatment, prioritized to the area (Santos et al, 2015).

Note - The importance of this program when accompanied by the same vein of thinking professionals who prioritize in its practical applicability of actions that become effective for the care in UBS.

Under the same point of view, it is observed that the MDP's coming also facilitates the development of activities provided by APS, thus optimizing the assistance



even with few resources so that we can provide service. According to the talks described

*"Well, I think so [...] facilitates the development of the team's activities and optimizes the assistance [...] nurse USF 3*

You can see then that the implementation of MDP added new experiences and practices in the care of health, which contributes to the improvement of APS, also offering support finds in the organization and provision of services, thus facilitating the development of activities that UBS (SANTOS, 2015).

*"Yes, the more medical program was instrumental in the formation of the team [...]" Nurse USF 4*

It's known that more than three years of MDP deployment in the country, which is widely reported by official data from the Ministry of Health indicate an increase in APS coverage throughout Brazil, as program physicians are becoming adders for FHS, thereby strengthening health actions at this level of attention (ANDRADDE, 2017).

The Pan American Health Organization (2015), reports that the MDP even exposing difficulties methodological, there is strong evidence of management that indicate that the expansion of the Strategy and Health through its teams can reduce child mortality and hospitalization for the simple fact to pay Primary increasingly strengthened.

However, it is observed in the reports that the MDP is seen as positive for Primary because in some locations would have the doctor on your team without the presence of the program. Thus the presence of this professional contributes to implementing preventive and curative actions, in addition to this team member take the pledge of allegiance, agreed in advance by the ministry of health, facilitating the development of the team's activities and improving care.

#### **Category 4 - Weaknesses and Strengths Pointed out by Nurses of Strategy and Family Health in Rural Area**

##### **Pvh - Ro**

The statements show that there are many difficulties faced not only for the nurse, but also for the team in general, because the lack of equipment, materials, supplies and medications needed undertakes all the work of the team. Occurring thus offering poor care for the resident population of these regions, which already have by nature the difficulty of access. The following reports describe this category.

*"The difficulty is not having adequate space, another difficulty is the issue of ACS that are often accommodated [...]" Nurse of USF1*

However it is considered that working in an environment where there is a good physical structure influences nursing practice, promoting its realization with the required technical quality. Upon the existence of an appropriate framework with regard to the comfort promotes more humane working conditions for the team, also favoring the

best quality of care to the user's health (Pedrosa et al, 2011).

In relation to the ACS Peixoto et al (2015) reports that it aims to carry out active and passive surveillance of the problems related to the community, because they usually occur mostly within the home. Thus the ACS identifies the people in your community and health disorders present in family, neighborhood and friendship. So it is the improvement of its projection and its status becomes meaningful and relevant importance within the team that is inserted.

Upon this, the next step moves through the nurse who is recognized by the capacity and ability to understand the human being in general, the ability to provide a friendly service and understand the social differences promoting the interaction and collaboration between users, the team health, regardless of their economic, cultural or social conditions, optimizing care interventions. However without proper performance of the ACS user demand compliance with established disease (BACKES, 2010).

It comes to the structure of the relevant equipment to the work developed by these professionals requires a constant and usual apparatus to make predictions and identify the existing conditions in the communities. The comment below expresses the reality of some current difficulties in the countryside of Porto Velho.

*"Lack of sonar equipment, lighting focus to prevention, lack of medication." Nurse USF 2*

It is thus explicitly as Moura et al (2010), the shortage of equipment, educational materials and medicines, involved in the quality of care to users, as it may hinder the realization of health promotion activities, jeopardizing the continuity of care. Taking into consideration that the Family Health Strategy has as one of its main lines of action to promote health and disease prevention.

Under these difficulties also points up the challenge of having a full team, as one of the professionals mentioned that since he started working in the unit did not have the opportunity to assist the community with a full team. The speech is then characterized situation.

*"Well, when I came from, since I started working in the family health strategy in the rural area, my team never fully complete. We have difficult access, because the unit is far away and the road is not very good, in some periods of the year, the absence of medications that are essential, we do not have financial support and extra materials for conducting activity in groups or in lectures [...]" Nurse USF 4*

Thus it appears that as Rodrigues et al (2011), teamwork is the result of the integration of actions and involvement of professionals. A hegemonic team has a set of characteristics consisting of: Soft division of labor; question the difference in valuation of the different



works and their agents; preserve the technical differences between the specialized work; exercise professional autonomy, taking into account the interdependence of the various professional fields; decentralize decision-making in the service staff; and build a global assistance project. However, having a complete team in the FHS, only adds benefits lends itself quality care to users.

As Lopes and Bousquat (2011), they highlight some difficulties that permeate the work in a FHS, such as the lack of professional qualification, difficulty of working in teams, structural difficulty lack of transportation to better access of workers in households and the deficit professionals in teams.

By the lines it is agreed that it is difficult to develop an attention of excellence for the population in the localities in which they are inserted into the service units. Difficult access, inefficient communication of the different means either by phone, mobile, internet and others. Physical structuring clash with that of standardization, lack of resources / equipment to which the trader can perform its function as it should in a humane way, are relevant factors to be cited.

On the other hand, nurses confirm that the interpersonal relationship is a positive in these units. The main point that awakened us to find what motivates, what makes these professionals selfless for their work in the villages of the countryside that with all the difficulties tend to persevere in the mission to fulfill its role of promoting health being what moves you are the people". The relationships created and narrowed with the community and with the teammates that in times of difficulties faced by their units are in each other the strength to persist in the Family Health Strategy these places, keeping in your proposal many positive points, but they need to be constantly reviewed and rated by who actually is on the edge of care conducted among communities who feel supported to know they can count on care of a doctor and especially with the Ethics and the commitment of a nurse. The following reports describe the thought.

*"[...] the good relationship with my teammates, and good relationship with the community [...]"  
Nurse USF 4.*

One might say that interpersonal relationships are important to understand the care in health professional practice, as this strengthens increasingly the process of working on a team in the FHS, in which empathy also consists in a key element, making the subject understandable at the time of a positive or negative judgment (FORMOZO et al, 2011).

With so many challenges pointed out by nurses interviewed stands out in speech after the presence of the doctors of the Program More Doctors, as they become the basis to encourage teams of locations the countryside.

*"The ease of development of my team is geared to physicians Program More Doctor." Nurse. USF 1*

The Program More Doctors strengthens primary care, enabling people to locations difficult to access pose a health service with a high satisfaction level with the present relationships between the community and the team (PAHO, 2012).

It is known that due to the great need to provide doctors to areas of vulnerability, the Federal Government took the initiative to deploy more medical Program, this was possible to have immediate, emergency and more sustainable answers is to provide doctors to care services Basic (BRAZIL, 2015).

In accordance with the report of Operational Audit of the Court of Audit (TCU), it demonstrated that after implementation of MDP listens growth of 33% in the number of consultations and 32% in home visits, indicating the increase in supply health service (SANTOS, 2015).

By the lines it is observed that it is difficult for nurses to develop an effective attention to the population due to lack of resources to enable the professional to perform its function with excellence. But even with the obstacles the interpersonal relationship of the staff and the community is what keeps the teams and the operation of the Family Health Strategy in these locations.

#### IV. FINAL CONSIDERATIONS

The study achieved the objective of analyzing the ESF and the MDP from the perspective of nurses, for in the course of the interviews it is clear that the ESF is stagnant, that despite the implementation of PMM who came to meet the need for doctors in remote locations It culminated in the structuring of many teams, but the problems arising from political and administrative issues hinder the Primary termination.

However according to the expressions of respondents, the MDP provided a high satisfaction of professional nurses with the inclusion of these medical teams in the localities of the countryside, given that the municipality had great difficulty in entering this professional by their own means. For them, the program's doctors strengthen the actions taken by the teams, and demonstrate that actually are involved and committed to what they propose the strategy.

On the provision of assistance and the progress of the UBS service was unanimous declarations in the case of difficulties in carrying out the work process, as there is shortage of other human resources, materials, medicines, and poor physical infrastructure, hindering the progress of the service. It was appointed although the reference and counter reference also reveals itself as a major obstacle to the day to day work of the teams, because the lack of a network of computers connected to the Internet prevents

the user from scheduling tests, procedures and or consultation with expert in the urban center, leaving the user waiting indefinitely scheduling, unlike what happens in the units of capital, in which users leave already regulated.

The analysis of the speech revealed a point considered primary optics of the nurse in the ESF, as it became clear that are professional self-sacrificing for their work, which with all the difficulties tend to persevere in the mission to fulfill its role of promoting health, linked with the interpersonal relationship. These relationships created and narrowed with the community and with teammates, is strengthened at the time of difficulties faced by the teams of the units.

The FHS and the MDPare proposed under construction representing the aspirations of the population in various corners of our country, but needs to be constantly re-evaluated and improved. And this is only possible if taken into account the points made by the teams that deal directly with these people who star in a poor part of our society, technicians, doctors and especially nurses who with his holistic view recognize the demands presented by these communities Rural Porto Velho Zone.

In this research we found setbacks in getting answers from the professionals to the interviews, and we have accomplished just taking losses because some did not fit the inclusion criteria. Through the lines, we observed that some professionals responded succinctly demonstrating discredit not specifically to the survey, but the theme and worked their lived realities.

The results presented here, contribute to the strengthening of the theme within the municipality as well as brings up the need to rescue the Family Health theme, Primary Care and Program More Doctors, aiming to broaden the debate between the actors directly and indirectly involved.

The research also helps to be able to analyze how they are being offered health services of the localities of the Rural Zone of Porto Velho. This being an analytical tool for the people, for health professionals and especially for municipal managers, causing them to know the reality faced by the teams and users. In addition to making online study to obtain knowledge in academia in health, aiming to expand research in looking for improvements to primary health care.

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# Experimental Determination of the Convective Coefficient of Heat Transfer Using the Global Capacitance Method

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**Abstract**—The heat transfer coefficient ( $h$ ) is an extremely important variable in the evaluation of convective heat transfer, however, its determination is a great challenge due to the various factors that influence it: fluid viscosity, fluid density, specific heat of the fluid, thermal conductivity of the fluid, coefficient of volumetric expansion, fluid velocity. The objective of this work is the experimental determination of the convective heat transfer coefficient by means of the global capacitance method. Three test bodies, two cylindrical bodies and one spherical body were used. These specimens were individually heated in a stove, and heating was monitored by means of a thermocouple and a data logger. The results showed a good concordance between the values of  $h$  obtained experimentally and the literature.

**Keywords**—Convective Coefficient, Global Capacitance, Heat Transfer, Transient Conduction

## I. INTRODUCTION

Heat transfer is defined as the transmission of energy due to a temperature difference in a medium or between different means. There are three modes of heat transfer: conduction, convection, and radiation. The heat transfer by convection is classified in natural convection and forced convection, according to the nature of the fluid flow. Natural or free convection is defined when fluid movement occurs as a result of only the differences in specific mass caused by temperature gradients. When the flow of the fluid is induced by external agents, such as a pump, the process is called forced convection. [1]

The coefficient of heat transfer by convection or film coefficient,  $h$ , according to Newton's law of cooling, is the key point to obtain the amount of heat transferred from a surface to a fluid or vice versa.  $h$  is, in fact, a complex function that depends on the fluid flow, the physical properties of the fluid medium and the geometry of the system in question. In the case of the physical properties of the fluid and its flow, we can mention: dynamic fluid viscosity, fluid density, specific heat of the fluid, thermal conductivity of the fluid, coefficient of volumetric expansion, fluid velocity, acceleration of gravity and temperature difference between the surface and the fluid. With regard to geometry we can cite the characteristic dimension, dimension that dominates the phenomenon of convection. **Error! Reference source not found.**

One of the major challenges remains the determination of the average coefficient of convective heat transfer ( $h$ ), for each process condition, which plays a decisive role in the processes involving heat transfer between a fluid and a solid. One of the most common causes of error in the calculation of the temperature of products is originated by the value adopted for this coefficient. In the literature there are recommended ranges for this value, but they do not adequately characterize the particular process. [3]

Considering the numerous variables that influence the calculation of  $h$ , there are no tables to obtain the convective coefficient. In general, in most engineering applications,  $h$  is determined experimentally and from empirical correlations. The importance of calculating the convective coefficient for a given specific situation, within



a precision range, is essential for an adequate dimensioning of the thermal demands in question. **Error! Reference source not found.**

The phenomenon of transient conduction occurs in numerous engineering applications and can be analyzed using different methods. The nature of the procedure is closely related to the hypotheses made for the process. If, for example, temperature gradients inside the solid can be neglected, the global capacitance method can be used to determine the temperature variation over time. That is, it is assumed that during the transient process the temperature of the system is uniform, but it is not constant.[4] The objective of this work is the determination of convective coefficient in convection of solid bodies using the heating transient, applying the global capacitance method.

## II. GLOBAL CAPACITANCE METHOD

Global capacitance method is based in the hypothesis that solid temperature is uniform in the space, for all time during transient process. That assumption means that temperature gradients inside solid are despicable.

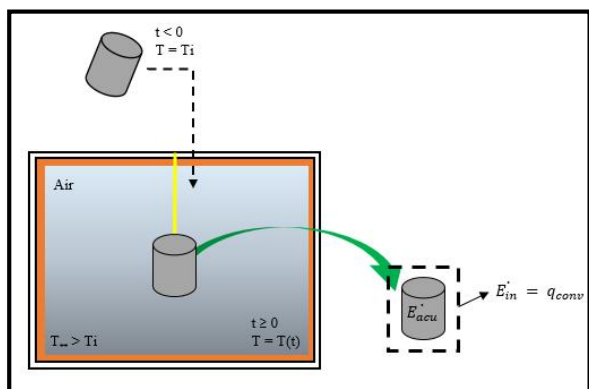


Fig.1: Heating a solid inside a stove

By Fourier Law, thermal conduction in the absence of a temperature gradient implies in existence of an infinity thermal conductivity. That assumption is impossible. However, the assumption is approximated if the resistance to conduction inside solid to be little in comparison to resistance to heat transference between solid and proximity [5].

By neglecting the temperature gradients inside the solid, it is not possible to analyze the problem using the heat equation, this because the heat equation is a differential equation that describe temperature spacial distribution inside the solid. An alternative is to determine the transient answer by formulation of an overall energy balance at solid [5].

Considering the situation in Fig.1: Heating a solid inside a stove, where a solid with uniform initial temperature  $T_i$  is heated inside a stove with higher temperature  $T_\infty > T_i$ . If the heat process begins at time  $t = 0$ , the solid temperature

will increase for times  $t > 0$ , until it reaches  $T_\infty$ . This increase is due to convective heat transfer at the solid-air interface. The overall energy balance must relate the rate of heat input at surface with the rate of variation of internal energy:

$$\dot{E}_{in} = \dot{E}_{acu} \tag{1}$$

or

$$hA_s(T_\infty - T) = \rho V c_p \frac{dT}{dt} \tag{2}$$

Setting the temperature difference as:

$$\theta = T - T_\infty \tag{3}$$

and recognizing that  $(d\theta/dt) = (dT/dt)$ , if  $T_\infty$  is constant, we have:

$$\frac{\rho V c_p}{h A_s} \frac{d\theta}{dt} = -\theta \tag{4}$$

Separating variables and integrating from the initial condition at which  $t = 0$  and  $T(0) = T_i$ :

$$\frac{\rho V c_p}{h A_s} \int_{\theta_i}^{\theta} \frac{d\theta}{\theta} = - \int_0^t dt \tag{5}$$

in which:

$$\theta_i = T_i - T_\infty \tag{6}$$

Making the integrations, it follows that:

$$- \ln \frac{\theta}{\theta_i} \frac{\rho V c_p}{h A_s} = t \tag{7}$$

The importance of the global capacitance method is its inherent simplicity for the resolution of transient heating and cooling problems, in its use it is necessary to determine under what conditions it can be employed with satisfactory accuracy. When Biot number ( $B_i$ ) is much less than 1 ( $B_i \ll 1$ ), the resistance to conduction inside the solid is much less than the resistance to convection through the boundary layer in the fluid. Thus, the hypothesis of uniform temperature distribution at the intersection of the solid is reasonable for the Biot number to be small [5]. Generally, the following relation is used to validate the use of the global capacitance method:

$$B_i = \frac{h L_c}{k} < 0,1 \tag{8}$$

For convenience, it is common to define the characteristic length ( $L_c$ ) as the ratio of the volume of the solid to its surface area:

$$L_c = \frac{V}{A_s} \quad (9)$$

### III. MATERIALS AND EXPERIMENTAL PROCEDURE

Table.1: Geometric and thermal properties of test body 1

	Body 1	Body 2	Body 3
<b>Geometry</b>	Cylindrical	Spherical	Cylindrical
<b>Diameter [m]</b>	0,0254	0,0502	0,0254
<b>Height [m]</b>	0,1524	-	0,1524
<b>Material</b>	Electrolytic Copper	Electrolytic Copper	Brass
<b>Density [kg/m<sup>3</sup>]</b>	8.890,0	8.890,0	8.530,0
<b>Cp [J/kg.°C]</b>	385,0	385,0	380,0
<b>k [W/m.°C]</b>	395,0	395,0	127,0
<b>T<sub>∞</sub> [°C]</b>	255,0	255,0	255,0
<b>Volume [m<sup>3</sup>]</b>	7,7232.10 <sup>-5</sup>	6,6238.10 <sup>-5</sup>	7,7232.10 <sup>-5</sup>
<b>Surface Area [m<sup>2</sup>]</b>	0,0132	0,0079	0,0132

Thermal properties were obtained in [5]. The test bodies and experimental apparatus are shown in Fig.2: Test bodies and experimental apparatus

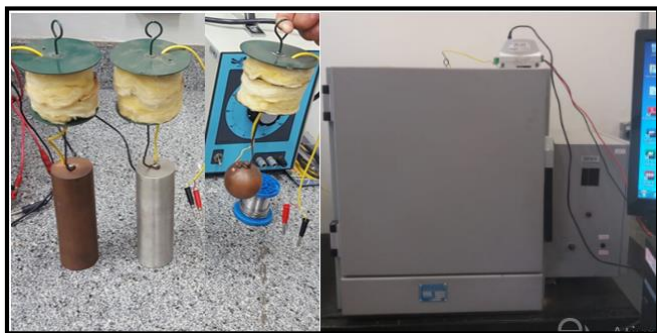


Fig.2: Test bodies and experimental apparatus

The experimental procedure consisted of heating the tests bodies individually inside the stove until a temperature of

For the accomplishment of the tests three test bodies were used, whose geometric characteristics and thermodynamic properties are presented in Table.1: *Geometric and thermal properties of test body 1*; a Magnus brand stove which reaches a maximum temperature of 300 ° C; a Novus Field logger data logger and T-type thermocouples.

200 °C, while the data logger recorded the temperature and time. Subsequently, the heat transfer coefficient was determined using the global capacitance method presented in item II.

### IV. RESULTS AND DISCUSSION

In order to calculate the convective coefficient, the obtained data were treated, and the curve  $-\ln(\theta/\theta_i) \times$  was lifted, and by means of the angular coefficient ( $m$ ), it was possible to obtain the convective coefficient using equation 7. The heating profile and the curve  $-\ln(\theta/\theta_i) \times$  time for each test body are shown in Fig.3: *Heating profile and  $-\ln(\theta/\theta_i) \times$  time for test body 1* Fig.4: *Heating profile and  $-\ln(\theta/\theta_i) \times$  time for test body 2* and Fig.5: *Heating profile and  $-\ln(\theta/\theta_i) \times$  time for test body 3.*

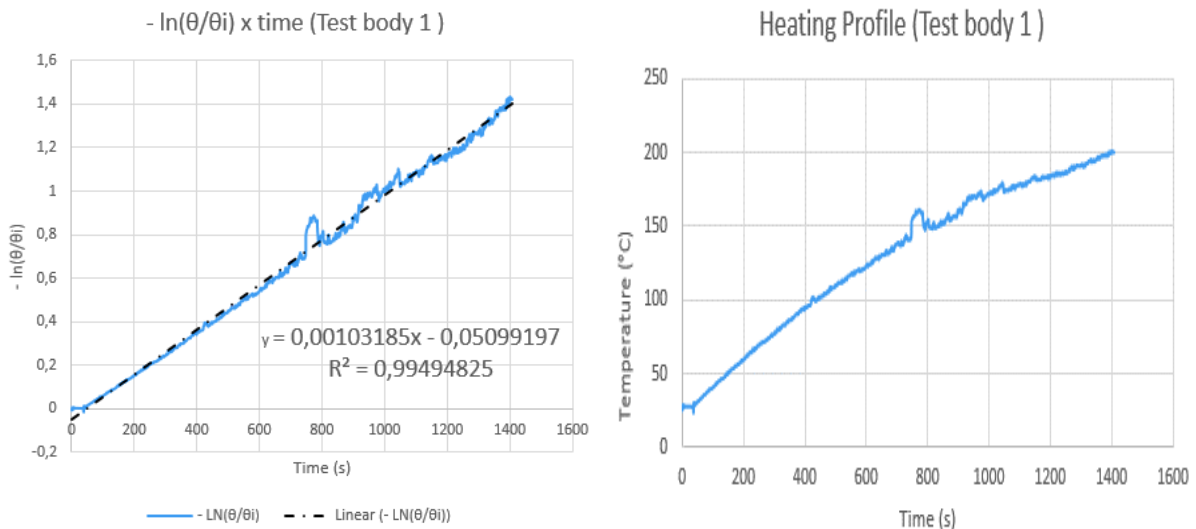


Fig.3: Heating profile and  $-\ln(\theta/\theta_i)$  x time for test body 1

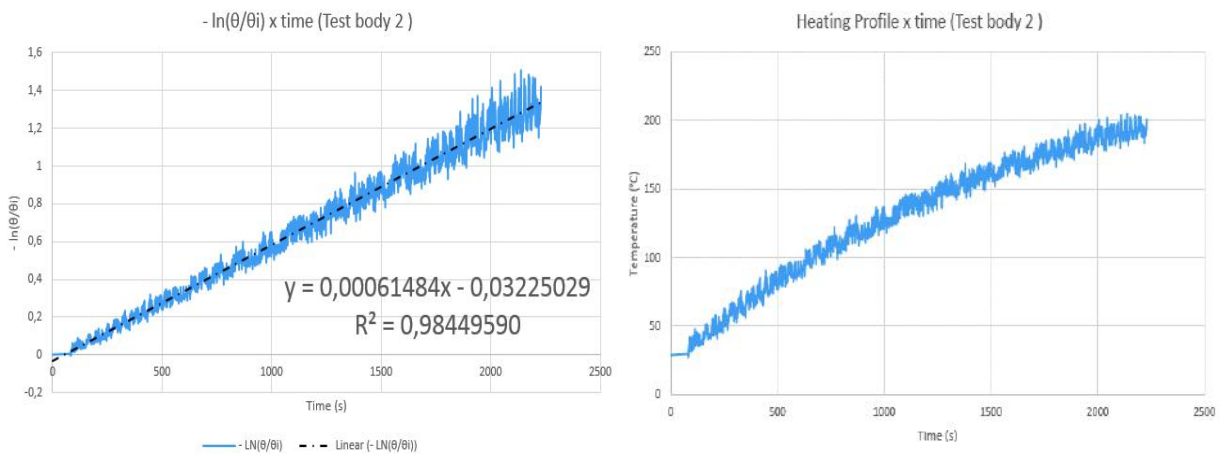


Fig.4: Heating profile and  $-\ln(\theta/\theta_i)$  x time for test body 2

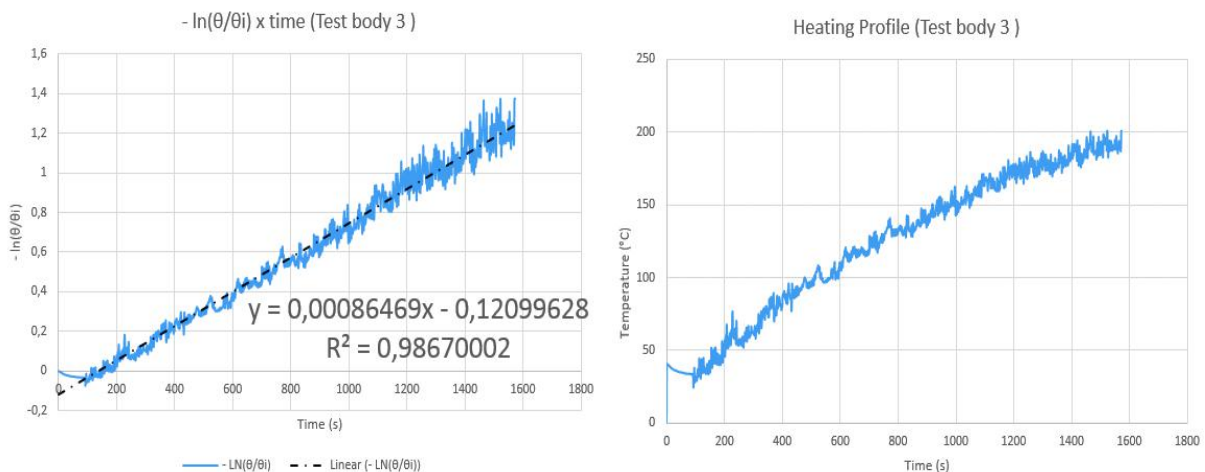


Fig.5: Heating profile and  $-\ln(\theta/\theta_i)$  x time for test body 3

Table.2: Main results presents the convective coefficients obtained during the thermal exchange of each of the test bodies and also the respective values for the Biot number.

Table.2: Main results

	Body 1	Body 2	Body 3
<b>m</b>	$1,032 \cdot 10^{-3}$	$0,615 \cdot 10^{-3}$	$0,865 \cdot 10^{-3}$
<b>h [W/m<sup>2</sup>.K]</b>	20,70	17,61	16,43

<b>lc</b>	0,0059	0,0084	0,0059
<b>Bi</b>	0,0003	0,0004	0,0008

It is important to note that the use of the global capacitance method for determining the heat transfer coefficient is valid because the Biot number values are much less than 0,1 for all test specimens, these values were calculated using equation 8 and are set forth in Table.2: *Main results 2*.

According to Incropera et al. [5], typical values for the convection heat transfer coefficient for natural convection gases are between 2 to 25 W/m<sup>2</sup>.K, so the values found were satisfactory, since they are within this range. The value of this coefficient for the copper cylinder (*test body 1*) was 20,70W/m<sup>2</sup>.K, while that of the sphere (*test body 2*) of the same material was equal to 17,61W / m<sup>2</sup>.K, which demonstrates the influence of the surface form. The heat transfer coefficient for the brass cylinder (*test body 3*) evaluated was equal to 16,43W/m<sup>2</sup>.K, demonstrating the influence of the material on the convective coefficient. The linear coefficient of the curves  $-\ln(\theta/\theta_i) \times \text{time}$  did not result in zero as expected. This deviation is due to the errors built into the experiment and the model, ie the temperature inside the greenhouse is not really constant over time and the temperature distribution inside the solid is not uniform.

## V. CONCLUSION

The heat transfer coefficient,  $h$ , was obtained experimentally from the global capacitance method, since its validity was proved for the situations analyzed. The obtained values indicate a good agreement with the typical values indicated in the literature for the natural convection range between gases and solid bodies. With the experimental results, it is possible to observe the sensitivity of the convective coefficient of heat transfer to the superficial form and also to the material. In addition, the simplicity of the use of the global capacitance method in simplified transient conduction situations and their applicability was verified.

## VI. ACKNOWLEDGEMENTS

The authors are very grateful to the PUC/MG (*Pontifícia Universidade Católica de Minas Gerais*), CNPQ (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*), CAPES (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*) and FAPEMIG (*Fundação de Amparo à Pesquisa do Estado de Minas Gerais*).

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